Assessment and Mitigation Planning for Risk Reduction

1 MILLION SAFE Schools & Hospitals
Make a Pledge, Save a Life.

Guidance Notes

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Photo credits:
Front and back - Remains of a hospital in Vietnam after a strong typhoon (WHO-Manila)

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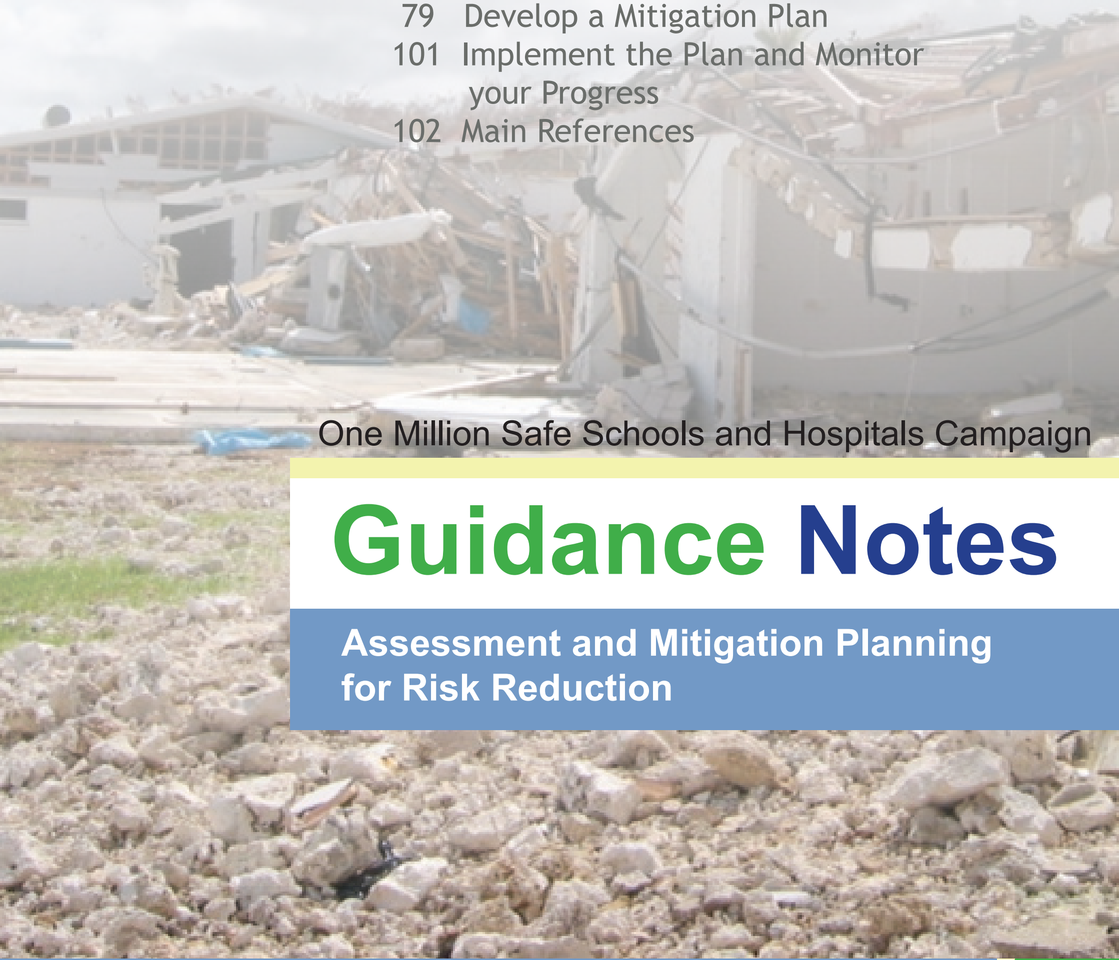


One Million Safe Schools and Hospitals Campaign

Guidance Notes

Assessment and Mitigation Planning for Risk Reduction

Terminology

Natural hazards are "Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage".

The term **hazard event** refers to the actual occurrence of a hazard. A hazard event may or may not result in the loss of life or damage to human interests.

A **disaster** is a "serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources".

Risk is the product of hazards over which we have no control and vulnerabilities and capacities over which we can exercise very good control.

Vulnerability is the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. A school is said to be 'at-risk' or 'vulnerable', when it is exposed to known hazards and is likely to be adversely affected by the impact of those hazards if and when they occur.

Exposure refers to people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses.

Mitigation refers to the process of the lessening or limiting of the adverse impacts of hazards and related disasters.

Disaster Risk Reduction is the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Preparedness is the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.

Building code is a set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage.

Prevention is the outright avoidance of adverse impacts of hazards and related disasters.

Response is the provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Retrofitting is the reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards.

The above definitions were cited from the United Nations International Strategy for Disaster Reduction Terminology (UNISDR, 2009)

http://safehospitals.info/index.php?option=com_zoom&Itemid=113&catid=13

1 A Summary of the Guidance Notes

The **Guidance Notes on Assessment and Mitigation Planning for Risk Reduction (AMPRR)** present general steps for assessment of schools and hospitals within the view of mitigation planning. Schools refers to all educational institutions and hospitals refers to all health facilities. The guidance notes consist of three components:

General information on Disaster Risk Reduction and advocacy points. (Section 2) briefly describes Disaster Risk Reduction for Schools and Hospitals and describes actions to ensure them on the need and rationale for assessing them to determine exposure to hazards, vulnerabilities and risks to buildings for mitigation.

Assessment and Mitigation Planning for Safe Schools and Hospitals: Introduction, Context (Section 3) describes mitigation planning and implementation in four main steps, namely a) preparing to assess, (b) conducting an assessment, (c) preparing a mitigation plan and (d) implementing the plan, and provides the focus on assessment in this guidance notes.

A series of suggested steps. (Section 4) details the planning steps and highlights key points that should be considered when assessing and planning for a safer school or safer hospital. School or hospital functionalities are divided into the structural, non-structural and functional components. Discussions on building performance level and the related protection levels are introduced.

2 Disaster Risk Reduction for Safe Schools and Hospitals

More than a billion students enrolled in primary and secondary schools, with about 875 million school children live in high seismic zones and hundreds of millions are exposed to regular flood, landslide, and extreme wind and fire hazards. Schools, which are not constructed nor maintained to be disaster resilient, can result to lifelong injuries and death to millions of children and adults in these schools causing irreplaceable loss to families, communities and countries[1]. Likewise, a large number of hospitals are possibly exposed to extreme hazards. Hospitals which fail to withstand strong forces or pressures of nature (e.g. seismic, wind, flood, etc.) can result to severe damage, further resulting to stress, injury and possible death to the hospital community (e.g. doctors, nurses, operators) specially to patients and casualties brought in for treatment or care during disasters2. The disruption of functions and related services arising from damage of the building structural and non-structural components can similarly have medium to long-term negative effects.

For Hospitals:

- Disruption in treating patients and victims

[1] *Disaster Prevention for Schools, Guidance for Education Sector Decision-Makers*, Consultation version, Nov. 2008. pp.3-4

[2] *Guidelines for Vulnerability Reduction in the Design of New Health Facilities*, the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.pp.13-16

immediately can result to continued physical and mental deterioration, further resulting to lifelong injuries and trauma.
- Damage and destruction of hospital or health facility infrastructure can significantly drain financial resources, and costs of reconstruction can be a substantial burden to owners (private or public). It is possible that the total cost of replacement or repair of damaged hospital equipment and materials may be significant compared to the cost of the structural damage.

Saving lives, reducing (and eliminating) harm to patients, disaster casualties and hospital personnel, become urgent and existing hospitals need to be identified, assessed for risks (site, structure and functions) and their structures made safer.

For Schools:

- Disruption of education activities may require moving classes into temporary (or make shift) classrooms, where the environment may not be as conducive for the child's learning or healthy development;
- School resources or budgets are used to rehabilitate, replace or repair the damaged facilities, thus reducing its available and allotted resource for other development programs or projects;
- Difficulty for school children to continue their schooling, especially when resources of the school

and their families are affected by the disaster and a similar difficulty to cope with the additional expense arises; and

- In the long term, schools when viewed as a center for community activities and an important social infrastructure, the damage and disruption can result to a weakened fight against poverty and illiteracy.

Saving lives, reducing (and eliminating) harm to students, teachers and school personnel, become urgent and existing schools at risk need to be identified, assessed for risks (site, structure and functions) and their structures made safer.

Disaster risk reduction in schools and hospitals

It has to be emphasized that promoting resilient buildings (school or hospital) are just one component for the campaign of safe schools and hospitals. The bigger picture is to view and implement the reduction of risks (or disaster risk reduction-DRR) through several approaches, namely:

Assess Buildings and their Sites - to analyze and manage the causal factors of disasters (hazard, vulnerability and risks) as applied to the environment, its site, structures and its related functions

Plan and Mitigate Risks - reducing impacts on the building components and functions (structural, non-structural and functional)

Promoting resilient school and hospital buildings is one component of the One Million Safe Schools and Hospitals Campaign.

which include reduced exposure to hazards or outright avoidance (prevention), lessened vulnerability of people and property, wise management of land and the environment

Prepare Schools and Hospitals - means knowledge and capacities are developed by the school or hospital, and in wider stakeholdership-professional organizations, government, communities and individuals, to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.

Being prepared can be achieved through DRR education, providing the necessary knowledge to the hospital or school community and enhancing their capacity towards providing emergency services, mitigation planning.

The **One Million Safe Schools and Hospitals Guidance Notes on Emergency and Disaster Preparedness for Schools and Hospitals** and similar documents developed by campaign partners (e.g. Guidelines for Hospital Emergency Preparedness Planning by GOIUNDP) provide detailed ideas and useful actions in achieving risk reduction.

For Safe Schools[3]

Reducing disaster risks result from programs and actions, which aim to save lives and prevent injuries; prevent interruption of education due to recurring hazards, develop a resilient citizenry able to reduce negative impacts of these hazards. These programs and actions can include:

- Creating safe learning environments with safe construction and retrofit
    - Selecting safe school sites, designing and building new safe schools
    - Prioritizing relocation, replacement or retrofitting unsafe schools
    - Reducing non-structural risks
- Maintaining safe learning environments with school disaster management
    - Engaging school administrators, staff, students and parents in ongoing school community disaster prevention activities
    - Practicing simulation drills for expected and recurring disasters and planning for safe reunification.
    - Identifying early warning systems and planning for school continuity in the event of a hazard
    - Maintaining building structural and non-structural safety

[3] Safe School concepts and texts taken from *Disaster Prevention for Schools, Guidance for Education Sector Decision-Makers*, Consultation version, Nov. 2008

measures.
- Protecting access to education with educational continuity planning
  - Planning and developing school and national contingency plans
  - Learning and implementing "Minimum Standards for Education in Chronic Emergencies and Disasters".
  - Incorporating the needs of children not-yet-in-school, children with disabilities, girls. Ensuring that all individuals have access to safe and protective schools
- Teaching and learning disaster prevention and preparedness in schools
  - Disaster prevention and preparedness and principles of disaster-resilient construction and environmental protection inside and outside the curriculum.
  - Engaging teachers and students in adapting, developing and testing strategies and materials for risk reduction education.
  - Training teachers and school administrators in disaster risk reduction and other essential skills to promote learners' physical and emotional well-being, and ensuring that instruction is learner-centered, participatory and inclusive
- Build a culture of access and safety
  - Developing and supporting training programmes for safe

    school construction and maintenance.
  - Incorporating this content into the curricula of pedagogic institutes and postsecondary trade schools.
  - Reaching out to and involve school communities through non-formal education.

For Safe Hospitals

Reducing disaster risks result from programs and actions, which aim to save lives and prevent injuries; prevent interruption of hospital services due to recurring and extreme hazards and to develop a resilient hospital community able to reduce negative impacts of these hazards. These programs and actions can include:

- Creating safe functional environments with safe construction and retrofit
  - Selecting safe sites, designing and building new safe schools
  - Prioritizing relocation, replacement or retrofitting unsafe hospitals and health facilities
  - Reducing non-structural risks
- Maintaining safe hospital environments with a hospital disaster management
  - Engaging hospital administrators, staff, and community for community disaster prevention activities.
  - Practicing simulation drills for expected and recurring disasters and planning for safe reunification.
  - Maintaining building structural and non-

structural safety measures.

- Ensuring that all individuals have access to safe and protective hospitals
- Establishing community disaster management committees and, within those committees, hospital disaster management committees
- Training hospital personnel and administrators in disaster risk reduction and other essential skills to promote learners' physical and emotional well-being, and ensuring that instruction is learner-centered, participatory and inclusive
- Building prevention into systems through creating hospital preparedness and evacuation plans. Identifying early warning systems and planning for hospital functional and service continuity in the event of a hazard
- Integrating disaster risk reduction themes into the formal curriculum
- Learning and practicing effective response procedures (drills, setting up of temporary or mobile hospital facilities and service, etc.)

3 Assessment and Mitigation Planning for Safe Schools and Hospitals: Introduction, Context

"Schools and hospitals can effectively reduce disaster risks by planning for mitigation and implementing them. In planning, an important step is to make an assessment."

What is mitigation planning?

Mitigation planning for schools and hospitals is a way of reducing adverse impacts of hazards and related disasters. The process as presented in this guidance notes comprises of four steps, namely: (a) preparing for an assessment, (b) conducting hazard, vulnerability (or risk) assessments (c) developing mitigation plan, and (d) implementing the plan.

An **assessment** is a process for analyzing the condition (e.g. susceptibility or proneness) of a site, a building, people and operations when exposed to a natural hazard. It provides for a statement needed by stakeholders to do action, such as to prepare, to allocate resources, get organized, pursue mitigation of negative impacts.

An assessment may be used for prioritizing actions to reduce risk (e.g. detailed inspection, retrofitting). It may have two levels - preliminary and detailed.

A **preliminary assessment** may be a simple and quick approach to determine compliance with a set of

The methods of assessment must be designed and developed to suit the culture and local conditions and practices of each country.

standards or acceptable criteria, usually, a qualitative inspection or rapid visual screening.

A **detailed assessment**, on the other end, usually entail quantitative techniques (e.g. structural modeling, more rigorous computations, detailed site inspection and structural testing), which may require experts (e.g. structural engineers, scientists) to conduct them. If the preliminary assessment uncovers deficiencies in the building's ability to withstand the hazard impacts, more detailed quantitative assessments are pursued.

The methods of assessment vary from country to country and the guidance notes provide broad directions in conducting hazard assessments, vulnerability assessment. Useful links and examples are provided in the highlighted boxes at the end of the section.

Schools and hospitals can effectively reduce disaster risks by planning for mitigation and implementing them. In planning, an important step is to make an assessment. Figure 1 provides the assessment, mitigation planning and implementation process[4]. Box 1 differentiates assessments for hazard, vulnerability and risk in terms of scope and coverage.

Mitigation Planning and Implementation Process

The first step is preparing to assess and concerns putting together a team or core group who will conduct the vulnerability or risk assessment. This includes identifying the core areas for the investigation, identifying the resources needed and the timeframe for conducting the investigation.

The second step involves making an assessment. This includes identifying the hazards of the place, identifying the exposure of the building elements and the people to the hazard and their vulnerabilities. The vulnerability assessment will include the non-structural, structural and functional aspects of the buildings. An inventory of assets (people, building, equipment, data, etc.) that can be affected by the hazards is included in this step. The preliminary assessment may be in the form of checklists or more detailed assessments identifying likely impacts (risks), which can be quantitative or qualitative in nature. The vulnerability and risk estimates and the performance levels expected from the facility provide a basis for pursuing actions.

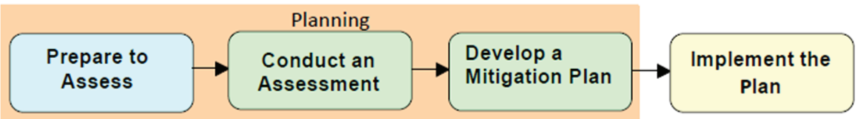


Figure 1. An Assessment and Mitigation Planning Process

The third step includes drawing up the mitigation plan needed to reduce the vulnerabilities and risks.

The fourth step is to implement the plan. Once the plan has been prepared, reviewed and adopted, it is implemented.

[4] *Adaptations from State and Local Mitigation Planning; How to Guides*, Federal Emergency Management Agency: (FEMA 386-1); September 2002, (FEMA 386-2);August 2001, (FEMA 386-3); April 2003, (FEMA 386-4); August 2003

What are the objectives of an assessment?

In general, **an assessment and recommendation statement** is needed for each building or institution, for reducing vulnerabilities and risks. The assessment may pertain to the structural, non-structural qualities and functional (or operational) qualities of these systems. It has the following objectives:

- To develop a systematic approach for evaluating natural hazard impacts to a site where schools and hospitals are located, to the people located within them.
- To develop a systematic approach towards an assessment of the factors comprising the building functionality of health and educational institutions (e.g. structural, nonstructural, and functional)[5,6].

This will be referred to as "building vulnerability assessment" which will then be categorized into "functional assessment", "non-structural assessment" and "structural assessment." The assessment may be visual, quick (or rapid) or preliminary and serves as a first step for prioritizing

[5]*Safe Hospitals in Emergencies and Disasters: Structural, Non-structural and Functional Indicators* (2009) by WHO-WPRO, Manila, Philippines: pp. 33

[6] *Guidance Notes on Safer School Construction* (2009) by UNISDR, INEE and World Bank, p.46

buildings towards a more detailed assessment.[7]

- To identify appropriate measures (e.g. prepare, mitigate, transfer risk) for improving performance against natural hazard impacts (e.g. seismic wind, flood events) of selected hospitals and schools;
- To prioritize these measures considering results of vulnerability and risk assessment, perceptions of risks, level of performance and protection desired, existing institutional arrangements, and capabilities to undertake risk reduction measures; and
- To disseminate findings, gain consensus on actions needed, plan with stakeholders in order to facilitate the implementation of the identified mitigation measures.

What should be done in an assessment?

In general, hospitals and schools have different approaches in assessing vulnerabilities and risks. One obvious difference is in their function; however, there are common steps that can be described in either vulnerability or risk assessment. The important

[7] On Different Assessments: Figure 2: Safer School Steps and Corresponding Process Flow Diagram. *Guidance Notes on Safer School Construction* (2009) by UNISDR, INEE and World Bank, p.16

Box 1- **General types[8] and levels of assessment**

A **hazard assessment** identifies and describes the hazard character and its impacts in terms of frequency of occurrence, coverage, degree of proneness of affected areas (e.g., where schools and hospitals are located) and other physical factors related to a location's condition. Its role in risk reduction may be used for a) analyzing the strength and frequency of hazards and the risk management system in place for risk identification; b) locating and designing of structural mitigation works; c) defining acceptable levels of risks (e.g., acceptable flood levels); and d) developing early warning systems for preparedness specific to a hazard.

A **vulnerability assessment**, with respect to a hazard, aids in the following: a) define degrees of exposure of population, and assets (buildings and its components) for risk identification; b) determine physical vulnerabilities of land areas; c) define zones for preparedness based on vulnerability; d) compliance of assets to meet safety regulations and in designing emergency-contingency plans.

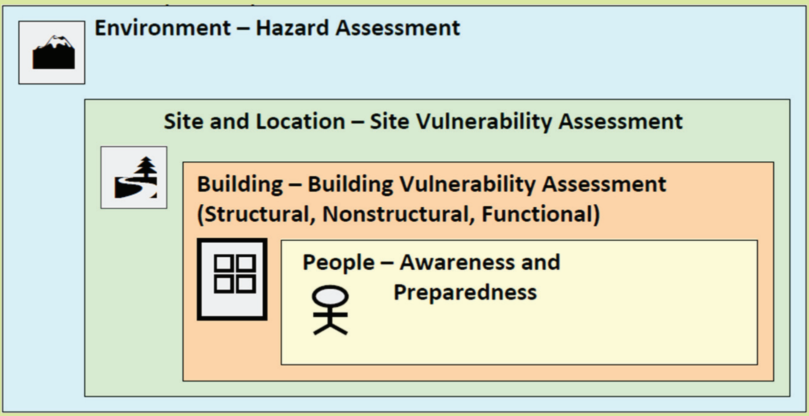
When the object of concern is a building, its vulnerability (proneness to damage from a hazard event) maybe defined by the intensity of exposure, the characteristics and response of the structure to the hazard event (e.g. magnitude, duration) and other factors, which magnify or weaken (e.g. soil) the impact. Human adjustments may be in the structures which protect them (e.g. structural, non-structural mitigation) or in the form of preparedness (e.g. DRR

[8] *Disaster risk management in development projects: models and checklists*, by Mora, S., Keipi, K. (2006): Bull Eng Geol Env (2006) 65: 155-165 DOI 10.1007/s10064-005-0022-1

education, awareness, drills)

A **risk assessment** on the other hand, takes the hazard and vulnerability assessment further by creating scenarios from combinations of various degrees of hazards and vulnerabilities. In essence, they are more useful in estimating negative consequences such as number of fatalities, injuries and monetary losses from direct and indirect damages with respect to a hazard, of specific time period. Its role in mitigation and prevention may be related more for economic-financial incentives to adopt risk management or risk reduction strategies, the compliance of assets to meet safety regulations and in designing emergency-contingency plans based on the risk estimates.

A Simplified Representation of the Various Levels of Assessment[9]



[9] R.T. Tanhueco and A.W.C. Oreta

elements[10], which make a vulnerability or risk assessment successful, are described as follows:

- Organizing a Team for assessing vulnerabilities and risks and planning for safe and protected facilities bring a variety of perspectives to the assessment process;
- Ensuring that all potential hazards that might affect the school or hospital and surrounding community, including areas in which stakeholders have to travel to and from school or hospital are considered;
- Having a set of applicable assessment guidelines (or checklists) and performance criteria or protection levels for the facilities and services;
- Understanding and inventorying existing resources and capabilities available to prevent or mitigate the impact of a vulnerability;
- Surveying potentially affected areas such as within school grounds or hospital grounds and facilities, the population and community about potential hazards and vulnerabilities;
- Reporting on the findings identified in the assessment, developing corrective actions and accountabilities, and using the findings to inform and update emergency management plans.

[10] Adaptations from *A Guide to School Vulnerability Assessments: Key Principles for Safe Schools* (2008), by U.S. Department of Education, Office of Safe and Drug-Free Schools, Washington, D.C.,p.8

How are the Guidance Notes to be used?

Basic guidance on assessment and vulnerability (or risk) reduction planning for schools and hospitals are presented here with the perspective of hazard mitigation and vulnerability reduction in schools and hospitals. It hopes to engage the reader, in learning more about school and hospital safety towards mitigation planning and be involved in raising awareness and initiating preliminary assessment of schools and hospitals.

The **Guidance Notes** are not intended as a blueprint response to assessment and mitigation planning. One can customize the application of the assessment or evaluation provided herein. Common actions or steps (mitigation planning or assessments) are described initially when it is assumed that such steps are generally applicable for a hospital or school. Examples or details are provided to describe their differentiation. Useful links on assessment, mitigation planning and related topics are provided and they should be localized/ regionalized and used as a platform for planning and implementing responses specially for reducing site and building vulnerabilities, according the resources, capabilities, and acceptable norm in their respective regions.

Useful Links for Assessment and Mitigation Planning:

Disaster Prevention for Schools, Guidance for Education Sector Decision-Makers, Consultation version, Nov. 2008

U.S. Department of Education, Office of Safe and Drug-Free Schools, *A Guide to School Vulnerability Assessments: Key Principles for Safe Schools*, Washington, D.C., 2008.

Building a Disaster –Resistant University, Federal Emergency Management Agency (FEMA), August 2003

State and Local Mitigation Planning; How to Guides, Federal Emergency Management Agency: Getting Started: Building support for Mitigation planning (FEMA 386-1); September 2002

State and Local Mitigation Planning; How to Guides, Federal Emergency Management Agency: Understanding Your Risks: Identifying Hazard and Estimating Losses (FEMA 386-2);August 2001

State and Local Mitigation Planning; How to Guides, Federal Emergency Management Agency: Developing the Mitigation plan: Identifying Mitigation Actions and Implementing Strategies (FEMA 386-3); April 2003

State and Local Mitigation Planning; How to Guides, Federal Emergency Management Agency: Bringing the Plan to Life: Implementing the Hazard Mitigation Plan (FEMA 386-4); August 2003

Identifying Earthquake-Unsafe Schools and Setting Priorities to make them Safe (2005) by GeoHazards International, Palo Alto, CA, 40pp. http://www.preventionweb.net/files/7353_gujesischoolSE2012620V8.pdf

4 Mitigation Planning and Implementation Process

A. Prepare to assess

This first step in making a school or hospital safer requires that stakeholders:(a) assess their readiness to plan and initiate assessment, (b) organize team for planning and assessing, and (c) check available and applicable guidelines and procedures for assessment.

Several related information are required for an assessment: hazards of the place; building and physical development plans (schools and hospitals); local government plans (e.g. mitigation plans, and development plans, zone plans); disaster information about the area, among others.

To do this, a Mitigation Planning Team will be needed for identifying the community of stakeholders needed for planning and assessing the school or hospital. Which actions, expertise, resources are needed? One important decision to make is to determine if there is a need to build the capability for an assessment.

An assessment team can be formed among a variety of individuals or organizations that are knowledgeable about: structures, a school or hospital's functional requirements, the community being served by these facilities, about known natural and man made hazards affecting the area and emergency management responses, among others.

For example, in schools[11]:

- A committee may be formed to collect information requirements for assessment and mitigation planning, to include existing organizational set up and roles, responsibilities, and formation procedures during emergencies;
- Teams may be created for the following activities: to establish goals and objectives for assessment, to develop a timeline for assessments, to assign roles and responsibilities for next steps, monitor progress on action items, and update and revise assessments as needed;
- Administrators such as principals or district representatives can serve as leaders in assessments and facilitate formation of teams by selecting and coordinating or supporting team members;
- School personnel such as general and special educators, school resource officers, security officers, administrators, school nurses, clerical and reception staff, paraprofessionals, guidance counselors, coaches, cafeteria and facilities staff, and bus drivers can provide valuable input into the daily occurrences within schools;
- Members of the community outside of school (e.g. school

[11] Adaptations from *A Guide to School Vulnerability Assessments: Key Principles for Safe Schools* (2008), by U.S. Department of Education, Office of Safe and Drug-Free Schools, Washington, D.C.,p.10

building and ground staff, residents of the surrounding neighborhood, residents of the larger community, Students, parents of students, public safety officials); and
- Students and family members in the vulnerability assessment process.

For hospitals:
- Hospital management and personnel: the doctors and the staff can identify safety related to functionality in the hospital during hazard event;
- Maintenance staff can provide knowledge of the facility and the possibility of carrying out periodic inspections of the mitigation measures adopted; and
- Socially deprived and marginalized groups like women and indigenous people help the committee to function successfully by ensuring it addresses the concerns of these groups in the community.

For a hazard assessment and a vulnerability assessment, engaging relevant stakeholders, hazard agencies and experts or specialists (e.g. engineers, architects, school or hospital administration) would be necessary to tailor an assessment procedure, to provide consultation, or for engaging them to do detailed work.

Are there applicable guidelines and procedures for assessment that can be used in your area? The guidelines may have been prepared by local or national government, professional organizations (e.g. structural engineers), non-government organizations, provisions in building or structural codes, among others. If there are none, international publications on relevant guidelines may be used (with caution).

Aftermath of Typhoon Xangsane in 2006.
Photo: WHO-Manila

B. Conduct vulnerability (or) risk analysis

The second step of the mitigation planning process involves identifying and evaluating natural hazards and assessing vulnerabilities and risks. These assessments should consider all the hazards affecting a place.

B.1 Assessing hazards

To identify and characterize the hazards of the place, the assessment team may be guided by the following questions:

- What are the potential hazards in the area?
- If there are strong hazard events experienced in your area, what hazard events resultedto a disaster?
- How did the hazard affect the schools and hospitals of the place?
- Which facility suffered disaster?
- What was the nature of the disaster?
- Has the facility responded to a disaster situation before?

Previous responses and outcome of damages and losses of the school or hospital facilities resulting from a hazard event can help in prioritizing mitigation actions.

The following steps may be useful:

B1.1. List the hazards that may occur and focus on the most important hazards.

Gather information from agencies mandated to provide hazard and land use and site planning information (e.g. weather, earthquakes, geology, environment or housing, etc.). If possible, obtain hazard maps affecting your area.

Hazard maps help to identify areas of hazard or susceptibility to areas to the hazards. The hazards may be overlaid on base maps (showing topography, political boundaries, streets and roads) along with location of schools and hospitals, among others. They may reflect various degrees of exposure to hazard. For example, in tsunamis, wave heights and extents overlaid with topography maps and built-up areas, may reveal degrees of susceptible areas under different heights.

B.1.2. Locate the facility (i.e. school or hospital) on a topographic map or road map and overlay this map with the hazard map.

B.1.3 For disasters experienced by the area, record the hazard event information.

Tables 1 and 2 provide samples of inventory forms.

To visualize previous events, you may need to transfer the geographic coverage of a previous hazard event in a map and record technical information in other textual forms (e.g. accompanying report).

Table 1. Inventory of previous disasters

Nature of Disaster	Date of Occurrence	Structural Damage	Repairs Done	Cost of Repairs

Source: WHO-WPRO. (2006). *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies*. (190pp). Manila, Philippines: WHO-WPRO

Table 2. Inventory of responses

Nature of Disaster	Date of Occurrence	Total Number of Casualties	Number of Casualties Treated by the Hospital

Source: WHO-WPRO. (2006). *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies*. (190pp). Manila, Philippines: WHO-WPRO

- Research the history of natural hazards in your vicinity from local historical groups, emergency services agencies, libraries, and newspaper files.

  It is important to consult with a local hazard expert or other professional familiar with past hazard events in order to identify hazards and interpret hazard information.

- Make a hazard assessment of your building site with the assistance of the local government and experts like geologist, seismologists, civil engineers, hydrologists, meteorologists, etc. Structural engineers, who are experts in building assessment, may be tapped for evaluation of the structural integrity of the hospital building/s after a disaster. Some defects may not be obvious.

  For example, in the vicinity of the building, are there unsafe grounds such as old foundations, slopes or embankments that could cave in or slide, low-lying and flood prone areas?

  Has the facility experienced damage or losses before? Was the facility evaluated about structural integrity after a disaster?

- The elderly and the community can provide an oral history of past disaster events (e.g. flooding, earthquake) vicinity of the school or hospital.

Useful References on Hazards and Hazard Mapping:

Udono, T., Sah, A.(2002). *Hazard Mapping and Vulnerability Assessment,* UNPAN Regional Workshop on Total Disaster Risk Management, August 7 – 9, 2002) (10 pp). Unpublished Report. New York. http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN009857.pdf

United Nations International Strategy for Disaster Reduction-UN-ISDR (2002), *Guidelines for Reducing Flood Losses*, UN Department of Economic and Social Affairs (DESA), National Oceanic and Atmosphere Administration (USA NOAA).

WORLD METEOROLOGICAL ORGANIZATION (1999): *Comprehensive Risk Assessment for Natural Hazards*, Hydrology and Water Resources Dept, WMO/TD No.955, Reprinted 2006

Classroom and learning materials damaged by flooding due to Typhoon Ketsana.
Photo: WHO-Manila

B.2 Inventory of assets

The physical assets refer to the structure of the buildings and their contents. Buildings that are highly exposed to a specific hazard (as from hazard maps) or had experienced serious damage or loss in the past should undergo further evaluation.

The building assessment for schools or hospitals may be done initially on a wider geographic coverage, identifying the highly exposed structures and then focusing on these buildings for individual building level inspection[12]. The overlays of the hazard and different schools and hospitals can determine the proportion of school and hospital buildings located in high hazard prone areas.

Additional information regarding their occupancy (e.g. no. of rooms, no. of beds, population served, their capacities and importance (to service) and (monetary) value of these buildings are helpful to aid in detailed assessments prioritizing mitigation measures. The decision to add or continue with a more detailed inventory may be based on the need to specify the structures that are at greatest risk of damage, and so, focus mitigation efforts on these buildings. Table 3 provides information for prioritizing buildings for assessment.

[12] Figure 2: Safer School Steps and Corresponding Process Flow Diagram. *Guidance Notes on Safer School Construction* (2009) by UNISDR, INEE and World Bank, p.16

Table 3. Prioritizing Building Structures for Assessment

Hazards	Possible Priority/ Focus on Element	Useful building information or group types for vulnerability assessment
Flood	Older buildings, critical facilities, or the assets that are closest to the flood hazard such as those in the floodway. Buildings whose structures or contents are most susceptible to flood damage, such as wood frame buildings, manufactured homes, or buildings with delicate contents or expensive machinery are also more vulnerable to flood damage.	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. Building code Lowest floor elevation. Identify the elevation of the lowest floor of the lowest enclosed area (including basement). Topography Distance from the hazard zone
Earthquake	Building material some buildings, such as those constructed of unreinforced masonry, perform very poorly in earthquakes. In addition, Building constructed prior to seismic building code requirements or under low seismic building codes will also perform poorly in earthquakes of a given intensity.	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. Building code Seismic design building code. Older buildings constructed under a low seismic design building code or without any seismic considerations are more vulnerable to earthquakes of a given intensity than buildings constructed to a high or moderate seismic design building code.

Hazards	Possible Priority/ Focus on Element	Useful building information or group types for vulnerability assessment
Tsunami	Buildings located inside the hazard boundary, Structures closest to the shoreline, and critical facilities.	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. Building type/ building foundation Distance from the hazard zone
Tornado/ Wind Hazards	Assets that are of particular importance from a public safety, historical, economic, or environmental standpoint. Structures not built to withstand the design wind speed, or assets that typically get damaged in tornadoes should examine the date of construction.	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. Building type/ building foundation Roof Material Roof Construction
Landslide	Infrastructure such as roads and bridges, but they can also affect individual buildings and businesses. Critical facilities	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. Topography Distance from Hazard Zone

Hazards	Possible Priority/ Focus on Element	Useful building information or group types for vulnerability assessment
Coastal storms	Critical facilities, Buildings and other assets closest to the coastal storm hazard area Buildings at lowest elevations and prone to the highest potential flood and tidal surge levels, wave velocities, and erosion hazards.	Size, replacement value, content and value, function use or value, displacement cost, occupancy or capacity. The condition, age, and primary building materials can be indications of the building's physical vulnerability to wind and water hazards. Wind provisions of the building code and the floodplain management regulations in effect at the time of construction Lowest floor elevation Base flood elevation Building Type and Type of Foundation Roof Material Roof Construction Topography Distance from hazard Zone

(Adapted from source: *State and Local Mitigation Planning; How to Guides,: Understanding Your Risks: Identifying Hazard and Estimating Losses* (FEMA 386-2), (August 2001) by Federal Emergency Management Agency)

The building components[13] vary depending on its use; however, for simplification, components of a School or Hospital may comprise the structural component, the non-structural component and the functional component.

The structural component refers to that part of a building that is designed to carry the weight of the building (dead load), contents and people (live load), and the impact of nature's forces such as wind and ground-shaking (dynamic load). The "structural elements" differ in each type of building, but generally they include the foundation, columns, slabs, beams, and "loadbearing" walls.

The non-structural component refer to the non-load bearing elements and includes the "building contents" such as fire systems, water systems, emergency system, gas system, emergency/access system materials, equipment used in school or hospital operations such as furniture, appliances, electronics, equipment, coolers and air-conditioners, stored items, the stairways, doors, windows, chimney, lighting fixtures, heating ducts and pipes, wall cladding, and false ceilings, and so forth.

[13] *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings* by Arya, A & Agarwal, A. (2007) (20 pages).New Delhi : GoI-UNDP. http://safehospitals.info/images/stories/3Resources/hospital-building.pdf

The functional component refers to the elements related to the site, accessibility and provision of spaces for movement of traffic.

B.3 Building vulnerability assessment

Safe schools and hospitals need to remain structurally sound and well organized. Hospitals in particular, must be fully operational at any time, especially during disaster emergencies. To ensure these, there must be proper assessment, and monitoring of its structural, nonstructural and functional indicators.

The nature of the vulnerability assessment may be qualitative, i.e., "quick" and straightforward assessment of the structural safety of the building. If the qualitative assessment uncovers deficiencies in the building's ability to withstand the hazard impacts, it may be necessary to carry out more detailed quantitative assessments.

The quantitative methods aim to evaluate the building's primary structure. For example it can be the seismic-force resisting system (for earthquakes) or the main wind force resisting system (for winds). Other variables of the actual site, structural system in place, quality of construction materials and use other factors such as the non-structural systems may also be used for the analysis in order to determine their degree of vulnerability to extreme hazard conditions (seismic, wind) and so possible corrective measures may be taken. These "detailed" and hazard specific assessments require large amounts of pertinent data and make them more precise than qualitative assessments in predicting the likely types of failure that may occur.

When the vulnerability assessments do not meet structural (or non structural) performance objectives required; retrofitting (structural and non-structural) is required to reduce the vulnerability of the structure to the hazard of concern.

The next sections describe the nature of these assessments. Useful links and examples are provided in the highlighted boxes and at the end of the document.

Useful Links on Qualitative Assessment Tools:

Qualitative assessment tools have been developed for health facilities and schools. Most of the existing tools are in the form of a checklist to assess the level of safety of the facility based on various indicators related to hazards at the location, structural and nonstructural aspects of the building and emergency preparedness. The checklist can guide the decision makers in identifying the weaknesses of the institution and buildings that needs to be addressed.

For Health Facilities:

• *Safe Hospital Checklist* (2005) by Pan American Health Organization (PAHO-WHO), 21 pp. http://www.preventionweb.net/english/professional/publications/v.php?id=1970

• *Hospital Safety Index – Guide for Evaluators*. (2008).by PAHO-WHO, 110 pp. http://www.preventionweb.net/english/professional/publications/v.php?id=8974

• *Safe Hospitals in Emergencies and Disasters: Structural, Non-structural and Functional Indicators* (2009) by WHO-WPRO, Manila, Philippines, 33 pp. http://www.wpro.who.int/NR/rdonlyres/390133EC-089F-4C77-902DDFEE8532F558/0/SafeHospitalsinEmergenciesandDisasters160709.pdf

• *Hospitals Should be Safe from Disasters* (2009) by WHO-WPRO). Manila: Philippines, 43 pp. http://www.wpro.who.int/NR/rdonlyres/390133EC-089F-4C77-902DDFEE8532F558/0/safe_hospitals_manual.pdf

For Schools:

• *Facility Inspection Tool Guidebook*. (2008), California's Coalition for Adequate School Housing. Sacramento, California, USA, 88 pp. http://www.cashnet.org/resource-material/FITGuidebook.pdf

• National Clearinghouse for Educational Facilities, *NCEF Safe School Facilities Checklist*. http://www.edfacilities.org/checklist/8

Sample of a Safe Hospital Checklist*

SAFE HOSPITALS CHECKLIST

1. Elements relating to the geographic location of the health facility to be evaluated (mark with an X where applicable).

1.1 Hospital location Refer to hazard maps. Request the hospital committee to provide the map(s) showing hazards at the site of the building.	**Safety Level** The following elements indicate the level of SAFETY, NOT of hazard.			
	NO	YES		
		LOW	AVERAGE	HIGH
1.1.1 Geological phenomena				
• **Earthquakes** Rate the safety level of the hospital in terms of geological and soil analyses.	☐	☐	☐	☐
• **Volcanic eruptions** Refer to hazard maps to rate the safety level of the hospital in terms of its proximity to volcanoes and volcanic activity, lava and pyroclastic flow, and ash fall.	☐	☐	☐	☐
• **Landslides** Refer to hazard maps to rate the safety level of the hospital in terms of landslides caused by saturated soils (among other causes).	☐	☐	☐	☐
• **Tsunamis** Refer to hazard maps to rate the safety level of the hospital in terms of previous tsunami events caused by submarine volcanic or seismic activity.	☐	☐	☐	☐
• **Others (specify)** Refer to hazard maps to identify other geological phenomena not listed above. Specify the hazard and rate the corresponding safety level of the hospital.	☐	☐	☐	☐
1.1.2 Hydro-meteorological phenomena				
• **Hurricanes** Refer to hazard maps to rate the safety level of the hospital in terms of hurricanes. It is helpful to take into account the history of such events when rating a facility. [I disagree.]	☐	☐	☐	☐
• **Flooding** Identify previous events that did or did not cause flooding in or around the hospital. Rate the safety level of the hospital in terms of such events.	☐	☐	☐	☐
• **Storm surge** Identify previous events that did or did not cause flooding in or around the hospital. Rate the safety level of the hospital in terms of such events.	☐	☐	☐	☐
• **Landslides** Refer to geological maps to rate the level of safety of the hospital in relation to landslides caused by saturated soils.	☐	☐	☐	☐
• **Others (specify)** Refer to the hazard maps to identify other hydro-meteorological phenomena not listed above. Specify the hazard and rate the corresponding safety level of the hospital.	☐	☐	☐	☐

B.3.1 Structural Vulnerability Assessment

The basic information for assessment may include terrain, building age, number of stories, plan dimension, total height, structural type, roof type, roof cover, soil type, a sketch of the school layout, designs and photos.

The structural condition includes information of observed distress in structural elements such as cracking and deterioration in reinforced concrete columns, slabs and beams, stairs and walls. The structural deficiencies, which are critical especially for earthquake hazards include vertical irregularity, soft story, torsion, plan irregularity, façade hazards, short column and lack of lateral rigidity.

(i)The general requirements of a "qualitative" structural assessment of a building (school or hospital)

A qualitative structural assessment may be in the form of a checklist for evaluation, or may use more sophisticated approaches that utilize information on structural performance of different building types against different hazard intensities14. Scientists and engineers normally prepare the information as may be obtained from previous studies or past hazard events. The information is used to formulate relationships between building typologies (i.e. a classification of building types) against building performance.

Parameters that may be used in the assessment may include the following:

- materials (e.g. stone, adobe, brick and mud, masonry, concrete);
- strengthening used in structure (e.g. reinforced or un- events reinforced),whether framed or unframed (e.g. moment resistant);
- based on height (e.g. number of storey).

These are rated against the extent of damage under different intensities or magnitudes of hazards. These relationships are typically called by structural engineers as structural fragility curves. They provide information to classify buildings based on building behavior or likely performance against the hazard of concern.

For example, a target building may be classified as “average”, “good”, or “weak” for the particular type of building (e.g. wooden, one storey, framed etc). The classification “good” may mean that the building behaves better than average buildings of that type whereas “weak” building behaves worse than an average building of the same type.

In addition, a qualitative review may include the following information:

Meeting approved structural and non-structural requirements such as a building code. A structural code usually provides the minimum of requirements for designing elements of the structure (e.g. beams, columns, walls, foundations). Non- structural requirements may pertain to aspects of access to persons, providing the proper setback of a building from its property lines, minimum utility specifications, and quality of construction, among others.

Changes in the Structures. Major alterations done on the building to create new spaces, or install new structures or equipment or simply to increase strength of the structure need to be assessed. It is possible that new alterations may weaken the structural elements of the building (e.g. beams, columns, walls)

(ii)The general requirements of a "detailed" structural assessment of a building (school or hospital)

In more detailed investigations, experts (e.g. civil engineers, structural engineers, and architects) perform more detailed investigations, or more detailed calculations of the structural qualities for different building types,(e.g. core sampling, destructive testing, modeling of lateral force resisting systems, topographic, soil and geologic studies to reveal existing conditions not possibly identified with visual inspections). For example, in earthquakes, it may include reviewing a building's structural design with actual data on resisting force system in place, guided by the most-up-to date structural engineering standards, among others.

The degree of structural retrofit will be based on the structural assessment, level of functionality (or protection desired) and the resources available to implement them.

Useful Links on Structural (Seismic) Vulnerability Assessments

For Health Facilities:

- *Health Facility Seismic Vulnerability Evaluation: A Handbook* (2006) by . WHO. Denmark, 65 pp. http://www.preventionweb.net/english/professional/publications/v.php?id=1958
- *Principles of Disaster Mitigation in Health Facilities* (2000) by PAHO, 127 pp. http://www.paho.org/english/dd/PED/mitigation3.pdf
- *Guidelines for Seismic Vulnerability Assessment of Hospitals* by WHO and National Society for Earthquake Technology-Nepal (NSET), 134 pp. http://www.gripweb.org/grip.php?ido=2222&idMat=42554882
- *A Structural Vulnerability Assessment of Hospitals in Kathmandu Valley*. (2002) by WHO-EHA Nepal, NSET & Ministry of Health of Nepal, 118 pp http://www.searo.who.int/LinkFiles/Nepal_-_EPR_Publications_assessment-hospital.pdf

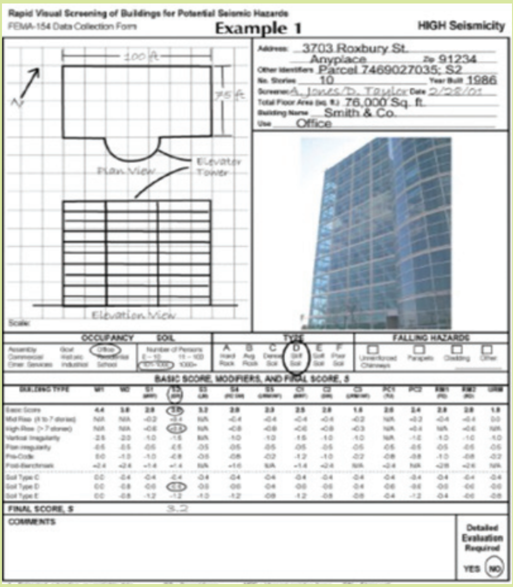
For Schools:

- *Seismic Vulnerability Assessment of School Buildings* (2008) by Bhakuni, C., International Conference on School Safety, Pakistan. (8 pp). http://www.schoolsafetyconference.org/Papers/General%20Papers/General%20-%20CHANDRA%20BHAKUNI.pdf
- *Identifying Earthquake-Unsafe Schools and Setting Priorities to make them Safe* (2005) by GeoHazards International, Palo Alto, CA , 40pp. http://www.preventionweb.net/files/7353_gujesischoolSE2012620V8.pdf

Remains of a hospital in Vietnam after a strong typhoon.
Photo: WHO-Manila

Examples of Rapid Structural Assessment for Buildings:

The FEMA 154 Report (2002), Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, is a methodology for rapid visual screening of buildings for potential seismic hazards which has been used in the US and other countries. It has also been modified to suit the local condition and codes of other countries like Canada and India.

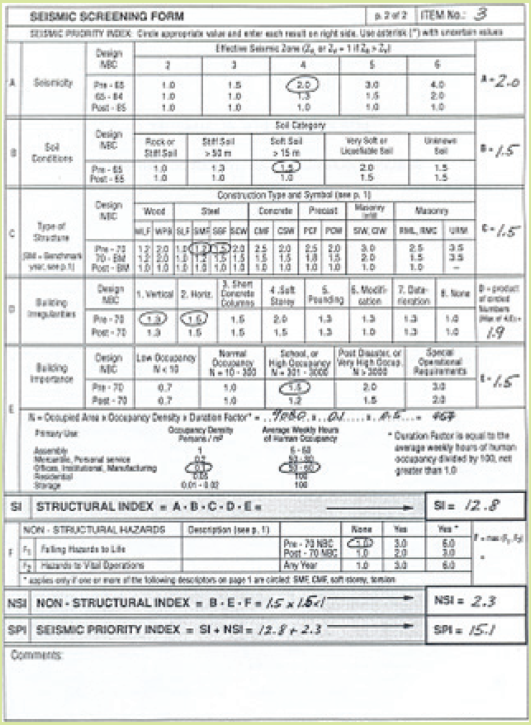


The RVS uses a methodology based on a "sidewalk survey" of a building and a Data Collection Form, which the person conducting the survey (hereafter referred to as the screener) completes, based on visual observation of the building from the exterior, and if possible, the interior.

The FEMA 154 Form*

**Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* (2002), (FEMA 154, 2nd Edition. By Federal Emergency Management Agency (FEMA), Washington, D.C., 164 pp. http://www.fema.gov/library/viewRecord.do?id=3556

The rapid visual screening procedure (RVS) has been developed to identify (1) older buildings designed and constructed before the adoption of adequate seismic design and detailing requirements, (2) buildings on soft or poor soils, or (3) buildings having performance characteristics that negatively influence their seismic response. Once identified as potentially hazardous, such buildings should be further evaluated by a design professional experienced in seismic design to determine if, in fact, they are seismically hazardous.



SEISMIC SCREENING FORM — p. 2 of 2 — ITEM No.: 3

SEISMIC PRIORITY INDEX: Circle appropriate value and enter each result on right side. Use asterisk (*) with uncertain values

		Design NBC	Effective Seismic Zone (Z_a or Z_v = 1 if $Z_a > Z_v$)					
			2	3	4	5	6	
A	Seismicity	Pre - 65 65 - 84 Post - 85	1.0 1.0 1.0	1.5 1.0 1.0	2.0 1.3 1.0	3.0 1.5 1.0	4.0 2.0 1.0	A = 2.0

		Design NBC	Soil Category					
			Rock or Stiff Soil	Stiff Soil > 50 m	Soft Soil > 15 m	Very Soft or Liquefiable Soil	Unknown Soil	
B	Soil Conditions	Pre - 65 Post - 65	1.0 1.0	1.3 1.0	1.5 1.0	2.0 1.5	1.5 1.5	B = 1.5

		Design NBC	Construction Type and Symbol (see p. 1)														
			Wood		Steel				Concrete		Precast		Masonry infill	Masonry		
			WLF	WPB	SLF	SMF	SBF	SCW	CMF	CSW	PCF	PCW	SIW, CIW	RML, RMC	URM	
C	Type of Structure (BM = Benchmark year, see p. 1)	Pre - 70 70 - BM Post - BM	1.2 1.2 1.0	2.0 2.0 1.0	1.0 1.0 1.0	1.2 1.2 1.3	1.5 1.5 1.0	2.0 1.5 1.3	2.5 1.5 1.0	2.0 1.5 1.0	2.5 1.8 1.0	2.0 1.5 1.0	3.0 2.0 1.0	2.5 1.5 1.0	3.5 3.5 –	C = 1.5

		Design NBC	1. Vertical	2. Horiz.	3. Short Concrete Columns	4. Soft Storey	5. Pounding	6. Modification	7. Deterioration	8. None	D = product of circled Numbers (Max of 4.0) =
D	Building Irregularities	Pre - 70 Post - 70	1.3 1.3	1.5 1.5	1.5 1.5	2.0 1.5	1.3 1.3	1.3 1.0	1.3 1.3	1.0 1.0	1.9

		Design NBC	Low Occupancy N < 10	Normal Occupancy N = 10 - 300	School, or High Occupancy N = 301 - 3000	Post Disaster, or Very High Occup. N > 3000	Special Operational Requirements	
E	Building Importance	Pre - 70 Post - 70	0.7 0.7	1.0 1.0	1.5 1.2	2.0 1.5	3.0 2.0	E = 1.5

N = Occupied Area x Occupancy Density x Duration Factor* = 7080 x .01 x .65 = 467

Primary Use:	Occupancy Density Persons / m²	Average Weekly Hours of Human Occupancy
Assembly	1	6 - 60
Mercantile, Personal service	0.2	60 - 80
Offices, Institutional, Manufacturing	0.1	60 - 80
Residential	0.05	100
Storage	0.01 - 0.02	100

* Duration Factor is equal to the average weekly hours of human occupancy divided by 100, not greater than 1.0

SI | STRUCTURAL INDEX = A · B · C · D · E = → SI = 12.8

	NON - STRUCTURAL HAZARDS	Description (see p. 1)		None	Yes	Yes *	F = max (F_1, F_2)
F_1	Falling Hazards to Life		Pre - 70 NBC Post - 70 NBC	1.0 1.0	3.0 2.0	6.0 3.0	
F_2	Hazards to Vital Operations		Any Year	1.0	3.0	6.0	

* applies only if one or more of the following descriptors on page 1 are circled: SMF, CMF, soft storey, torsion

NSI | NON - STRUCTURAL INDEX = B · E · F = 1.5 x 1.5 x 1 → NSI = 2.3

SPI | SEISMIC PRIORITY INDEX = SI + NSI = 12.8 + 2.3 → SPI = 15.1

Comments:

The NRC-Canada Form**

***Manual for Screening of Buildings for Seismic Investigation* (1992). National Research Council Canada, 88 pp, http://www.nrc-cnrc.gc.ca/eng/ibp/irc/catalogue/seismic-investigation.html

B.3.2 Non-structural Vulnerability Assessment

Non-structural elements include items like architectural elements such as non-bearing walls, facades, or equipment and component (e.g. mechanical, electrical, communications and plumbing equipment) needed for a school or a hospital. These elements are essential to the daily operations of schools, hospitals and health facilities. Severe damage to the non-structural element can cause structural damage to buildings and lead to functional collapse and risk to lives of people inside them.

For example, the addition of new heavy equipment on an upper floor changes its response to movement (earthquakes). The additional load may produce stress on ceilings and floors that can result to failure. Heavy equipment or those likely to topple, slide or move should be identified and be firmly anchored to a structural element of the building to avoid possible structural damage, physical injury or obstruction to persons in the room or building.

Similarly, chemicals and potentially hazardous substances may cause injury simply by their toxicity or by the subsequent reactions that may arise (i.e. fire). Proper storing of chemicals and other substances, proper arrangement and grouping, and restraint must be made to avoid accidents. Inventories of equipment must be prepared, indicating their location and condition.

Schools

Important non-structural elements that schools should take into consideration when conducting a vulnerability assessment include: (a) architectural elements (such as ceilings, windows, and doors), (b) location and protection of school laboratory equipment, containers with hazardous materials, (c) lifelines (mechanical, electrical, and plumbing installations), (d) location, storage of materials and (e) safety and security issues.

Hospitals

Important non-structural elements that hospitals should take into consideration when conducting a vulnerability assessment include: Include: (a) architectural elements (such as ceilings, windows, and doors), (b) availability, location and protection of medical and laboratory equipment, containers with hazardous materials, (c) lifelines (mechanical, electrical, and plumbing installations), (d) location, storage of materials (e.g. medicines, chemicals, hazardous substances), and (e) safety and security issues.

The non-structural vulnerability assessment should be conducted by specialists of the field (e.g. doctors, school administrators) and by persons who undergo trainings for assessment.

Table 4. Sample inventory of equipment location in a hospital

Where are the following located? (Please put the number of units in the appropriate spaces.)

Equipment	Building Location	Basement	Ground Floor	Second Floor	Third Floor	Above 3rd Floor
Central Air-Con Unit						
X-ray Equipment						
CT Scan Machine						
MRI Machine						
Electric Generator						
Boiler						
Hydrotherapy Pool						
Respirator						
Anesthesia Machine						

Source: WHO-WPRO. (2006). *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies*. (190pp). Manila, Philippines: WHO-WPRO

Example of an assessment involving individual components[15]

The identified critical systems and facilities need to be visited (school or hospital) to evaluate the vulnerability of the individual components. All equipment and components must be inventoried and rated in terms of different levels of damage: very high, medium and low. In an earthquake for example, a light sized earthquake (MMI III-IV) can cause little damage to equipment, and little movements to small objects or to furniture; but a severe earthquake (MMI VI-IX) can cause damage and further create several dangerous situations:

1. *Tall or narrow furniture can fall!*
   Objects that are taller than their width or depth can easily topple forwards, backwards or sideways. Objects that are much heavier on the top than on the bottom can easily topple in all directions.

2. *Items on wheels or smooth surfaces can roll or slide!*
   Objects on wheels can roll, or on slippery surfaces can slide. Objects that are much heavier on the bottom than on the

[15] *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings* by Arya, A & Agarwal, A. (2007) (20 pages).New Delhi : GoI-UNDP

top can also slide, but not overturn.

3. *Large or small things can knock into each other!* Objects can bang and collide with each other. Small objects can fall, and cause dangerous breakages and spills

4. *Hanging objects can fall!* Heavy objects that are hung on walls or from the ceiling can fall. Cabinet doors can swing open and shelf contents can tumble out. For example, in an earthquake, items inside the building can fall harming people and blocking exits.

Photo: WHO-Manila

Table 4. Sample inventory of equipment location in a hospital

How are the following anchored? (Please check all appropriate spaces.)

Equipment	Anchorage		Material			Location of Anchorage		
	Attached to Wall	*Not anchored*	*Use of metal*	*Use of wood*	*Use of rope*	*At the base*	*On top*	*At the sides*
Central Air-Con Unit								
X-ray Equipment								
CT Scan Machine								
MRI Machine								
Electric Generators								
Boilers								
Hydrotherapy Pools								
Respirators								
Suction Machines								
Substations								
Refrigerator / Freezer								
Television Sets								

Source: WHO-WPRO. (2006). *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies*. (190pp). Manila, Philippines: WHO-WPRO

Useful Links on Non-Structural Vulnerability Assessments:

For Health Facilities:

- *Non-Structural Vulnerability Assessment of Hospitals in Nepal* (1st ed). (2003) by WHO-EHA Nepal and National Society for Earthquake Technology-Nepal (NSET), 96 pp. http://www.searo.who.int/LinkFiles/Nepal_-_EPR_Publications_Final_Report_Hospital_assessment_.pdf
- *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings.* (2007) by Arya, A & Agarwal, A., GoI-UNDP, New Delhi, 20 pp. http://safehospitals.info/images/stories/3Resources/hospital-building.pdf

For Schools:

- *Case Studies of Seismic Nonstructural Retrofitting in School Facilities* (2005) by EFRC & NIEPR, 25 pp. http://www.nier.go.jp/shisetsu/pdf/e-jirei.pdf
- *Protection of Educational Buildings Against Earthquakes, Educational Building Report 13* (1987) by Arya, A. Bangkok, Thailand: UNESCO Principal Regional Office for Asia and the Pacific, 68pp. http://www.unesco.org/education/pdf/6_51.pdf

Example of an assessment of a system's vulnerability

Based on the assessment of the individual components of the respective systems (ex. emergency operations, laboratory), the critical systems and facilities (ex. water supply and distribution, gas piping) are examined to understand implications of damage or disruption on the response and continued performance of the system.

Schools

Some points to consider…

Consider the levels of potential damages to the different elements and its consequences for the performance of the individual components and as a system; likewise, identify system functionalities, services and responses which are likely to be disrupted or stop school operations.(e.g., power cut-off, broken pipelines; contamination of water reservoirs; cleaning of school premises after being used as evacuation center; security problems; equipment, books and school records immersed in flood waters)

Consider likely scenarios that may result to greater stress to the system or further aggravate risk to life of persons inside the school building (e.g. lack of open space for evacuation during earthquakes, fire and heavy smoke, shattered windows, walls that may collapse and ceilings that may fall)

Consider mitigation options for each system identified and critically evaluate them in terms of ease and cost of implementation and of their expected efficiency regarding vulnerability reduction.

Hospitals

Some points to consider…

Consider the levels of potential damages to the different elements and its consequences for the performance of systems. The assessment should identify system functionalities, services and responses, which are likely to be disrupted or stop hospital operations (e.g. emergency operations, laboratory, and provision of water among others).

Consider the likely scenarios that may result to greater stress to the system which may further aggravate risk to life of persons inside the hospital (e.g. shutdown of power can stop surgical operations).

Consider mitigation options for each system identified and critically evaluate them in terms of ease and cost of implementation and of their expected efficiency regarding vulnerability reduction (e.g. cost of protecting water supplies and avoiding breakages).

B.3.3 Assessment of Functional Vulnerability

The next step is to ensure that school and hospital services will keep running to meet the demands of the community at a time when these services are needed. When functional vulnerability is assessed, among the concerns are (a) site and accessibility (b) availability of open spaces (c) safe service areas and protected utilities (d) adequate stocks for emergencies.

Site and accessibility. One should ensure that the school or hospital, or temporary sites for these facilities (e.g. surge hospitals, temporary school sites) be near good roads and that adequate means of transportation are available. In addition, these connecting structures (e.g. roads and bridges) must be assessed. A weak bridge against a strong flood or earthquake may be damaged and may isolate the school or hospital thus making it inaccessible to from people seeking or providing help. Road blockages may also happen (e.g. from a landslide) and an alternative route leading to the facility may need to be provided. Resources must also be evaluated for transporting people for evacuation or relocation, or in moving casualties from the field to a health facility.

Schools

For areas in the school, the facility should have maps and signs to indicate escape routes and locations of safe areas, to allow people to find their way around and towards these safe places.

The assessment[16] should reveal the preparedness of the school to meet emergencies. The public should be informed about the preparedness and disaster plan so that operations are functioning and disaster operations are properly coordinated.

Hospitals

Hospitals on the other hand, may need to be zoned showing their interrelationships and kept simple to allow people to go

[16] *Disaster Disaster Prevention for Schools, Guidance for Education Sector Decision-Makers*, Consultation version, Nov. 2008, pp.6-14

to the different units: For example, some principles for the designation of areas[17] are as follows:

Hospital departments most closely linked to the community are best located nearest the entrance. These departments may include outpatient service, emergency room, administration, and primary health care support.

Departments that receive their workload from the above areas mentioned are best located next to the radiology, laboratories and pharmacy, while in-patient departments should be in the interior zones and wards.

The assessment should identify and reveal points, which may need to be closed off to limit and control the number of people entering the facility, avoid overcrowding, and ensure security of the premises.

Open spaces should be identified where possible temporary facilities may be staged, especially in the event that the influx of people may not be accommodated. For example, in a mass casualty, these temporary areas must be available and be provided with the basic utilities to be functional. Obstructions to patients, personnel and services must be avoided.

[17] *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies. (2006). by WHO-WPRO, Manila, Philippines, 190pp.*

Service areas, which are necessary for the continuous operation of the facilities, must be assessed against potential leaks or explosions from boilers, fuels and gases. The general services are preferably located in a separate structure to house various components such as water storage facilities, kitchen, laundry area, communications facilities, etc. They must be assessed to ensure safe and reliable operations. This may also include lighting, firefighting and other equipment.

Utilities must be assessed and they should reveal conditions that affect the hospital or health facilities' service functions. For example, is the supply of water still adequate, safe and potable during disasters? Regular sanitary surveys should help in assessing conditions and practices that can increase public health risks during disasters, such as possible contamination during, procurement, transport and storage of water.

Necessary supplies should be assessed if stocks are available in advance. Whether it is a school or hospital, emergency kits shall be available and that stocks of supplies and equipment for managing emergency situations must be available. For example, in hospitals, systems should be in place for estimating drug requirements, maintain inventory, storing and stocking drugs, and issuing and controlling the use of drugs.

The assessment should reveal the preparedness of the hospital to meet emergencies. The public should be informed about the preparedness and disaster plan so that operations are functioning and disaster operations are properly coordinated.

Areas to Consider in Functional Vulnerability Assessment

School. Functional aspects in schools may include (a) Control of access and egress to buildings including vehicular and pedestrian traffic patterns, (b) Identification of "all persons" in the building—including contractors, food service workers, and itinerant staff, (c)Safe Interior and exterior facilities,(d) Safe landscaping, (e) Identification of evacuation routes and predetermined evacuation locations as well as alternate locations,(f) Identification of shelter-in-place locations and safe zones, (h) Communication systems including inter-school, intraschool, home-school emergency notification, first-responder interoperability, alarms, and surveillance equipment; (I)Inventory of emergency supplies and go-kits for each setting (i.e., classroom, facilities, central office),(j) Threat assessment team and process, and (k) Staff and student knowledge of emergency procedures.

Hospital. The functional vulnerability of a health facility will include the general physical layout of the facility; the individual services; medical (equipment and supplies) and non- medical (utilities, transportation and communication), that are vital to the continuous operation of the facility. Functional aspects include: (a) site and accessibility, (b) internal circulation and interoperability, (c) equipment and supplies, (d) emergency standard operations procedures and guidelines, (e) logistic system and utilities, (f) security and alarm, (g) transportation and communication systems, (h) human resources, and (I) monitoring and evaluation.

Useful Links on Functional Assessment and Emergency Preparedness:

Schools:

- Beynon, J. (1997). Physical Facilities for Education: What Planners Need to Know, *Fundamentals of Educational Planning*, 57. (103pp). Paris: UNESCO: International Institute for Educational Planning
- US-Department of Education. (2008). *A Guide to School Vulnerability Assessments: Key Principles for Safe Schools*. (90pp). Washington, D.C.: US-Department of Education, Office of Safe and Drug-Free Schools. http://rems.ed.gov/views/documents/VA_Report_2008.pdf
- Iqbal, S. (2008). *Multi-Hazard Disaster Risk Modeling and its Application in School Safety: Experience from Guijarat* (International Conference in School Safety, Pakistan). (5 pp). Unpublished Paper. http://www.schoolsafetyconference.org/Papers/General%20 Papers/General%20-%20SEHAR%20IQBAL.pdf
- *Emergency Preparedness Planning Guide for Utah Schools* (2007) by Utah State Office of Education, USA http:// www.schools.utah.gov/finance/facilities/safety/documents EmergencyPreparedPlanningGuide2007.pdf
- *Better be Prepared…Protected School, 4.* by International Federation of Red Cross (IFRC). Geneva, Switzerland, 52 pp. http://www. proventionconsortium.org/themes/default/pdfs/CRA/VCA4_en.pdf
- Andjelkovic, I. (2001). *Guidelines on Non-Structural Measures in Urban Flood Management.* (89pp). Paris: UNESCO, http://unesdoc. unesco.org/images/0012/001240/124004e.pdf
- SEEDS. (2008). *Ankur: Post Flood School Restoration Initiative.* (36pp). New Delhi: SEEDS http://www.seedsindia.org/reports. aspx?Page=2&St=1
- Parkash, S. (n.d.). *Framework of Comprehensive Guidelines for Siting of Human Settlements in Landslide Prone Hilly Terrains.* (20pp). Unpublished document http://nidm.gov.in/idmc/Proceedings/ LandSlide/A2_26,%20Surya%20Parkash.pdf

• Spiker, E. & Gori, P. (2003). *National Landslide Hazards Mitigation Strategy – A Framework for Loss Reduction*. (64pp). Reston, Virginia: U.S. Geological Survey http://pubs.usgs.gov/circ/c1244/
• *Typhoon Resistant School Buildings for Vietnam.* (1987) Facilities Department Ministry of Education of Bangladesh, K.J. Macks Architect & Educational Facilities Service UNESCO, Bangkok., 112pp. Bangkok: UNESCO, http://unesdoc.unesco.org/images/0012/001206/120616eo.pdf

Hospitals:
• PAHO.(2000).*Principles of Disaster Mitigation in Health Facilities.* Retrieved http://www.paho.org/english/dd/PED/mitigation3.pdf
• *Guidelines for Hospital Emergency Preparedness Planning* by GOI-UNDP. DRM Program (2002- 2008), 83 pp. http://safehospitals.info/images/stories/3Resources/Guidline%20Final.pdf
• *Pocket Emergency Tool.* 2nd Ed. Health Emergency Management Staff, Department of Health, Manila, Philippines. and WHO-WPRO, 116 pp., http://www.wpro.who.int/internet/resources.ashx/EHA/docs/Pocket_Emergency_Tool_2005.pdf
• *Training on Safe Hospitals in Disasters.* (58pp). Manila, Philippines: WHO-WPRO http://www.wpro.who.int/sites/eha/trn/training_HSFD.htm
• *Field Manual for Capacity Assessment of Health Facilities in Responding to Emergencies.* (2006). by WHO-WPRO, Manila, Philippines:. 190pp. http://www.wpro.who.int/NR/rdonlyres/AAF327BF-0795-4FF6-AB5E-44A5A31F0F7D/0/who_fieldmanual_r1.pdf
• *Surge Hospitals* (2006). by. Joint Commission on Accreditation of Healthcare Organizations, 29pp. http://www.jointcommission.org/PublicPolicy/surge_hospitals.htm

B.3.4 Sizing Up the Performance of Buildings Facilities and Prioritizing Mitigation Actions

Once the assessment is completed, providing recommendations to reduce the hazard, vulnerability and risk should be prepared. In drawing up the mitigation plan (Discussed in Section C), it is necessary to define the role that the existing facility will still play, both in normal times and during emergencies of various kinds of hazards. The level of overall functional performance must be set for the contemplated facility.

For example, in the case of a hospital facility, will the structure continue providing its vital services as smoothly as possible even as the emergency is unfolding? Is the structure to withstand the disaster in such a way that recovery and rehabilitation can take place after a reasonably brief interruption of services?

The level of performance is a function of the level of protection selected for each of the functions or services provided. The assignment of a protection level may be based on the criticality (or importance) of the functions or service in question, and which should continue during, immediately, and long after a disaster. This assignment of protection levels, with considerations of the vulnerabilities and risks assessed the nature of adjustments to be made to reduce risk, the resources available, among others, provide a prioritization of needed actions for risk reduction in making the school or hospital safe.

What performance levels may be adopted for existing schools or hospitals to aid in prioritizing actions?

Performance levels for existing structures may be borrowed from indicators used for designing new facilities (see note in box below); however, whether the desired performance level or the corresponding level of protection can reasonably be afforded and implemented under existing building conditions, stakeholders should consider feasibility of performing the adjustments (i.e. retrofit, replacement, relocate, etc.). Decision makers will need to compare costs against benefits of pursuing the level of protection desired; consider the implications of pursuing the adjustments, such as, the possible disruptions and temporary transfers; consider future plans for continuing use or abandoning the facility or service, as well as, the available resources to meet the proposed adjustments for risk reduction, among other considerations.

The parameters and definitions for level of service and protection levels in this section are taken from existing guidelines meant for new construction. This section of the guide notes on performance levels suggests adopting these parameters for existing structures. The definitions and concepts as written here are not comprehensive, nor should be taken as applicable for all cases. Much of the material on performance levels are taken from the Guidelines for Vulnerability Reduction in the Design of New Health Facilities, the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

Levels of Performance

In practical terms, three broad performance objectives are suggested: life safety investment protection, and functional protection (FP-for hospitals) and continuous operation (CO-for schools[18]). In general, protection levels may be assigned for the facility as a whole, or to its components, namely: service and facility's systems, equipment and components. In order to meet the performance levels, certain protection levels need to be performed. These corresponding actions related to mitigation are italicized in each level.

LIFE SAFETY (LS) requires that the infrastructure (i.e., hospital or school) meet the minimum requirement for and the criterion most commonly used in the design and construction of health facilities or school facilities. In terms of service protection levels, it is acceptable for the service to suffer considerable damage to its structural or nonstructural components (to a specific hazard), as long as, such damage does not put lives at risk. As a result, it may be necessary to carry out significant repairs after the disaster.

Hospitals and Health Facilities

In view of the hospital systems, equipment and components; damage to structural and nonstructural components is acceptable so

[18] *Guidance Notes on Safer School Construction* (2009) by UNISDR, INEE and World Bank, p.32-39

long as it does not endanger the patients, visitors, or staff. Repairs may be expensive and interfere severely with the operations of the facility in the medium and even long term. *To meet the LS level, the building is reviewed, possibly redesigned according to local code. It is assumed that the code sets the minimum requirements to meet life safety.*

Schools

For school systems, equipment and components; damage to structural and nonstructural components is acceptable so long as it does not endanger the students, visitors, or school community in general. Repairs may be expensive and interfere severely with the operations of the facility in the medium and even long term. *To meet the LS level, the building is reviewed, possibly redesigned according to local code. It is assumed that the code sets the minimum requirements to meet life safety.*

INVESTMENT PROTECTION (IP) requires the protection of all, or at the very least, the key components of, the school or health facility's infrastructure and equipment, even if the facility itself cannot continue to function. Based on this criterion, it is possible to design nd build infrastructure that can resume operations within a reasonable time at a cost that can be met by the client institution.

Meeting the service protection level means that the goal is to prevent damage to the infrastructure of those services that would be difficult or costly to replace.*To meet this goal, both the structural and the nonstructural components must perform similarly well. In some cases, investment protection may result indirectly in functional protection.*

Hospitals and Health Facilities

In view of the hospital systems, equipment and components, damage to the structural system is acceptable so long as the replacement of service components is not unduly difficult or expensive. It should be possible to repair any damage that occurs, at a reasonable expense and in a short period of time, so as to minimize interference with the functions ordinarily performed. *Aiming for an IP, one may check code compliance and address nonstructural vulnerability.*

Schools

For school systems, equipment and component, damage to the structural system is acceptable so long as the replacement of service components is not unduly difficult or expensive. It should be possible to repair any damage that occurs, at a reasonable expense and in a short period of time, so as to minimize interference with the functions ordinarily performed. The protection of important documents such school records should be a priority. *Aiming for an IP, one may check code compliance and address nonstructural vulnerability.*

FUNCTIONAL PROTECTION (FP) for hospitals or CONTINUOUS OCCUPANCY (CO) for schools assumes that the Investment protection (IP) level is met, and in addition, this requires systems that can remain operational during a disaster or recover their functional capacity in a relatively short time.

Hospitals and Health Facilities

In view of service protection, the facility is able to operate normally immediately after an emergency. Losses in functional capacity, if any, are temporary and do not endanger patients or staff. To meet this goal, infrastructural (structural and nonstructural) components and organizational or functional components must perform with a similar degree of success and should only suffer a limited degree of damage. The functional protection objective implicitly incorporates the investment protection and life-safety performance objectives.

In view of the facility's systems, equipment and component, the structural system must perform in such a way that the building can continue to be used safely both during, and immediately after, an adverse event. *The structural elements must remain nearly as rigid and resistant as before the emergency. No repairs are required to continue operations. Nonstructural components should continue to function without alteration, both during and after the emergency. Any damage should be minimal and allow for immediate occupancy of the premises.*

Schools

In view of service protection, the facility is able to operate normally immediately after an emergency. Schools that will be used as shelter or evacuation sites must aim for a continuous occupancy (CO) performance level. Losses in functional capacity, if any, are temporary and do not endanger the school community. *To meet this goal, infrastructural (structural and nonstructural) components and organizational or functional components must perform with a similar degree of success and should only suffer a limited degree of damage. The functional protection objective implicitly incorporates the investment protection and life-safety performance objectives.*

In view of the facility's systems, equipment and component, the structural system must perform in such a way that the building can continue to be used safely immediately after, an adverse event. *The structural elements must remain nearly as rigid and resistant as before the emergency. Minimal repairs are required. Nonstructural components should continue to function without alteration, both during and after the emergency. Any damage should be minimal and allow for immediate occupancy of the premises.*

Aiming for an FP or CO level, one should address non-structural vulnerability and retrofit structures to increase capacity.

A summary of the relationship of performance levels and risk reduction measures may be seen in Figure 2 below.

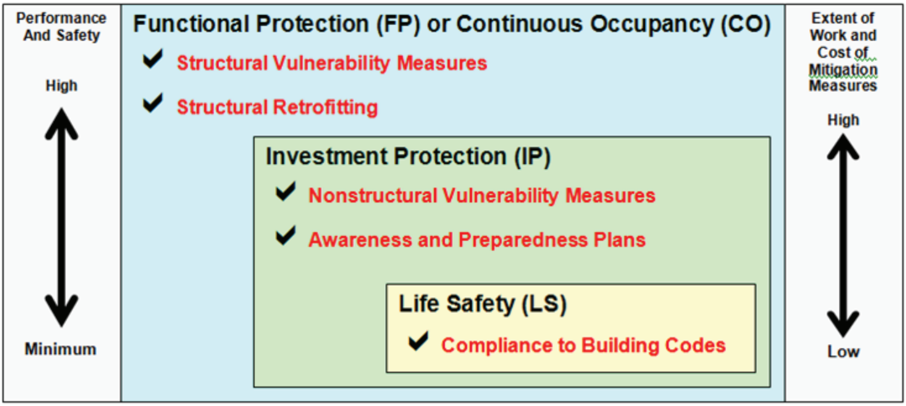


Figure 2. Relationship of Performance Levels and Risk Reduction Measures[19]

[19] R.T. Tanhueco and A.W.C. Oreta

Sample Case on Protection Levels for Hospitals

In a hospital, basic services (e.g. medical and support services) shown in Tables 7a and 7b, are assigned protection levels for one or more intensity levels for each hazard.

Table 7a. Typical medical services in a hospital

Blood Bank	Kinesiotherapy	Pediatric Neurology
Cardiology	Laboratory	Pediatric Surgery
Dental Services	Neonatology	Pharmacy
Dermatology	Nuclear Medicine	Plastic Surgery - Burns
Ear, Nose and Throat	Obstetrics and Gynecology	Pneumology
Emergencies - Adults	Oncology	Psychiatry
Emergencies - Children	Ophtalmology	Recovery Rooms
Endoscopy	Ophthalmology	Sterilization
General Inpatient Care	Orthopedics and Traumatology	Surgery
Hemodyalisis	Other Medical Services	Surgical Wings
ICU/ITU	Outpatient Clinic	Urology
Imaging, Diagnostic	Pathological Anatomy	
Internal Medicine	Pediatrics	

Source: *Guidelines for Vulnerability Reduction in the Design of New Health Facilities,* the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

Table 7b. Typical support services and systems

Administration	Emergency Standby Electrical System	Mobilization and Transport
Air Conditioning (HVAC)	Escape Routes	Non-sterile Materials Storage
Boilers, Thermal Power Station	Filing and Case Management	Oxygen System
Clinical Gases	Fire Alarm/Supression System	Sewerage
Communications	Food Services	Sterile Materials Store-Rooms
Drinking Water	Industrial Gases	Elevator/Scalator System
Electricial Distribution	Industrial Water	Other Support Servics, Systems
Electrical Power Station	Laundry	

Source: *Guidelines for Vulnerability Reduction in the Design of New Health Facilities,* the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

In order to properly choose the correct protection objective for each service, it is advisable to consider the risks to which it will be exposed, the activities involved in providing the service, the characteristics of its components, and its relative importance.
An example of a form for evaluating Performance Objective for Support systems and Services is shown in Table 8.

Depending on the classification of each service as shown in Table 9, as dictated by the importance of the activities and components of the service in question, performance objectives such as those recommended in Table 10 should be set.

The protection goals contained in Table 10 may be redefined, depending on the economic capacity of the client institution

Table 8. Sample form for evaluating performance objective for support systems and service

Hazard level[1]:

☐ Likely or credible maximum

☐ Minimum recommended

Type of hazard ____________________

____

Variable that characterizes the hazard ____________________

____

Hospital performance objective[1]:

☐ Functional protection(FP) ☐ Investment protection (IP) ☐ Life safety (LS)

Performance objectives for medical and support systems and services[2]:

Medical services

	FP	IP	LS
Blood bank			
Cardiology			
Clinical gases			
Dental services			
Dermatology			
Ear, Nose and Throat			
Emergencies - Adults			
Emergencies - Children			
Endoscopy			
General In-patient Care			
Hemodyalisis			
ICU/ITU			
Imaging, Diagnostic			
Internal Medicine			
Kinesiotherapy			
Laboratory			
Neonatology			
Non-sterile Storage			
Nuclear medicine			
Obstetrics and Gynecology			

	FP	IP	LS
Oncology			
Ophtalmology			
Orthopedics and Traumatology			
Oxygen System			
Outpatient Clinic			
Pathological Anatomy			
Pediatric Neurology			
Pediatric Surgery			
Pediatrics			
Pharmacy			
Plastic Surgery - Burns			
Pneumology			
Psychiatry			
Recovery rooms			
Sterile Storage Area			
Sterilization			
Surgery			
Surgical Wings			
Urology			
Other Medical Services			

Source: *Guidelines for Vulnerability Reduction in the Design of New Health Facilities,* the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

Support systems and services:

	FP	IP	LS
Administration			
Air Conditioning (HVAC)			
Boilers, Thermal Power Station			
Communications			
Drinking water			
Electrical distribution			
Stand-by electrical System			
Escape Routes			
Filing and Case Management			
Fire Alarm/Suppression System			

	FP	IP	LS
Food Services			
Industrial Gases			
Industrial Water			
Laundry			
Mobilization and Transport			
Electrical Generator			
Sewerage			
Vertical Transport System			
Other Support Systems/Services			

Table 9. Classification of medical and support systems

Critical Services and Systems	Must be classified as specified below:
Critical services involving life-saving or other essential functions	Those services that must remain in operation to meet the vital healthcare needs of inpatients and provide first aid and other services to the victims of the disaster. Also included in this group are services whose failure could cause prolonged delays in the recovery of critical services.
Critical services involving hazardous or harmful materials	Damage to these services increases the risk of fires, explosions, air pollution, or water contamination that could injure the staff, patients, or visitors.
Critical services whose failure may cause the patients or staff to panic	Those services whose failure may cause alarm, chaos or confusion among the staff, patients, or visitors to such a degree that the quality or even the provision of health care may be compromised.
Special Services and Systems	Services that, while not critical, involve components that would be difficult or expensive to replace.
Other Services and Systems	Those services that can suffer minor failure and can be repaired quickly, without causing significant decreases in health service quality.

Source: *Guidelines for Vulnerability Reduction in the Design of New Health Facilities,* the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

Table 10. Protection objectives for the services

Classification of the Service	Protection objective		
	FP	IP	LS
Critical services			
Vital or essential	✔		
Hazardous or harmful	✔		
Likely to cause chaos or confusion	✔		
Special services		✔	
Other services		✔	✔

Source: *Guidelines for Vulnerability Reduction in the Design of New Health Facilities,* the PAHO/WHO Collaborating Center for Disaster Mitigation in Health Facilities, University of Chile, April 2004.

and the project's role and importance within the overall health network. Priority should be given to functional protection.

For support systems and services, a reasonable level of protection for the nonstructural components of each service should be chosen: Structural level of protection must similarly be chosen against the degree or intensity of the hazard to be resisted. Designs for a possible worst case scenario may be taken as the event for meeting functional criteria.

The protection objective set for the facility as a whole, together with the level of risk estimated by the multidisciplinary group of specialists who participate in its conception, should determine the degree of detail with which the retrofit or review is to be pursued.

Useful Links on Building Rehabilitation:

Schools:

• *Incremental Seismic Rehabilitation of School Buildings* (K-12), FEMA 395 – December 2002, http://www.fema.gov/library/viewRecord.do?id=1980

• *ASCE 31, Seismic Evaluation of Existing Buildings* (ASCE, 2003) (Available from the American Society of Civil Engineers)

• *ASCE 41-05, Section 11 Seismic Rehabilitation of Buildings* (ASCE, 2007) (Available from the American Society of Civil Engineers)

Hospitals:

• PAHO.(2000). *Principles of Disaster Mitigation in Health Facilities.* Retrieved http://www.paho.org/english/dd/PED/mitigation3.pdf

• *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds*, FEMA 577 / June 2007, http://www.fema.gov/library/viewRecord.do?id=2739

• *Incremental Seismic Rehabilitation of Hospital Buildings; Providing Protection to People and Buildings*; FEMA 396 December 2003, FEMA, http://www.fema.gov/library/viewRecord.do?id=1981

• *Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide* (FEMA 74). FEMA 2009 http://www.fema.gov/library/viewRecord.do?id=3843

4 Develop a Mitigation Plan

The third step focuses on identifying and documenting mitigation measures to help achieve reduction of future disaster-related losses. Buildings must be designed to reduce accidents and be secured against disasters including, earthquake, strong winds and floods among others. Hazards like earthquake and strong winds can cause bodily injury as a consequence of building damage or from falling or flying debris. Poorly constructed or poorly maintained buildings create high risks to school population. It should be expected that new buildings must be designed to survive very strong ground shaking, strong winds and frequent floods, among other hazards of the place.

The results of the vulnerability assessment; its evaluation, along with the assignment of performance levels or protection level to each of the services and support systems and to the structure; the nature of the adjustments proposed; the resources available and the capacity to pursue adjustments, compliance with country standards, timeframe considered, among others, result to a final set of proposed risk reduction actions[20].

[20] Example may be seen from *Non-Structural Vulnerability Assessment of Hospitals in Nepal* (1st ed). (2003) by WHO-EHA Nepal and National Society for Earthquake Technology-Nepal (NSET),p.76-83

C.1. Develop risk reduction goals and objectives

The mitigation goals should articulate a school's or hospital's desire to protect people and structures, reduce the costs of disaster response and recovery, and minimize disruption especially following a disaster. The levels of performance (in Figure 2) desired and the corresponding protection needed can serve as the performance or protection objectives.

For example, if one is aiming for an FP or CO level for a certain service, one should address non-structural vulnerability and retrofit structures to increase capacity. The functional components must perform. The next activity should be to identify and develop alternative strategies to achieve this FP or CO level.

C.2. Identify and develop the strategies

In general, it is possible to divide mitigation recommendations into two categories, namely:(a) those that are easy to implement and should be carried out by the school or hospital's maintenance staff or by contractors and (b) those that require consultation with specialists and capital, such as costly modifications or new constructions to be implemented in the medium or the long term. Based on the performance objectives or level of protection set for the facility and the results of the vulnerability (or risk) assessment, the following questions may help guide the strategies for risk reduction (or providing protection).

- What actions can be carried out immediately?
- Who will do this?
- When will this be done?
- How will it be done?
- What will be needed?
- Which of the actions require funding or technical personnel?
- How much will it cost? And where will it be sourced?
- Are the resources available?
- Who will be responsible?
- What capacities are available? Which needs to be organized or strengthened?

C.2.1 Strategies Requiring Structural Mitigation

How does one remove the potential threat from structural hazards?

Once an element (or system) has been identified as a potential threat and its priority established in terms of loss of lives, or property and/or function, the appropriate measures should be adopted to reduce or eliminate the hazard. The strategies may include (among others):

(i) Structural Retrofitting

Structural retrofitting aims to improve a building's capacity to withstand the forces and pressures exerted on them. The type of structural retrofit may be defined by the nature of the hazards affecting them (e.g. seismic structural retrofits, wind structural retrofits, etc.) So for example, for buildings experiencing hurricane force-winds, they must withstand the high pressures exerted on them.

Bhubaneshori Lower Secondary School-**Before**

Bhubaneshori Lower Secondary School-**After**

Source of Image: *Safer Society, NSET's decade-long efforts to make communities earthquake-safe and Annual Report 2008*, National Society for Earthquake Technology-Nepal, 2009

As a measure, the building structural members (e.g. trusses and anchors) and nonstructural elements (e.g. roof) should be reinforced, that will not allow the force of the wind to penetrate the buildings interior. This prevents creating internal pressures that could threaten the structural integrity of the facility as a whole. The retrofitting should relieve the existing structure of those deformations and stresses that increases its vulnerability.

Schools and Hospitals may need to schedule their resources for these retrofits; nevertheless they should be assessed structurally. Stakeholders should sit down, discuss and plan for the assessments and later, possibility of retrofits or other options. It may be better to plan and build a new school or hospital later rather than retrofit.

(ii) Changing use or occupancy

Changing use or occupancy may result to lessening loads or relieving stresses to an old structure. Avoiding location of new heavy equipment or water tanks in higher floors or roof decks (i.e. after structural reviews by an engineer) can avoid the dangers of collapse, such as during strong earthquakes.

C.2.2 Strategies Requiring Non-Structural Mitigation

Having a large number of vulnerable buildings (schools and hospitals) can become problematic, since the cost of replacement or repair become high when disasters occur. The strategies requiring non-structural mitigation may include the following:

(i) Relocating the structure or building or its components

Relocating is a way of avoiding the threat of the hazard. For example, against floods, building damage may be avoided if they are built on non-erodible, high ground. Against potentially liquefiable areas, or at known fault lines, damage to buildings or collapse can be avoided if built away from these areas. This may be a favorable option, especially if the cost of relocation is better than the cost of doing structural retrofits, among other considerations (e.g., when the economic life of the building is no longer significant, availability of land, strategic location of new facility).

New buildings must consider meeting performance levels and the corresponding levels of protection in its design and construction.

(ii) Non-structural Mitigation in Buildings

A nonstructural element can be identified from an assessment as a potential threat and its priority can be established in terms of the potential injury, possible loss of lives, loss of property and/or function. The appropriate measures must be adopted to reduce or eliminate the threat.

The following examples are useful non-structural mitigation measures[21,22]. Note that some of these examples are hazard specific. (i.e. more useful under some hazards). The challenge is identify the threats during a hazard event or chain of events (i.e. strong groundshaking, flooding, fire etc.) and avoid the risk it creates.

Removal of the threat away from the area is probably the best mitigation option in many cases. An example is a hazardous material that could be spilled during a violent earthquake, but it could be stored outside the premises without much risk. On the other hand, better fastenings or the use of stronger supports for its containers can be adopted but removal can perfectly eliminate the potential problem in the area.

In a strong flood event, is there a chance that a hazardous material can contaminate your water supplies? Would it be better relocated elsewhere?

Relocation of objects within the area, which could reduce danger, is another option. For

[21] *Non-Structural Vulnerability Assessment of Hospitals in Nepal* (1st ed). (2003) by WHO-EHA Nepal and National Society for Earthquake Technology-Nepal (NSET).

[22] *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings* by Arya, A & Agarwal, A. (2007) (20 pages).New Delhi : GoI-UNDP. http://safehospitals.info/images/stories/3Resources/hospital-building.pdf

Can you think of cases where you can adopt the strategy to good use in your hospital?

example, in a school office or laboratory, a very heavy object on top of a shelf could fall and seriously injure someone, or even cause further damage or functional loss. If it is relocated to a floor-level shelf it would not represent any danger to human lives or to property.

Heavy furniture and contents should be kept away from the places where people sit (or sleep). If items cannot be secured to a sound structural member, they may need to be moved to a place where they will not cause a hazard. Corridors and exit routes should be kept free of obstructions. Large occupancy rooms should have atleast two exist doors.

Restricted mobility of objects by using restraining supports or chains can prevent them from falling or breaking.

For example, in a hospital, gas cylinders (in laboratories, hospitals) can shift as long as they do not fall and break their valves. Chains or supports or chains can be placed around cylinders to keep them from shifting or being knocked off its stand.

Anchorage is the most widely used precaution. Bolts, cables or other fastening materials can be used to prevent valuable or large components from falling or sliding. One can secure the furnishings and equipment to walls, columns or floors.

It is best to consult an engineer before fastening heavy objects to structural members.

An example is a water heater, of which there will probably be several in a hospital. They can be heavy and can easily fall and break a water main. The simple solution is to use metal straps to fasten the lower and upper parts of the heater against a firm wall or another support.

In an earthquake, the heavier the object, the more likely it is that it will move due to the forces produced.

Flexible connections sometimes are used between buildings and outside tanks, between separate parts of the same building, and between buildings. They are used because the separate objects move independently, in response to vibrations, such as from an earthquake. For example, if there is a rigid connection pipe joining a pump anchored to the ground and a water tank located separately in another building; together, the tank will vibrate at frequencies, directions and amplitudes that are different to those of the other building where the pump is located, causing the pipe to break. A flexible pipe between the two would prevent ruptures of this kind.

Can you think of other cases where you can adopt the above strategies to good use in your area?

Hanger Supports are suitable in many cases.
For example, ceilings are

Can you think of other ways to modify objects so it can avoid risks from natural hazards?

usually hung from cables or rods that only withstand the force of gravity. When subjecting them to the horizontal stresses and torsion of an earthquake, they easily fall. Ensuring adequate number of hangers at the right places can reduce serious injury to the people who are underneath them and avoid obstruction of evacuation routes.

Substitution by something that does not represent a seismic hazard is appropriate in some situations.

For example, a heavy tiled roof does not only make the roof of a building heavy, it is also more susceptible to the movement of an earthquake or from high tsunami waves adding pressure to the roof. The individual tiles tend to come off, creating a hazard for people and for objects. One solution would be to change it for a lighter, safer roofing material.

Modification by use of adhesives is a possible solution for an object that represents a seismic hazard.

For example, earth movements twist and distort a building, possibly causing the rigid glass in the windows to shatter and launch sharp glass splinters onto the occupants and the passers-by around an office. Rolls of transparent adhesive plastic may be used to cover the inside surfaces and prevent them from shattering and threatening those inside. The plastic is invisible and reduces the likelihood of a glass window causing injuries.

Isolation of small, loose objects to avoid being thrown around or fall off their shelves or containers

For example, an addition of side panels placed on open shelves, or doors with latches on the cabinets can isolate the contents and probably will not be thrown around if an earthquake were to occur.

Strengthening of non-structural elements (e.g., walls, chimneys) such as using wire meshes, interlocking bricks, additional bracing among others.

For example, an unreinforced infill wall or a chimney may be strengthened, without great expense, by covering the surface with wire mesh and cementing it.

Can you think of other cases where you can adopt these strategies to good use in your area?

It is best to consult a civil or structural engineer or this type of intervention.

Redundancy or duplication of items such as having several water supply sources and storage, having additional supplies are a examples. Storing extra amounts of certain products provide a certain level of independence from a main supply, which could be interrupted in the case of earthquakes. Likewise, opening new routes for entrance or exit or having additional lines for water distribution during emergencies during emergencies can be useful.

Rapid response and repair is a mitigation measure used for utilities such as pipelines. A school or hospital should have spare plumbing, power and other components on hand, together with the suitable tools, so that if something is damaged, repairs can be easily made. Emergency entrance doors or panels should be available to enter the area quickly in case a utility shuts down, or pipe or utility line breaks during a hazard event. For example, during an earthquake the water pipes may break; it should be possible to ensure that everything necessary for quick repair.

Non-structural risk reduction is something that is unique to each and every school or hospital. Investments may be worth making against risks from non-structural elements.

Hospitals

In hospitals, the safety of patients, doctors and nursing staff are of highest importance. Anything that can harm them or block safe evacuation should be given top priority. Hazard prone areas like chemistry labs or electrical warehouses should be secured as these areas can have a multiplier effect leading to fire and hazardous material release and thereby greatly increasing the number of casualties. Any other designated area, which would serve as a control room during emergencies should also be secured. These areas ensure operational continuity in times of emergency. In a potential mass casualty situation, there is a greater need to reduce moderate or minor injuries; this should be addressed by the hospitals in the area.

Ultimately, the final decision on what would be the best way to implement the nonstructural mitigation plan lies with the hospital management. The adjustments in the design and layout of the building, availability of open spaces, and building performance levels and service functions to be protected for the hospital etc. are important factors that determine the priorities for implementation.

To carry out measures to reduce nonstructural vulnerability, the performance levels and the protection plan (or disaster mitigation plan) for the facility must be developed with the involvement of several professionals: hospital director, chief administrator, head of maintenance, head of clinical and support services and professionals involved in safety and disaster risk reduction.

Schools

In schools, the safety of students, teachers and administrators and staff are of highest importance. Anything that can harm them or block safe evacuation should similarly be given top priority.

Hazard prone areas such as chemistry or biology labs or stock rooms should be secured as these areas can have lead to fire and hazardous material release and thereby greatly increasing the number of casualties such as during strong earthquakes.

Ultimately, the final decision on what would be the best way to implement the non-structural mitigation lies with the school administration. It may be appropriate to include professionals who are experts in applying mitigation measures to be part of the implementation.

Useful Links on Design and Retrofitting:

Mulithazard:

- Cornelius, E. (2001). *Structural Vulnerability Assessment of Selected Government Facilities: Antigua and Barbuda* (2001) by Cornelius, E. OAS/USAID, Washington, D. C.(122 pp). http://www.oas.org/pgdm/document/structur.htm
- *Homeowner's Handbook to Prepare for Natural Hazards.* (2007 by Hwang, D & Okimoto, D., University of Hawai'I Sea Grant, Honolulu, Hawai'I, 108pp http://www.soest.hawaii.edu/SEAGRANT/communication/NaturalHazardsHandbook/Homeowner%27s%20Natural%20Hazard%20Handbook.pdf

<u>Schools</u>

- *Guidance Notes on Safes School Construction* (2009) by UNISDR, INEE and World Bank, 141 pp. http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=10478
- *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds* (FEMA 424) (2004) by Federal Emergency Management Agency, Washington, D.C., 361 pp. http://www.fema.gov/library/viewRecord.do?id=1986

Useful Links on Design and Retrofitting:

Earthquake:

• *Techniques for the Seismic Rehabilitation of Existing Buildings* (FEMA-547). (2006). by Rutherford & Chekene Consulting Engineers & National Institute of Standards and Technology. FEMA, Washington, D.C.,(571pp). http://www.fema.gov/library/viewRecord.do?id=2393

Schools

• *Case Studies of Seismic Retrofitting – Latur to Kashmir & Lessons Learnt* (2008) by Desai, R. International Conference on Construction "Managing Earthquake Risk", India: National Center for Peoples'- Action in Disaster Preparedness, Gujarat, India, (NCPDP), 9 pp. http://www.ncpdpindia.org/images/03%20RETROFITTING%20LESSONS%20LEARNT%20LATUR%20TO%20KASHMIR.pdf

• *Protection of Educational Buildings Against Earthquakes, Educational Building Report 13* (1987) by Arya, A. Bangkok, Thailand: UNESCO Principal Regional Office for Asia and the Pacific, 68pp. http://www.unesco.org/education/pdf/6_51.pdf

Hospitals

• *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings.* (2007) by Arya, A & Agarwal, A., GoI-UNDP, New Delhi, 20 pp. http://safehospitals.info/images/stories/3Resources/hospital-building.pdf

• *Non-Structural Vulnerability Assessment of Hospitals in Nepal* (1st ed). (2003) by WHO-EHA Nepal and National Society for Earthquake Technology-Nepal (NSET), 96 pp. http://www.searo.who.int/LinkFiles/Nepal_-_EPR_Publications_Final_Report_Hospital_assessment_.pdf

Useful Links on Design and Retrofitting:

• *Principles of Disaster Mitigation in Health Facilities* (2000) by PAHO, 127 pp. , http://www.paho.org/english/dd/PED/mitigation3.pdf

Wind

• *Is your Home Protected From Hurricane Disaster? A Homeowner's Guide to Hurricane Retrofit* (2002). By Institute of Business & Home Safety. Tampa, Florida, USA, (35pp). http://www.nhc.noaa.gov/HAW2/pdf/hurricane_retrofit.pdf

<u>Schools</u>

• *Cyclone Resistant Rural Primary School Construction: A Design Guide* (1981) by Sinnamon, I. & Loo, G. , Bangkok, Thailand: UNESCO Regional Office for Education in Asia, 72pp. http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=7346

• *Typhoon Resistant School Buildings for Vietnam* (1987) by . Facilities Department Ministry of Education of Bangladesh, K.J. Macks Architect & Educational Facilities Service, UNESCO, Bangkok, 112 pp. http://unesdoc.unesco.org/images/0012/001206/120616eo.pdf

<u>Hospitals</u>

• *Disaster Mitigation in Health Facilities*. (2005) by PAHO/WHO, Dominican Republic, 21pp. http://www.disaster-info.net/viento/english/guiones/nonstructural.pdf

• *Guidelines for Prevision Against Wind in Hospitals and Health Centers.* (2002) by Company,C. ,). PAHO-WHO, Washington, D.C. , 38pp http://www.preventionweb.net/files/1953_VL206310.pdf

Useful Links on Design and Retrofitting:

Flood/Tsunami

• *Disaster Resistant Construction Practices: A Reference Manual* (2007) by Santhakumar, A. R., UNDP, New York, 24 pp. http://www.sheltercentre.org/library/disaster+resistant+construction+practices+reference+manual

• FEMA. (2008). *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*. (176pp). Washington, D.C.: FEMA , http://www.fema.gov/library/viewRecord.do?id=3463

• Andjelkovic, I. (2001). *Guidelines on Non-Structural Measures in Urban Flood Management.* (89pp). Paris: UNESCO, http://unesdoc.unesco.org/images/0012/001240/124004e.pdf

• Ahmed, K.I. (2005). *Handbook on Design and Construction of Housing for Flood-Prone Rural Areas of Bangladesh*. (93pp). Pathumthani, Thailand: Asian Disaster Preparedness Center http://www.adpc.net/AUDMP/library/housinghandbook/handbook_complete-b.pdf

C.2.3 Strategies for Functional Vulnerability Mitigation

School physical facilities, to remain functional, economic, structurally sound and attractive usually involve different special trades, engineers, builders, planners among others and their expertise should be sought to meet the operational levels needed. It is important that schools and their components are built in the right places with the right spaces. Educational specifications are usually given in country building codes, (e.g., size, to indicate the number of students accommodated per unit time and space layout, which links with accessibility; partitioning of rooms, collection areas such as shelving areas, among others) and must be adhered to by the school or hospital. Other considerations for design and location include furniture's and room sizes; ingress and egress in case of emergencies; facilities for learners who are physically challenged, that will allow them accessibility during emergencies (ex. ramps, guides). Other physical features that support safety in schools, during normal periods and emergencies are as follows:

- Presence of adequate water and power supply
- A working drainage and sewerage system
- Working smoke detectors and alarm system; fire exit signage; access way for fire fighters
- Provision for ventilation
- Provision for gender sensitive requirements

(e.g. toilet and bath) clothes changing facilities, among others, and
- Provision of guides and signs towards safe areas for a safe evacuation

Strategies for better functionality of **hospitals** should consider the following:

a. strategic location of the health facility,
b. availability and immediate access of equipment or materials for providing medical attention,
c. accessible and safe entry points of the health facility,
d. having regular inventories,
e. readily available emergency kits,
f. continued availability of water supply, electricity, gas, warning systems and safety equipment,
g. available transportation and communication,
h. available and functioning public information system,
i. adequate human resources for planning and implementing these requirements
j. continued advocacy on resilient school community.

Information dissemination to the hospital community on hospital zoning and on service relationships among the different areas of the facility should help the hospital community better understand how the hospital can adequate function in case of emergency or disaster.

The mitigation plan should describe the arrangement, relationship and requirements for efficient flow between outpatient consultation areas, patient facilities, areas surrounding the structure, and emergency services, and the creation of a specially protected area for general support services during emergency periods so that efficient hospital operations and appropriate treatment of casualties result.

C.3 Identify, list mitigation actions and document them

The mitigation plan document should capture the required adjustments for risk reduction. The plan may contain the following information:

a. a description of the planning or assessment process,
b. a description and map of the planned area,
c. a hazard and vulnerability assessment,
d. the goals and objectives for performance and protection,
e. the identified alternative mitigation strategies (for structural, non-structural and functional) to meet the performance levels,
f. other requirements such as organizational framework, timeframe for implementation,
g. compliance with the relevant laws and codes,[23]
h. source of funding or resources for

[23] Experiences by the State of California (USA),Office of Statewide Health Planning and Development (OSHPD)on implementation, enforcement and compliance of California Hospital Seismic Safety Law is a good material on legal approaches for implementing DRR. Communications with Dr. Fouad Bendimerad, Earthquakes and Megacities Initiative,2009.

implementation.

Information should also be provided on how the monitoring, evaluation, and updating of the mitigation plan are to be pursued. Necessarily, it should be easy to read.

The mitigation plan with the emergency management plan (preparedness and response) comprise the risk reduction plan for the school or hospital(or health facility).

The planning team should review the draft plan. It may also be helpful that other higher agencies (ex. those with jurisdiction over the facility) be given the opportunity to review the plan.

C.4 Determine cost of implementing the strategy

It is important that the costs and benefits be made against these various mitigation measures to meet the desired performance level for a service or support system. Benefits may come from potential savings that may result from avoiding damage to the assets or in saving lives. Costs can include the initial costs for implementing mitigation (e.g. construction), maintenance and operations for the mitigation; as well as, remaining damage costs that may still arise even with the mitigation in place (such as from meeting stronger events other than the event used for the designing mitigation).

Determine cost

At this point, one should have a mitigation plan detailing the different alternatives, costs, and other important evaluations, the assignment or performance levels, compliance with existing laws (or codes) and decisions arrived at, that may affect the selection of the strategies and their implementation.

5 Implement the Plan and Monitor your Progress

This fourth step of the risk reduction planning process involves adopting, implementing, monitoring, and reviewing the plan. A periodic review of the mitigation plan ensures that the plan's goals and objectives are met and keeps the plan up to date.

Getting the plan adopted ensures the support and approval of the governing authority having jurisdiction.

Implementing the plan requires identification of the actual sources of funding, personnel time and other resources. Alternative sources of funding, identifying responsible parties for implementing planned actions, and ensuring that appropriate authority is present are key points to successful implementation of mitigation plans[24,25]. Monitoring and evaluating the outcomes of the mitigation actions are essential to knowing whether measures taken are successful in reducing the risks of the place. Successes and limitations of the efforts should be documented as part of the evaluation process.

[24] Examples of Success Stories may be read from D*isaster Prevention for Schools, Guidance for Education Sector Decision-Makers*, Consultation version, Nov. 2008,p.12-21.
[25] *Safer Society, NSET's decade-long efforts to make communities earthquake-safe and Annual Report 2008* (2009), National Society for Earthquake Technology-Nepal.

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- California Experience Presentation for Preparatory Meeting for the Workshop on WHO Indicators for the Assessment of Safe Hospitals in Emergencies and Disasters (Dec 7,2009), Pan-Pacific Hotel, Manila, by Dr. Fouad Bendimerad, Chairman Earthquakes and Megacities Initiative. http://www.emi-megacities.org

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- *Disaster Prevention for Schools, Guidance for Education Sector Decision-Makers*,Consultation version, Nov. 2008, http://www.preventionweb.net/english/professional/publications/v.php?id=7556

- *Disaster Risk Management in Development Projects: Models and Checklists*, by Mora, S., Keipi, K. (2006): Bull Eng Geol Env (2006) 65: 155–165 DOI 10.1007/s10064-005-0022-1

- *Disaster Risk Management – Document Series: Seismic Safety of Non-Structural Elements and Contents in Hospital Buildings* by Arya, A & Agarwal, A. (2007) (20 pages). New Delhi: GoI-UNDP. http://safehospitals.info/images/stories/3Resources/hospital-building.pdf

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• *Guidance Notes on Safes School Construction* (2009) by UNISDR, INEE and World Bank, 141 pp. http://www.preventionweb.net/english/professional/trainings-events/edumaterials/v.php?id=10478

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• *Non-Structural Vulnerability Assessment of Hospitals in Nepal* (1st ed). (2003) by WHO-EHA Nepal and National Society for Earthquake Technology-Nepal (NSET), 96 pp. http://www.searo.who.int/LinkFiles/Nepal__EPR_Publications_Final_Report_Hospital_assessment_.pdf

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- *State and Local Mitigation Planning; How to Guides,: Understanding Your Risks: Identifying Hazard and Estimating Losses* (FEMA 386-2),(August 2001) by Federal Emergency Management Agency

- *State and Local Mitigation Planning; How to Guides: Developing the Mitigation Plan: Identifying Mitigation Actions and Implementing Strategies* (FEMA 386-3), (April 2003) by Federal Emergency Management Agency

- *State and Local Mitigation Planning; How to Guides: Bringing the Plan to Life: Implementing the Hazard Mitigation Plan* (FEMA 386-4), (August 2003) by Federal Emergency Management Agency

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