Guidance Notes on **Safer School Construction**

Global Facility for Disaster Reduction and Recovery

International Strategy for Disaster Reduction

INEE

THE WORLD BANK

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INEE is a global, open network of over 3,500 members working in 115 countries within a humanitarian and development framework to ensure all persons the right to safe, quality education in emergencies, disasters and recovery. www.ineesite.org

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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" if we do not take measures to prevent these impacts.

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.

Capacity is the combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve disaster reduction and prevention. In this context, capacity refers to the knowledge, skills, human social and political relationships that can be used to reduce vulnerabilities.

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

Hazard (or Disaster) Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

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.

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

Responses 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.

Recovery is the restoration and improvement, where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.

Retrofit 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 which "aims to promote common understanding and common usage of disaster risk reduction concepts and to assist the disaster risk reduction efforts of authorities, practitioners and the public"(UNISDR, 2009*).*

Worldwide, approximately **1.2 billion students are enrolled in primary and secondary school**; of these, **875 million school children live in high seismic risk zones** and hundreds of millions more **face regular flood, landslide, extreme wind and fire hazards**.

Executive Summary

In January 2009, the Center for Research on Epidemiology of Disasters highlighted a spike in the number of people killed in natural disasters: the 2008 death toll of 235,816 was more than three times the annual average of the previous eight years. Moreover, it noted that the biggest losses, from Cyclone Nargis and the Sichuan earthquakes, could have been substantially reduced had schools been built more disaster resilient. Worldwide, approximately 1.2 billion students are enrolled in primary and secondary school; of these, 875 million school children live in high seismic risk zones and hundreds of millions more face regular flood, landslide, extreme wind and fire hazards. Although these children spend up to 50 percent of their waking hours in school facilities, all too often schools are not constructed or maintained to be disaster resilient. The death of children and adults in these schools causes irreplaceable loss to families, communities and countries and lifelong injury to millions of children around the world. The time to say NO MORE to these preventable deaths is NOW; every new school must be constructed as a safer school and existing unsafe schools must be retrofitted to be disaster resilient. The Education for All (EFA) and Millennium Development Goals (MDGs) will not be achieved without the construction of safer and more disaster resilient education facilities.

The *Guidance Notes on Safer School Construction* present a framework of guiding principles and general steps to develop a context-specific plan to address this critical gap to reaching EFA and the MDGs through the disaster resilient construction and retrofitting of school buildings. The guidance notes consist of four components:

1. **General information and advocacy points** (Sections 2-4) briefly address the need and rationale for safer school buildings as well as the scope and intended use of the Guidance Notes. They also feature several success stories and list a number of essential guiding principles and strategies for overcoming common challenges.
2. **A series of suggested steps** (Section 5) that highlight key points that should be considered when planning a safer school construction and/or retrofitting initiative. Each step describes the processes, notes important decision points, highlights key issues or potential challenges, and suggests good practices, tools to facilitate the actions, and references resources to guide the reader to more detailed and context-specific information.
3. **A compilation of basic design principles** (Section 6) to identify some basic requirements a school building must meet to provide a greater level of protection. These principles are intended to facilitate a very basic understanding of the measures that can be taken to make a school building more resilient to hazard forces.

4. **A broad list of references to resources** (Appendix 3) for more detailed, technical and context-specific information.

The *Guidance Notes on Safer School Construction* should be used by policymakers and planners of local, regional and national government bodies and all other organizations interested or engaged in enhancing the safety of school populations through improved hazard resistant construction and retrofitting of schools buildings. They can be used to guide discussion, planning and design, implementation, monitoring and evaluation of school construction and should be utilized to strengthen Education Sector Plans and to develop National Action Plan for Safe Schools.

The guidance notes were developed through a consultative process involving hundreds of experts and practitioners from around the world who provided suggestions drawn from experience and sound research. In addition, the development involved an extensive vetting process of existing materials, good practices and case studies on safer school construction. As a result, the suggestions contained within the guidance notes are drawn from a wide variety of individuals and groups, including governments, donors, disaster management organizations, engineers and architects, planners, construction managers, multilateral organizations, UN agencies, NGOs, academic institutions and educators. This is an evolving document that will be regularly revised to include new and appropriate research, insights and practices, thereby maintaining its relevancy and usefulness. To provide feedback, please email: network@ineesite.org and GFDRR.

The Need for Safer Schools: Introduction, Context and Scope

> ***If we are not making our contribution to keeping children alive, and not holding others to account for their part, what is the rest of our work about?***
> (Save the Children Child Survival Campaign)

At a time when the frequency and magnitude of extreme climatic events is rising, a growing number of the world's school-going children are increasingly exposed to earthquakes, wildfires, floods, cyclones, landslides and other natural hazards. Where these events impact human settlement, the tolls taken on the lives of children, the school infrastructure, and the educational opportunities for survivors are distressing. For example:

- The Sichuan earthquake (2008) killed more than 7,000 children in their schools and an estimated 7,000 classrooms were destroyed.
- The cyclone Sidr in Bangladesh (2007) destroyed 496 school buildings and damaged 2,110 more.
- The Super Typhoon Durian (2006) in the Philippines caused $20m USD damage to school, including 90-100% of school buildings in three cities and 50-60% of school buildings in two other cities.
- The earthquake in Pakistan (2005) killed at least 17,000 students in schools and seriously injured another 50,000, leaving many disabled and over 300,000 children affected. Moreover 10,000 school buildings were destroyed; in some districts 80% of schools were destroyed.

As these statistics demonstrate, non-disaster resilient schools not only kill and injure children, but the damage to and/or destruction of the physical infrastructure is a great economic loss for a country; the cost of reconstruction can be a substantial burden on the economy. As highlighted within the World Bank's *Education Note* on Building Schools, putting all children worldwide in school by 2015 will constitute, collectively, the biggest building project the world has ever seen. Some 10 million new classrooms will be built in over 100 countries. The cost of achieving EFA is already much higher because of past failures to maintain schools properly. Of the estimated $6 billion annual price tag for EFA construction, $4 billion is to replace classrooms that are literally falling down (Theunynck, 2003). It is critical to get safer school construction right *the first time around.*

In addition to saving lives, sustaining economies and minimizing harm to students, teachers and school personnel, safer school construction is urgent because:

- ✓ Safer schools can minimize the disruption of education activities and thus provide space for children's learning and healthy development
- ✓ Safer schools can be centers for community activities and constitute social infrastructure that is critical in the fight against poverty, illiteracy and a disease free world
- ✓ Safer schools can be community centers to coordinate response and recovery efforts in the aftermath of a disaster
- ✓ Safer schools can serve as emergency shelters to protect not just the school population but the community a school serves

Moreover, approaches to safer school construction and retrofit that engage the broader community in the integration of new knowledge and the acquisition of disaster prevention skills can have an impact that reaches beyond the school grounds and serve as a model for safer construction and retrofit of homes, community health centers, and other public and private buildings. Schools also provide a hub and learning place for an entire community. Children are the quickest learners, and are able to not only integrate new knowledge into their daily lives but also serve as the source of family and community knowledge on health and safety behavior, which they carry home from school. Thus, making disaster prevention a school focus, by empowering children and youth to understand the warning signs of hazards and the measures that can be taken to reduce risks and prevent disasters, is a crucial starting point for building the disaster resilience of an entire community.

Objectives and Scope of the Guidance Notes on Safer School Construction

The institutionalization of guiding principles for the construction of more disaster resilient schools has been identified by governments, international organizations, and school communities as a critical need for reducing, and ideally preventing, the devastating consequences of countless hazard events. Although there are many governments and organizations engaged in the construction, retrofit and repair of safer schools as well as the production of knowledge based on experience and research, there is presently no one reference point from which to easily navigate and obtain the appropriate technical knowledge and valuable insights gained from similar initiatives around the world. Therefore, the development and utilisation of these Guidance Notes on Safer School Construction, which articulate a series of recommendations and guide readers to more technical and context-specific information, is an important first step in a global effort to ensure that schools in hazard-prone regions are designed and built to best protect their inhabitants. By making use of this knowledge to design new schools and rehabilitate existing schools, we can ensure that our children's learning environments become a safe haven rather than a potential danger to their lives and our future.

These Guidance Notes use as their foundation the *INEE Minimum Standards for Education in Emergencies, Chronic Crises and Early Reconstruction* (2004) in which the second and third standards for 'Access and Learning Environment' state that learning environments should be "secure and promote the protection and mental and emotional well-being of learners" and that education facilities be conducive to the physical well-being of learners. The indicators for these standards further state that the learning structure and site should be accessible to all, regardless of physical ability, "free of dangers that may cause harm to learners, and be appropriate for the situation.

The Guidance Notes on Safer School Construction are not intended as a blueprint response to safer school construction. As such they should be adapted to the local context, and used as a platform for planning and implementing an appropriate response to safer school construction.

Scope: This document specifically addresses the following hazards: earthquakes, storms, floods, landslides, and wildfires. It focuses only on hazards that pose a threat to school structures and hazards for which measures can be taken to help prevent a disaster. The document does not address human-induced nor health or hygiene-related hazards. While other hazards may not be addressed, the steps articulated for planning and implementation should prove useful in other hazard environments.

Hazard resilient school buildings are just one component of a safe school. Other measures that are essential in reducing risk and creating a child friendly learning environment are:

- ✓ Ensuring that all individuals have access to safe and protective schools and that no individual is denied access because of discrimination
- ✓ Establishing community education committees and, within those committees, school disaster management committees
- ✓ 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
- ✓ Building prevention into systems through creating school preparedness and evacuation plans
- ✓ Identifying early warning systems and panning for school continuity in the event of a hazard
- ✓ Integrating disaster risk reduction themes into the formal curriculum
- ✓ Learning and practicing effective response procedures through, for example, safety drills

For further information please see the companion volume: Disaster Prevention for Schools: Guidance for Education Sector Decision-Makers (http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=7344) and the INEE Minimum Standards (http://www.ineesite.org/standards)

These guidance notes do not directly address all of the means of reducing a school's risk. Nevertheless, it is imperative to understand that without addressing these additional components, a school and its learners remain unnecessarily vulnerable.

We CAN make school buildings safer: Case Studies and Guiding Principles

The following examples from case studies on safer school construction highlight the fact that **safer school construction *IS* achievable and critical:**

Sangzao Middle School – Sichuan Province

The students lined up row by row on the outdoor basketball courts of Sangzao Middle School in the minutes after the earthquake. When the head count was complete, their fate was clear: all 2,323 were alive. Just 20 miles north, the collapse of Beichuan Middle School buried 1,000 students and teachers.

Mr. Ye Zhiping started working at the school 30 years ago as an English teacher and has taught in every classroom and became the school principal in 1996.

Nervous about the shoddiness of the main school building, Mr. Ye pestered county officials for money. Eventually the education department gave $58,000. It was a troublesome process because the county was poor and thus tight with money, Mr. Ye said, but officials saw the need to ensure the safety of children. He had workers widen concrete pillars and insert iron rods into them. He demanded stronger balcony railings. He demolished a bathroom whose pipes had been weakened by water. Each classroom had four rectangular pillars that were thickened so they jutted from the walls. Up and down the pillars, workers drilled holes and inserted iron reinforcing rods because the original ones were not enough, Mr. Ye said. The concrete slab floors were secured to be able to withstand intense shaking.

Mr. Ye not only shored up the building's structure, but also had students and teachers prepare for a disaster. They rehearsed an emergency evacuation plan twice a year. Because of that, students and teachers say, everyone managed to [evacuate] in less than two minutes.

Excerpts from: Wong, E. (2008, June 16). How Angel of Sichuan Saved School in Quake. The New York Times

"One of the few buildings still standing after the Nura village earthquake in South Kyrgyzstan on 6 October 2008, which killed 75 people, was the public school, designed and constructed by the Kyrgyz Scientific Research and Design Institute of Seismic Construction" **–***Excerpts from: European Commission Humanitarian Aid Department Press Release*

Madagascar "Shock Response" Fund

By means of a government development fund, 2,041 cyclone-resistant school buildings in Madagascar have been constructed or retrofit to withstand cyclone winds of up to 250 km/hour. The International Development Fund IV (FID IV) project "emerged in mid-2004 after two strong cyclones (Gafilo and Elita) struck the country's East and West coasts, damaging 3,400 schools--of which 1,420 were completely destroyed–and leaving more than 200,000 people without shelter. Under a FID IV Project component known as 'Shock Response', school buildings and primary health centres are built or retrofitted using cyclone-resistant construction codes".

"The success of the FID IV project relies entirely on the leadership, management and ownership of the local community. A local association is formed by community members who submit a formal funding request to the FID for the construction or rehabilitation of a public building".

"Upon approval of the request, a "project manager" status is conferred on the community members'/parents' association to supervise the administrative, technical, financial and business-related aspects of the development of the building including the design, construction codes, tender, selection of contractors/sub-contractors, business negotiations, follow-up, and completion of work".

"After construction is completed, the local association also takes full responsibility of maintaining and administering the building."

Excerpts from: http://www.unisdr.org/eng/public_aware/world_camp/2006-2007/pdf/case-study-madagascar-en.pdf

GUIDING PRINCIPLES

There are many challenges to realizing safer school construction. Chief among them is inadequate existing infrastructure in many hazard-prone areas and the lack of clearly-defined responsibilities and accountability mechanisms. This is complicated by a limited political will and resource allocation, which are often stretched thinly across a variety of other objectives. In such cases, arguments for investment in additional infrastructure may garner little support. Additionally, when hazard events occur less frequently, the urgency to take precautionary measures may quickly diminish. Finally, the unique context of each school, and consequently, the unique set of factors which must be considered to mitigate loss and damage, is a challenge. Hazard characteristics may differ by type, intensity, and frequency. The vulnerabilities and capacities of schools and communities will differ. Considering these variables, a one-size fits all approach is not only ineffective, but at worst, may be counter-productive and even harmful.

Despite these challenges, there are financially feasible and sustainable strategies that the international community must take up in order to realize safer school construction. Included here are several principles derived from the successes and failures of efforts to increase the safety of schools across the globe. Practical strategies and case studies, based on these principles, will appear throughout the steps outlined in these guidance notes. **The seven basic guiding principles** proposed here are:

- ✓ Raising awareness
- ✓ Fostering community ownership
- ✓ Cultivating innovation
- ✓ Encouraging leadership
- ✓ Evaluating the process for improving practice
- ✓ Assuring quality
- ✓ Continuing Assessment

Raising awareness

"Education, knowledge and awareness are critical to building the ability to reduce losses from natural hazards, as well as the capacity to respond to and recover effectively from extreme natural events when they do, inevitably, occur" (Wisner, 2006). Creating and maintaining a safe learning environment means sharing knowledge about hazards, their potentially damaging effects, and most importantly, what we can do about them. With the assistance of science and engineering and the essential knowledge a community possesses, simple and effective measures can be taken to make school buildings safer. Every stage of the process of making schools safer is an opportunity for teaching and learning and anyone with the appropriate knowledge, from a primary school student to the highest state official, can contribute.

Fostering community ownership

For a hazard resilient school building to meet its potential to mitigate damage and loss, its community must understand the risk that hazards pose and the building's capacity to reduce that risk. Fostering a sense of ownership by the individuals and groups who use and maintain the building will help ensure its protective capacity is sustained throughout its years of use.

If these individuals are to feel a sense of ownership of the building, they must be delegated an active decision-making role in the assessment, design, implementation, monitoring and evaluation of the initiative.

Ownership should be fostered not just within the school community, but with all involved partners. When partnerships lead to mutual benefit and all parties involved see their own needs being met, sustainable collaborations are formed.

Assuring quality

Although hazard resilient buildings need not be overly complex, adherence to the precise technical requirements which make them safer is essential. Oversight or disregard of these requirements can quickly jeopardize the future safety of the school population. Giving due attention to the engagement of engineers qualified to advise on hazard resilience and to all planning/engineering-related requirements will help ensure the building meets its intended safety objective.

Cultivating innovation – minimizing cost and maximizing resources

Innovation is the process of creating a new solution to a problem given a set of constraints, resources and capacities. Cultivating innovation means shifting the overall outlook from a focus on *how something should be accomplished* to *how many different ways might it be accomplished*?

To cultivate innovation within a group:

- ✓ Include a broad range of individuals in planning activities
- ✓ Actively search out new knowledge to share with the group
- ✓ Encourage the expression of even the least feasible suggestions – innovation will most commonly arise from piecing together a number of different suggestions.

Good innovations are simple, realizable and build on existing knowledge and resources.

⚠ It is important to note that the many efforts have been made to integrate appropriate technologies into school construction. When these innovative practices were foreign and complex, the necessary technical support to design, construct and maintain buildings most often resulted in high costs and poor sustainability.

PERU—Stronger Bricks for Earthquake Resistant Construction

"In Peru, Mujeres Unidas para un Pueblo Mejor developed techniques for constructing more earthquake-resistant bricks using inexpensive local materials (with support from the NGO Estrategia). Producing these bricks is an income generating enterprise for women who built affordable, earthquake resistant houses in a 20 home pilot some years ago.

They have sold bricks to municipal government in recent years for use in public facilities. Although they have been sharing the technique with local communities in and outside of Peru through peer exchanges over time, it took the 2007 earthquake to get the government's attention on how they could support building affordable, safe houses in informal settlements using anti-seismic bricks produced by grassroots women's enterprises".

Source: http://www.disasterwatch.net/resources/recipesforresilience.pdf

PHILIPPINES—Students lead campaign to relocate their school

After their school was spared from a mudslide, the students in Santa Paz, Southern Leyte, led by their 16 year old school president, Honey, initiated a writing campaign to lobby for the relocation of their school. In spite of the construction of a concrete wall and drainage ditches they consulted with hazard specialists and found that their school was intolerably vulnerable. With the help of a sympathetic former governor, the students convinced local authorities to relocate their school in spite of the protests of many of the adults of Santa Paz. They are now in a new school that is designed to resist earthquakes and serve as a community shelter.

Source: http://www.plan-uk.org/pdfs/childrenindrr.pdf

Encouraging leadership

Leaders represent the path by which social change occurs. Be it within a community or the government, these are the individuals who facilitate the consideration of new perspectives and motivate change in social values and corresponding behaviors. In school communities, principles are often the pivotal leaders. However, leaders are not always those who are technical experts, or those who hold formalized leadership roles. In the case of a school in The Philippines, it was students who provided the leadership necessary to create a safer learning environment (see adjoining case study).

To encourage leadership at any level:

- ✓ Search out respected individuals capable of motivating change
- ✓ Work towards a shared understanding of the need for safer schools. If this is accomplished,
- ✓ Collaboratively identify how best to plan for change, and
- ✓ Support their role in doing so.

Evaluating the process to improve practice

Regular monitoring of the evolving needs of the population as well as the extent to which the initiative meets those needs will allow the initiative to remain relevant and responsive. A systematic and impartial evaluation of the initiative that includes all involved, will allow for improved practice and enhanced accountability. Information collected impartially and transparently and shared with others from the local to the national and international community can benefit future safer school construction advocacy, programs and policies. Critical factors for success are:

- ✓ realistic and practical planning with clear aims and objectives;
- ✓ adequate resources allocated to monitoring and evaluation within planning;

- ✓ the involvement of all key partners;
- ✓ the identification and selection of relevant indicators that demonstrate impact as well as cause-effect relationships and outcomes; and
- ✓ the application of lessons learnt to improve practice and policy.

Continuing Assessment

The risk to a school and its occupants is a function of many factors. Environmental change and land use practices can intensify the hazard risks in a particular location. Risk is equally influenced by our understanding of hazards and our capacity to mitigate the damage and loss they may cause. As these factors are all dynamic, a school community s risk too, is dynamic. Making a school a safer place means working with its community to identify ways to continue monitoring the known hazards, maintaining the protective capacity of the school buildings, and learning new ways to reduce their risk.

HOW SAFE ARE YOUR SCHOOLS?

- Have all natural hazards posing a threat to schools been identified?
- How often are these risks reassessed?
- Are the school population and the local community aware of the risk?
- Were the school buildings designed to meet building code standards?
- Who designed the schools?
- Did (Does) the building code provide guidance on hazard resilient design?
- Was the soil tested before the school was built?
- Were builders trained to apply hazard-resilient techniques?
- Was the school construction supervised by a qualified engineer?
- Who is responsible for managing the school maintenance program? Are mechanisms in place to ensure school maintenance is financed and executed?
- Do natural hazard events regularly create disruptions in the school calendar? Is there a backup plan to ensure that school operations continue?
- Are school furnishings and equipment designed and installed to minimize potential harm they might cause to school occupants?
- Do students, teachers, staff, and school administrators know what to do before, during and after a hazard event?
- Has a safe location been identified if the school must be evacuated? Is the passage to that location also safe?
- Does a disaster management committee exist in the school or the local community?
- During a hazard event, does the school serve as a shelter? Has it been designed to do so?
- Are the school population and local community aware of how they can reduce their vulnerability to the damaging impacts of a hazard event? Are they actively taking measures to do so?

Suggested steps towards greater safety of school buildings

When thousands of existing schools may be unsafe and more potentially unsafe schools are being built every day, how does one identify where to begin? Incorporating hazard-resilient features into new school buildings can be done inexpensively if careful attention is given to ensure effective design and construction. A joint UNDP-Government of Uttar Pradesh, India safer school initiative found that the construction of a new hazard resilient school cost only 8% more than a school built to non-hazard resilient standards (Bhatia, 2008). With such a minimal added investment, ensuring that future schools are built to hazard-resilient standards is a suggested first priority.

Yet the schools at greatest risk are those existing schools whose buildings were not designed to resist the damaging effects of hazards and that host hundreds of thousands of school children throughout the year. Enhancing the hazard resilience of a potentially large quantity of existing schools can be a time-consuming effort, but by prioritizing those schools at greatest risk, assuring quality in design and implementation, and engaging the community throughout the process, retrofitting efforts can achieve excellent and cost-efficient results. Between 2007 and 2008, the Istanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) Turkey, retrofit 364 schools and reconstructed 106 others. The cost of retrofitting small and medium-sized school buildings was only 10-15% of the cost to replace the building (Miyamoto).

Figure 1: DJ Primary/Community Based High School, Hasis, Pakistan – Before and after seismic retrofit

Photo Courtesy and copyright of Aga Khan Building and Planning Service, Pakistan

A note on the overall project approach

Political will, existing infrastructure, technical capacity, availability of resources, and project scale are all factors which will influence the approach you choose. The suggested steps outlined here attempt to provide guidance regardless of the approach taken.

Yet, several key enabling factors have been observed in successful and sustainable approaches.

- ✓ School communities understand their risk, and the extent to which a hazard resilient school can reduce that risk.
- ✓ School communities play a major decision-making role throughout the various steps of the project.
- ✓ Care is taken to foster an on-going dialog of mutual learning and understanding between project engineers and the school communities.
- ✓ Rigorous attention is paid to the technical requirements of the assessment, design, and construction/retrofitting supervision.
- ✓ The final new school or retrofitting design is simple, builds on local building capacity and materials, and can be maintained inexpensively by the school community.
- ✓ Education and awareness-raising are components of each and every activity.

Community driven development – One approach

Research on school construction throughout Africa and many Asian countries has shown that one of the most cost-efficient and effective approaches to school construction is a community-driven development (CDD) approach. In CDD, the community manages the school construction, provides and contracts work to the local builders, and receives support and resources from the Ministry/Department of Education and local government (Theunynck, 2008).

Although this research does not specifically address hazard resilient school construction or retrofitting, the approach, when accompanied with strong training and awareness-raising efforts, has been employed successfully by governments and NGOs in hazard prone countries such as the Philippines, India, Madagascar and Pakistan.

In the majority of these cases, the project initiators provide the technical engineering capacity for the assessment, design, and supervision/inspection of works. Funding is commonly allocated to the community management body in installments. The completed project, upon approval of a quality inspection team and all other parties, is turned over to the community, who is responsible for the school building and its maintenance.

Besides overall effectiveness, properly-implemented community-driven approaches have additional benefits:

- ✓ They benefit local economies
- ✓ Community ownership of the process helps to ensure the maintenance of the new safer learning environment.

- ✓ New capacities are developed within the community which can be applied to residences and other buildings.

One notable challenge is that when larger, more complex school facilities are constructed that requirie multiple contractors to provide a variety of services, the project may require professional contract management services. In such cases, the approach must be adapted or another approach adopted.

PHILIPPINES–Principal-led school building program

In the Philippines, the Department of Education (DepED) adopted the Principal-Led School Building Program approach, wherein principals or school heads take charge of the implementation management of the repair and / or construction. Assessment, design, and inspection functions are provided by the DepED engineers, who also assist the Principal during the procurement processes. The Parent Teacher & Community Association (PTCA) and other stakeholders in the community are responsible to audit all procurements. With support from AusAid, 40 classrooms were retrofit to resist typhoons using this approach. Complementing the retrofitting works, training is provided to teachers, students and staff and disaster management is integrated into the school curriculum.

Source: http://www.adpc.net/v2007/Programs/DMS/PROGRAMS/Mainstreaming%20DRR/Downloads/Philippines.pdf

An overview of the suggested steps

The following suggested steps provide guidance on both the construction of new hazard-resilient schools and the retrofitting of existing schools to higher safety levels. The majority of the steps apply to both new construction and retrofitting. However, as these processes differ at various stages of the project, certain steps or guidance within a step may apply solely to the case of new construction or of retrofitting. Where this occurs, a note will be made to indicate which case is being addressed.

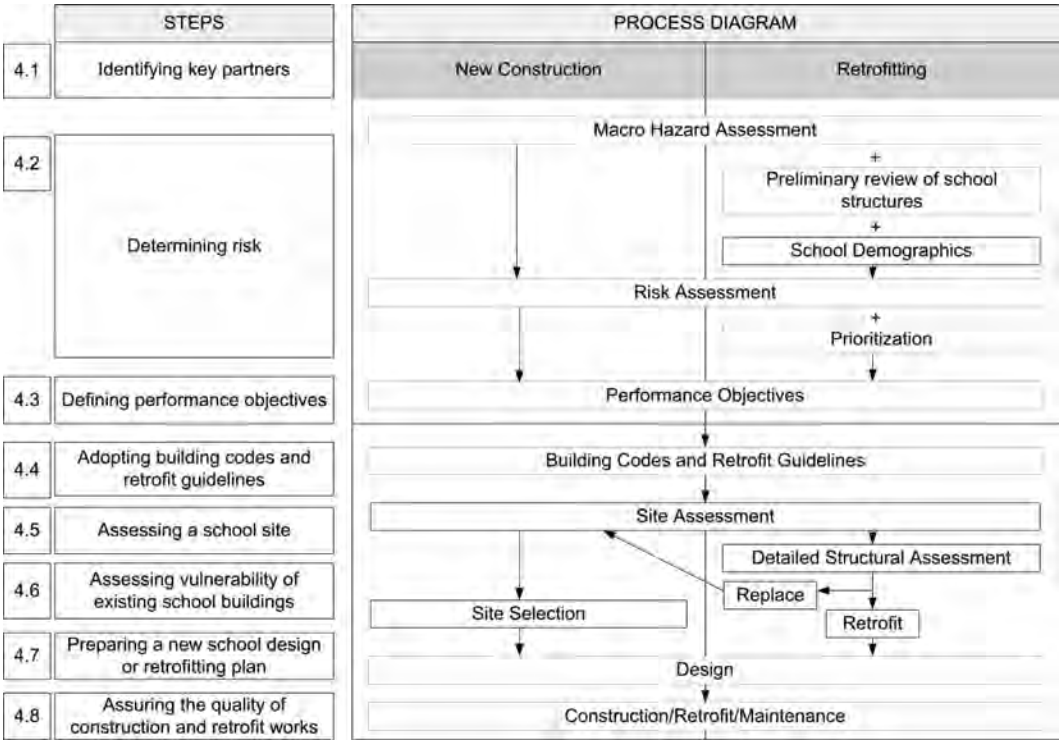
The guidance notes propose eight steps.

1. **Identifying key partners** – Who can contribute to the initiative?
2. **Determining risk** – What hazards pose a risk to existing and prospective schools and where is that risk the greatest?
3. **Defining performance objectives** – How do you determine the maximum amount of damage or disruption that can be tolerated? What level of hazard resilience should schools be designed to meet?
4. **Adopting building codes and retrofit guidelines** – What guidance and standards exist to ensure a new school or retrofitting plan can meet the performance objectives?

5. **Assessing a school site** – What makes a site more or less vulnerable to hazards? What other hazards pose a risk? Are there any conditions that make a site particularly vulnerable? How are local buildings constructed? What materials and skilled resources are locally available?
6. **Assessing vulnerability of existing school buildings** – What are the conditions of the existing school? Should it be retrofit or rebuilt? What measures might be taken to strengthen the building? How can the school community be involved?
7. **Preparing a new school design or retrofitting plan** – What are the design considerations for a new school or retrofitting plan? Who should be involved in the design process? What tradeoffs might need to be made? Are there any special considerations when retrofitting a school?
8. **Assuring the quality of work and maintenance** – What are some strategies for developing a transparent construction project? What are some approaches to training builders to use hazard resilient techniques and materials? What mechanisms can be adopted to encourage compliance to the hazard resilient design? What should be considered when setting up a maintenance program?

The steps correspond to the assessment, planning, and implementation processes illustrated in Figure 2.

Figure 2: Safer School Steps and Corresponding Process Flow Diagram



The discussion of each step begins by defining the objective of the step, stating its purpose within the overall process, and noting how it relates to other steps. The guidance provided for the planning of each step is also organized into three sections:

Introduction	Defines new concepts and/or provides general notes on the step as a whole
How do you do it?	Describes the processes, notes important criteria for decision-making, highlights key issues or potential challenges, suggests good practices, and references tools to facilitate the process.
Key points to consider	Identifies enabling factors, strategies corresponding to the guiding principles outlined in Section 3, and any further considerations based on the experience of other safer school initiatives.

Although the steps have been organized sequentially, many of the activities can be conducted simultaneously.

4.1 IDENTIFYING KEY PARTNERS

What is the objective of this step?	To identify potential collaborators who can contribute to a safer schools initiative, and form a coordinating group to lead the initiative.
What is the purpose?	To create a network of collaborators that can provide the leadership and resources to ensure that existing and future schools are safer places.
How does this step relate to others?	The partners identified in this step will play various roles in planning, implementing, and evaluating all the proceeding steps.

4.1.1 Introduction

No single entity possesses all of the skills, knowledge and experience necessary for the effective design, construction, retrofit, use and maintenance of a school. Creating and maintaining a positive learning environment requires project managers, engineers, architects, school administration, teachers, students and community leaders, and a skilled workforce at a minimum.

Where schools are created to resist hazard forces, new knowledge and skills must be shared with all of these entities; thus, advocates, communications experts, and trainers all have a role to play in creating safer schools.

Additionally, there are many other entities sharing similar objectives that can make valuable contributions to the process.

The process of creating safer schools begins with identifying those potential partners and allies who together can ensure that school buildings serve to protect their occupants and prevent potential disasters.

4.1.2 How do you do it?

1. Locate potential partners possessing the necessary skills, knowledge and resources

School construction, most commonly, is the ultimate responsibility of one or several government departments who may undertake the work or contract it to non-governmental sources. Understanding the existing mechanisms and determining 1) who is responsible for what, 2) to whom are they accountable, and 3) how the accountability is enforced is a strong starting point for identifying potential collaborators. Table 1 provides a list of sample governmental and non-governmental bodies that may play a role in hazard resistant school construction, retrofitting and maintenance.

Table 1: Sample Government and Non-government bodies involved in school construction

Component	Governmental bodies:	Non-governmental bodies
Hazard assessment	National or local emergency or disaster management agencies, Scientific and technical research institutes, Universities	Private consultancy firms
Building code enactment	National, state, or provincial ministry/ departments of public works, architecture and construction, municipal affairs and housing	Building industry entities, building product manufacturers
Building code enforcement	National, regional, or local government	Independent code enforcement bodies, testing laboratories
Design and construction of schools	Ministry/department of education, public works; regional or local government	Private school owners, Materials suppliers, construction companies, local builders, professional engineering, architecture, and building associations
Maintenance	School district, schools	Community
Provision or acquisition of school site	District or local government	Community
Land use planning	Ministry/department of planning or urban and rural development. Town and Country Planning Department, Development Authority	Urban and rural planning organizations, Planning professional associations
Financing	Ministry/department of education or finance, planning Commission, program coordination unit	Donor organizations, NGOs, INGOs, regional banks and other lenders

Component	Governmental bodies:	Non-governmental bodies
School administration	Ministry/department of education, local school boards or school districts,	School administrators associations, local school management committees
School – Community relations	Ministry or department of education, school boards or districts	Local schools, community-based organizations, NGOs, Parent/ Student/Teacher associations
Materials supply		Private sector businesses, NGOs, donor-organizations, communities

Where new knowledge and methods exist to strengthen a building's ability to resist hazards, skills training and awareness raising will help to cultivate an understanding of hazards, risk and the capacity to reduce risk. Table 2 lists several sample partners who might provide skills training and conduct awareness-raising activities.

Table 2: Sample Training and Awareness-Raising Partners

Component	Governmental Bodies	Non-governmental bodies
Training provision for skilled and unskilled workforce	Ministry/department of vocational and technical training	Trade unions/associations, technical/ vocational schools, NGOs, structural engineers, disaster management organizations, private sector companies
Training provision and certification of engineers and architects	Ministries /Departments of Education or Human Resource Development, National Disaster Management Organizations	University degree programs, professional associations of engineers or architects, private sector companies
Awareness-raising (local-level)	School district, or local government officials	Existing experts within the community, disaster management organizations, NGOs, CBOs, local media, students and teachers
Awareness-raising (national-level)	Ministry/department of education	National media, NGOs,

Other individuals and groups, not typically associated with school construction, may share similar motivations, needs, or objectives. Some examples are:

- ✓ Industries concerned with protecting valuable assets may share valuable hazard assessment data (eg. Insurance companies)
- ✓ Informed teacher unions can help garner support of teachers and advocate for larger-scale change.
- ✓ Trade associations may assist by identifying current building practices and materials and providing skills training.
- ✓ Micro-lending bodies that couple loans with skills development training.

2. Conduct a stakeholder analysis

Each context will have its own set of actors with varying levels of engagement and interests. Several questions may help to identify other partners who can assist in providing information and resources, implementing activities, and ensuring the sustainability of the initiative:

- ✓ Who might share similar objectives, motivations, or needs?
- ✓ Who is already engaged in disaster risk reduction in the education sector and elsewhere?
- ✓ What leaders exist amongst those involved?
- ✓ Who else might benefit from more hazard-resilient schools?
- ✓ Who might be negatively impacted or mobilize against efforts to create more hazard-resilient schools?

The use of a stakeholder analysis tool such as the one illustrated here may facilitate the identification and analysis of these potential partners and the roles they may play.

Potential Stakeholder/ Partner	How are they involved?	What impact might they have? +/-	How interested/ motivated are they? +/-	What can the stakeholder provide?	What perceived attitudes or risks may be associated with stakeholder?	What responsibilities might they hold?
				Adapted from: (Zeynep Turkmen. ProVention Consortium ECA Coordinator/BU CENDIM)		

A thorough analysis will also prove helpful in forming a communications and knowledge management strategy that effectively delivers relevant information to decision-makers, implementers, advocates, and other partners at all levels. Likewise, it can serve to identify awareness-raising and capacity-building within the network of partners.

Partner Relationships

Don't forget to give attention to the existing and prospective relationships among the potential partners. A network of partners functions well when the internal relationships are strong and generative. One noted challenge for many initiatives is establishing ***a strong learning relationship*** between engineers and school communities. The quality of this relationship is essential, in which technical processes and requirements are clearly under-

stood by the school community and important functional requirements and valuable local information is effectively shared with engineers.

3. Set up a coordinating group

It is not within the scope of this document to provide detailed guidance on setting up a coordination group. However experience suggests that the inclusion of certain key partners can greatly influence the effectiveness and sustainability of a safer school initiative. School communities, qualified structural engineers, disaster risk management organizations, and relevant government bodies are featured based on their required expertise, existing involvement in the school construction process and their potential role in sustaining these efforts.

School communities

Schools, and the communities which they serve, are the direct beneficiaries of hazard-resilient school construction and retrofitting.

School communities consist of:			
• Students	• Administrators	• Local leaders	• Existing management committees
• Teachers	• Staff	• Local businesses	• Community disaster management organizations
• Parents	• Neighbors	• Local builders	

The potential damages and losses due to a hazard event are damages to their interests, and loss of their lives. School communities that understand the increased risk posed by unsafe schools and are actively engaged in reducing that risk can make extensive contributions by:

- ✓ Conducting assessment activities such as community-led vulnerability and capacity mapping
- ✓ Informing school design considerations such as locally available building materials
- ✓ Identifying local expertise
- ✓ Managing the procurement and construction process
- ✓ Conducting quality audits during the construction or retrofitting work
- ✓ Ensuring sustained maintenance of new or retrofitted school structures
- ✓ Making the school design, construction, and retrofit process into a permanent learning experience for the school and broader community
- ✓ Sharing knowledge and experience with neighboring school communities
- ✓ Advocating for large scale institutional change

Qualified engineers

The technical expertise of qualified engineers is required throughout each stage of the construction or retrofit of a school. Civil/structural engineers determine how various forces will affect a building and what is required for a building to resist these often powerful forces. Although engineers can be contracted to provide services as needed, it is advis-

able that at least one play a more permanent role within the coordinating body. The services of a competent structural engineer with a specialization or considerable experience in designing hazard resistant structures will:

- ✓ Help determine the extent and accuracy of assessment required.
- ✓ Approve a suitable site for school construction
- ✓ Conduct building assessments of existing schools
- ✓ Inform on technical feasibility and cost of retrofitting schools
- ✓ Provide guidance on the identification of appropriate building codes and retrofitting guidelines
- ✓ Approve the use of particular building materials
- ✓ Design a functional/structural plan for the construction or retrofitting of a school
- ✓ Approve architectural plan for new school construction
- ✓ Supervise construction or retrofitting implementation

Existing disaster management organizations

From the international to the local level, disaster management organizations coordinate efforts and provide policy guidance on mitigation, preparedness, response, and reconstruction. Partnering with these entities will help to situate hazard resilient school buildings in the broader scope of school readiness, response and recovery. Existing disaster management institutions can assist by:

- ✓ Establishing necessary linkages for sharing information and working together across, education, construction and risk reduction sectors
- ✓ Advocating for hazard resilient school construction and retrofitting policies at appropriate governmental levels.
- ✓ Organizing local regional or national training and awareness raising activities on

the value of hazard resilient construction and retrofit
- ✓ Locating and analyzing existing hazard, vulnerability, capacity, and prior damage assessment data
- ✓ Providing technical expertise for safe infrastructure design and construction
- ✓ Identifying leadership capacity or change agents

In addition, data, resources, challenges and successes during the project should be shared with disaster management organizations to further enhance their knowledge and capacity.

Relevant line ministry/department representatives and others partners
Planning, design, regulation and enforcement mechanisms are most commonly the ultimate responsibility of various government entities. Their representation:

- ✓ Enhances government-wide acceptability of the strategic plan, and allocation of resources.
- ✓ Helps establish an accurate assessment of the effectiveness of relevant existing mechanisms. These mechanisms, where effective, should be utilized.
- ✓ Creates opportunity for awareness-raising of cross-cutting disaster risk reduction issues that require the collaboration of multiple departments at multiple levels.
- ✓ Creates capacity building opportunities vital to mainstreaming disaster risk reduction measures in the education sector.
- ✓ Forms a base from which to advocate for a nationally-recognized platform, if one does not already exist.

Please see Appendix 3 for references on planning DRR projects

4.1.3 Key Points to consider

- ✓ Involvement of key and relevant partners, who have a stake in the education sector, provides positive synergy to the endeavor. A primary achievement of broad based involvement is the consequent sharing of information with all involved. It has been observed that greater involvement of stakeholders ensures enhanced transparency in the construction of schools.
- ✓ Engineering capacity – Most structural engineering schools and programs do not require the study of hazard resistant structural design. Identifying engineers with education and experience in assessment and design of hazard resilient buildings is essential to improving school safety. If it is necessary to engage international experts, pairing local and national engineers with these experts can build local engineering capacity. Training programs designed to educate a larger number of engineers are most effective when they include extensive hands-on learning activities.

Please see Appendix 3 for references to resources engineer training and sample terms of reference

- ✓ Fostering leadership – School and community leaders can help identify local organizations to formalize the school community's role throughout the process. Valuable leadership may be found in existing school boards, school management committees, community or school disaster management committees, and parent teacher student associations.
- ✓ If private and religious schools are to be addressed, a different approach may be required. One strategy is to establish incentive programs for private school owners that encourage hazard resistant construction and retrofitting.

4.2 DETERMINING RISK

What is the objective of this step?	To calculate an approximate measure of risk within a given geographical area in order to 1) identify where prospective new and existing schools will require more hazard-resilient features and 2) determine those existing schools in need of urgent intervention.
What is the purpose?	In order to focus efforts on preventing disasters rather than responding to them, it is necessary to estimate the potential damaging consequences and expected losses when an extreme event, such as a flood or earthquake, impacts a prospective or existing school population. Determining a measure of risk for a given geographical area will allow you to: ✓ Identify those schools which are at greatest risk of damage, harm and loss and set priorities for action. ✓ Create a basis for conducting more detailed site and building assessments. ✓ Develop programs and policies to execute these measures in the immediate and long-term.
How does this step relate to others?	This step introduces hazard and vulnerability assessments at a macro-level. Step 4.5 discusses the more detailed hazard and vulnerability assessment necessary to selecta site for new school construction. Step 4.6 discusses the more detailed vulnerability (structural and site) assessment of existing school buildings to determine whether a building should be retrofit and what retrofitting measures can be implemented.

4.2.1 Introduction

What is risk assessment?

Risk assessment, or risk analysis, is the process of answering the question, What would happen if a hazard event occurred? What would be the consequences of the event in terms of lives, health, Infrastructure and/or the ongoing school operations? Risk assessment estimates the nature and extent of risk by:

- ✓ Analyzing the potential hazards a school faces (**Hazard Assessment**),

- ✓ Identifying the school assets and determining their value.
- ✓ Evaluating the conditions which make a school population and valuable school services and assets more or less susceptible to the potential impacts of a hazard (**Vulnerability Assessment**).

What is hazard assessment?

Hazard assessment is the process of estimating 1) the likelihood of hazard events within a specific period of time, 2) and the intensity of these occurrences for a given geographical area.

What is vulnerability assessment?

Vulnerability assessment is the investigation into the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. A vulnerability assessment poses such questions as:

- ✓ How well would existing structures protect the lives and assets of the school?
- ✓ What are prevalent perceptions of a hazard and what can be done to mitigate risk?
- ✓ How has the community responded to past disasters and what indigenous mechanisms are in place to mitigate damage and loss?

What are some approaches to assessing risk?

There are several approaches to estimating risk. Two of the more common approaches are:

- ✓ Probabilistic assessments, which consider past statistics and historical information to estimate the likelihood of a hazard event of a given magnitude.
- ✓ Deterministic assessments, which rely on scientific understanding of the hazard in a given area to establish a worst-case event.

As risk assessment attempts to measure what might happen, there will always be a degree of uncertainty. Therefore a combined approach is often preferable. When insufficient data exists to determine risk using a probabilistic approach, it may be necessary to deterministically assess a worse-case event.

Please see Appendix 3 for references on resources on risk assessment

What are risk, hazard and vulnerability maps?

The map is a common and effective tool for representing the results of risk, hazard, and vulnerability assessments. Maps allow you to establish geographically 1) the frequency/

probability of hazards of various magnitudes or durations, 2) the schools which are exposed to these hazards and 3) the estimated vulnerability of these schools. There are several benefits to using maps to represent risk data:

✓	Hazard, vulnerability (e.g. building types and ages), and school location data can be overlaid on the map to help estimate the risk levels of different areas
✓	The clear visual representation of data, if kept simple, facilitates analysis and decision-making
✓	Maps are easily adaptable for public awareness and other educational purposes
✓	Maps of any scale (e.g. national, regional, local) and level of detail can be created based on intended use.

Please see Appendix 3 for references on resources on risk, hazard, and vulnerability mapping

4.2.2 How do you do it?

1. Identify hazards and their characteristics at a macro-level.

A. What hazard data is needed?

The very first task is to determine which hazards affect the school(s) in the geographic area under consideration. In many areas, a school may be exposed to more than one hazard. For example, a coastal region prone to cyclones may also experience flooding due to storm surge and a school built on the slope of a mountain in a seismically active area, may be exposed to landslides.

⚠ It is important to identify and assess each of the potential hazards. The most recent hazard event may not be the hazard which poses the most immediate or greatest danger

For each hazard, you will need to determine these four main variables:

1. Magnitude
2. Duration
3. Likelihood of occurrence
4. Affected Area

B. Where can you find existing hazard studies?

An ever-growing amount of data at global, national and sub-national levels is being collected with the advent of GIS systems, modeling software, and satellite imagery. Much of this data is publicly available. A good place to begin the search is with any national, regional or local disaster management organizations. Research institutes that study geological or hydro-meteorological processes and professional scientific and engineering associations are also likely to possess the hazard data you require.

If the data you need is not available from a single national, sub-national or local government source, other sources such as the health or industrial sectors, may have conducted hazard studies to better protect critical facilities such as hospitals or refineries. One question to pose is, "*Who else might have valuable assets or structures exposed to hazards?*"

Following is a list of other potential sources of existing hazard studies.

✓ Land use planning agencies	✓ Insurance companies	✓ Meteorological Department
✓ Structural engineers	✓ Architects	✓ Fire Department
✓ Environmental engineers	✓ Universities worldwide	✓ Geotechnical Agencies
✓ Public works departments	✓ Media records	✓ Hospital industry
✓ Government records	✓ Private schools	✓ Ministry of Education
✓ Ministry of Interior / Home	✓ Industrial sector	✓ NGOs and INGOs
✓ Agricultural Sector	✓ Health Sector	✓ Private Risk Management Consultancy Firms

A growing amount of data, collected internationally, is publicly available. The Global Seismic Hazard Assessment Program (GSHAP) and the Natural Hazards Assessment Network (NATHAN) are two examples of international hazard data and maps accessible via the internet. Online disaster databases, such as EM-DAT , inTERRAgate, and DesInventar, collect measures and records of past disasters for analysis.

Please see Appendix 3 for references to hazard data resources

While collecting hazard data, keep in mind:

Changing hazard characteristics–Is the data outdated? Recent research has shown that human interaction with the environment contributes to the intensity and frequency of certain natural hazards. Increased erosion of riverbanks and coastlines commonly effect flood areas and elevations. Global climate change, induced by such factors as increased population growth, reliance on fossil fuel technologies, and large-scale deforestation has led to average increased temperatures and sea levels (Bureau of Meteorology-Australia). In flood prone coastal areas, such a change may affect both the frequency and intensity of flooding.

C. How to organize the data

Existing hazard assessment studies may come in various formats, scales, and units of measurement. Compiling the data into a standard format of uniform scale and a standard unit of measurement will help to effectively compare hazard characteristics across the given geographical area.

For the purpose of determining risk, potential hazard events are commonly defined as a function of their magnitude and likelihood of occurrence. Thus a potential earthquake might be described as a 50 year - M7 earthquake. The United States Federal Emergency Management Agency (FEMA) suggests the creation of a matrix to represent risk. Table 3, illustrates a generic example of this. On one axis, hazard magnitudes or intensities are classified. On the other axis, frequencies are defined. Geographical areas are then assigned a risk level based on the approximate magnitude and frequency of a potential hazard event.

Table 3: Sample Magnitude - Frequency Matrix

Frequency	**Very high**	**IV**	**IV**	**V**	**V**
	High	**III**	**IV**	**IV**	V
	Medium	**III**	**III**	**IV**	**IV**
	Low	**II**	**III**	**III**	**IV**
	Very low	**II**	**II**	**III**	**IV**
		Low	Moderate	High	Very high
		Magnitude			

Another effective way to represent hazard characteristics and the potentially affected areas is by plotting this information on a map. Figure 3 illustrates a seismic hazard map of the Gujarat state of India. Where several hazards exist, maps of the same scale can be overlaid to quickly identify those areas facing multiple hazards.

Such maps can be important planning tools for future school construction. When overlaid with maps which identify vulnerabilities of existing schools, they can be an effective means of approximating risk of existing schools.

Please see Appendix 3 for references to resources on planning hazard assessments

2. Identify the location of schools

To identify the hazards to which a given school or prospective school is exposed and their potential magnitudes and likelihood of occurrence, you will need to determine the location of schools in question. If you are using hazard maps, school locations can be plotted directly on the hazard maps.

At this point, *if you are considering new schools*, you should have the necessary information to:

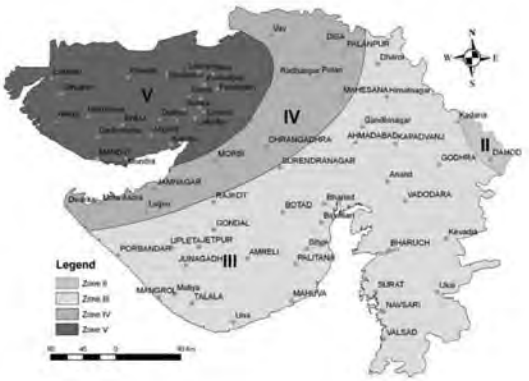
- ✓ Determine an approximate measure of risk of building a new school within the geographic area of consideration. Note: You will still need to conduct more detailed assessments when selecting a site. Site characteristics may greatly influence the

both the intensity and frequency of hazard events. Site-specific secondary hazards may also exist that require assessment before approving a school design.

- ✓ Identify an appropriate building code which will guide the design and construction of more hazard resilient schools.

If you are considering one or a relatively small number of existing schools and have the resources to immediately conduct detailed vulnerability assessments, you will not need to establish a prioritization schema. Step 4.6 provides guidance on conducting detailed school vulnerability assessments.

Figure 4: Seismicity Zoning Map - Gujarat, India



Source: Institute of Seismic Research, Govt. of Gujarat, India

If you are considering a large number of existing schools the following section will outline the iterative process of assessing the risk of existing schools and prioritizing them for retrofitting.

3. Determine risk of existing schools and prioritize for retrofitting measures

Where a large number of schools are being considered, conducting detailed assessments of each and every school in order to determine those schools at greatest risk may not be financially feasible. Adopting a transparent and technically-based prioritization schema, or risk screening plan, can help to quickly identify the most vulnerable schools.

Creating a prioritization schema based on risk

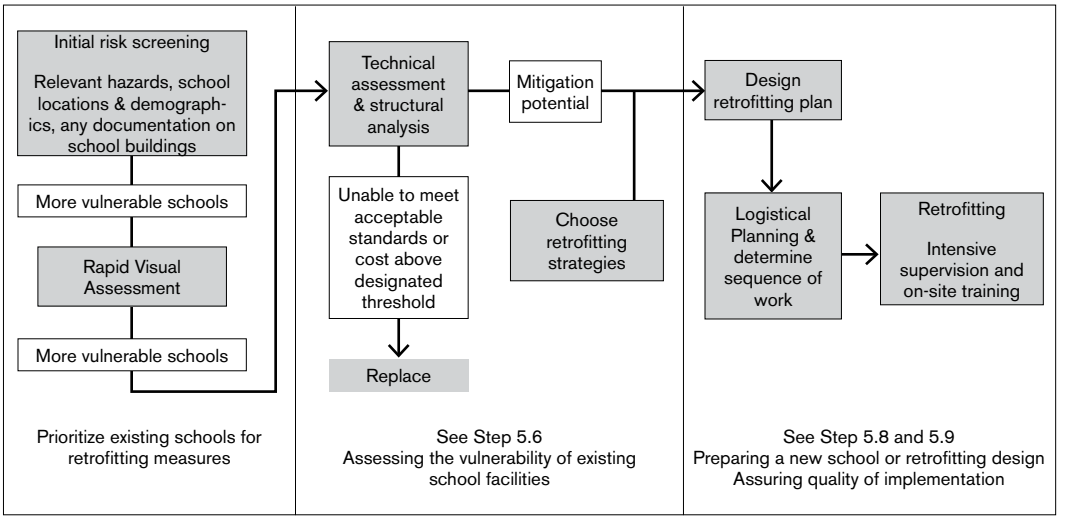
A general model:

- ✓ Begins with correlating the initial hazard assessment data, school locations, school populations, and the age and type of buildings. From this information you can determine those schools in high hazard zones with the most vulnerable buildings and the largest school populations.

- ✓ If further prioritization is required to meet resource constraints, a rapid visual assessment of the higher risk buildings can be conducted to select the most vulnerable buildings for detailed assessment. See appendix 3 for references to visual assessment tools.
- ✓ Finally, detailed assessments of these buildings will provide the necessary information to determine what mitigation measures can be taken (Petal, 2008).

Figure 5 illustrates the prioritization process within the larger retrofitting sequence of events

Figure 5: Example of Retrofit Workflow Diagram



Please see Appendix 3 for references on risk screening tools for prioritizing retrofit efforts

What other criteria might be considered when prioritizing existing schools

Other criteria may warrant consideration when prioritizing schools for retrofitting.

✓ Disruption of school operations	✓ Accessibility of hazard data
✓ Resource mobilization	✓ Site accessibility
✓ Political pressure	✓ Type of school (public, private, etc.)
✓ School calendar, occupancy	✓ Number of buildings and rooms

⚠ Avoid prioritizing schools based on a single hazard type within a multi hazard area (IFRC & the Provention Consortium, 2007). For example within a cyclone-prone area, one might choose to design a heavier roof to prevent roof blow-off. If this area is also prone to earthquakes, a lighter roof is preferable. In such a case, a solution must be found to account for the forces of both hazards.

NORTH PAKISTAN—Demonstration effect of retrofitting

As part of the Aga Khan Planning and Building Service, Pakistan (AKPBSP) Habitat Risk Management (HRMP) Program in Northern Pakistan, the HRM program initiated a public and private building retrofitting project, in collaboration with the Eastern Midlands Housing Association, in summer of 2008. The projects' aim was to promote earthquake resistant construction technologies and to build the capacities of local population. The objective was achieved through a community-driven approach that 1) implemented the structural and non-structural activities of seismic retrofitting (public buildings and houses); 2) re-constructed houses, 3) trained artisans in safe construction trades and 4) trained female youth in village mapping, land use planning and disaster management measures. As capacity building was a main focus of the program, one important criterion for the choice of locations was the potential for the dissemination of disaster risk knowledge and skills throughout the district.

The retrofitting of schools was included to propagate the seismic safety message to communities through children, who inevitably take information home and convince their parents who typically construct their own houses. In this way the initiative of making school safer against earthquake not only protects school children, but also educates communities to protect themselves and informs them of the local availability, and use, of the tools to do so.

In addition to the four schools, one health facility and 20 houses retrofitted to seismic standards, the project trained 23 builders in seismic resistant construction practices with four female youth trained in risk mapping exercises. As of January 2009, the project noted that, "The masons trained in the retrofitting works have begun a transfer of technology into their own work and replication of retrofitting techniques has been started in the area."

Source: Promotion of Earthquake Resistant Construction Technologies in Ishkoman/Ponial Valleys of Northern Areas, Pakistan: Project Completion Report. Courtesy of Aga Khan Planning and Building Services, Pakistan.

4.2.3 Key Points to consider

- ✓ Many interim measures can be initiated in schools awaiting retrofit work. School disaster preparedness and response training, and simple non-structural measures (such as re-hinging doors to swing away) all can make a school safer.
- ✓ For larger scale initiatives, this assessment can lead to the elaboration of an impact study of disasters on the education sector. Such studies can be powerful tools to advocate for support and policy development and can be undertaken with assistance of local consultants, universities or technical institutes.

Please see Appendix 3 for references on hazard impact studies on the education sector

- ✓ The data you have collected and compiled may be of great value to a variety of government agencies, organizations, businesses, and especially school communities. Disseminating this information widely can be an effective advocacy strategy and awareness raising tool.

CAMBODIA—Hazard impact study on the education sector

To build up evidence-based rationale for raising awareness on disaster risk reduction in the education sector and to advocate for new policies, practices and hazard resilient school construction, the Ministry of Education, Youth and Sports, the National Committee for Disaster Management and ADPC conducted a sector wide hazard impact study.

The study focused on the following points:

- ✓ Socio-economic and physical impacts of disasters on education sector
- ✓ Review of current practices in school construction
- ✓ Solution oriented recommendations to:
  - Minimize the social and economic impacts of disasters, especially on education sector;
  - Improve procedures and guidelines for school construction;
  - Identify specific opportunities to improve safety in school construction in pipeline projects over the following 3 years.

Source: http://www.adpc.net/v2007/IKM/ONLINE%20DOCUMENTS/downloads/2008/Mar/MDRDEducationCambodiaFinal_Mar08.pdf

4.3 DEFINING PERFORMANCE OBJECTIVES

What is the objective of this step?	To assign performance objectives for the mitigation of damage, loss and disruption to important school assets and services.
What is the purpose?	Defining performance objectives is a process of prioritizing important school assets and services and determining the maximum level of damage or disruption that can be tolerated for a hazard event of a given magnitude and frequency. These objectives become the safety standards a new school or retrofit design will attempt to achieve.
How does this step relate to others?	Designated performance objectives will inform: The analysis, selection, or development of building code or retrofit standards (Step 4.4) The selection of a school site (Step 4.5) The structural assessment of existing schools (Step 4.6) The design of a school or retrofitting plan (Step 4.7)

4.3.1 Introduction

What are performance objectives?

In a few cases, the risk posed to a school may be eliminated. Relocating existing schools outside of a landslide hazard zone is one example. Yet most often, siting a school outside

the hazard affected area is not feasible. In these cases, efforts must be made **to reduce** the risk posed by hazards. Performance objectives, in the context of hazard resilient construction and retrofit, are objectives which describe an **acceptable damage level** for a given building and a given hazard or hazards. Performance objectives set a goal for how a building will be designed to perform during and after a hazard event, given technical, financial and other considerations. They may be referred to as protection levels, safety levels, or acceptable risk levels.

⚠ **The minimum performance objective for any school should be to protect lives.**

4.3.2 How do you do it?

1. Identify school services and assets

Creating a list of school assets, services, and their relative importance, will help to systematically establish the maximum damage, harm and disruption that can be tolerated during and after a hazard event.

- ✓ The primary asset of any school is the school population. The school facilities such as classrooms and offices are assets. Other assets may include laboratory and computer equipment, the school electrical system and school records.
- ✓ The primary service a school provides is education. Schools may also be community centers and quite often they serve as shelters, or safe havens, during a flood, windstorm, or landslide.

2. Setting performance objectives for school assets and services

Performance objectives may vary somewhat based on hazard. Further research and advice from a qualified structural engineer will assist you to identify the appropriate performance objective variables. Three common performance objectives, relevant to most hazards, are Life Safety, Infrastructure Protection, and Continuous Occupancy.

Performance Objective	Description
HIGHEST: Continuous Occupancy (CO)	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. Any damage that occurs should be minimal, with no repairs required for school or shelter operational continuity (what is known as controlled damage). 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.
MODERATE: Infrastructure Protection (IP)	Damage to the structural system is acceptable so long as the specified assets are protected. It should be possible to repair any damage that occurs, at a reasonable expense and in a short period of time. (Records of costs of repair and construction of existing schools should provide sufficient estimations necessary to define acceptable cost criteria.)

Performance Objective	Description
MINIMUM: Life Safety (LS)	Damage to the structural and nonstructural components is acceptable so long as it does not endanger human life. Repairs may be expensive and interfere severely with school operations in the medium and even long term
	Adapted from (Guidelines for Vulnerability Reduction in the Design of New Health Facilities, 2004)

For each asset and service identified, an appropriate performance objective should be designated. Pay special note to services or assets which may be hazardous or harmful, life-saving or essential, or likely to cause panic or chaos during or after a hazard event. For example, if a particular school building is to serve as a storm shelter, the school community must be able to use it safely during and after the storm. Therefore, the building must be assigned the *Continuity of Operations* performance objective. Table 4 lists a sampling of assets and services for which you may want to consider a higher performance objective. The minimum performance objective should always be *life safety.*

Table 4: Sample of assets and services that may require a higher performance objective

Service or asset	MIN: LS	MOD: IP	HIGH: PO	
School administrative office		✓		Are there important documents or records which should be protected?
Hazard shelter			✓	If a building or entire school is to serve as a shelter it must remain functional throughout a hazard event .
Science laboratory		✓		Does valuable equipment warrant additional protection? Are chemicals stored which could create a secondary hazard?
IT laboratory		✓		Does valuable equipment warrant additional protection?
Cafeteria/kitchen		✓		Is there fuel-driven equipment which could possibly become a secondary hazard?
Toilets			✓	If school building is to serve as a hazard shelter, are toilets accessible? In flood-prone areas, flooding toilets can create a secondary hazard.
Other…				

The cost of implementing additional mitigation measures to meet a higher performance objective will vary. Consulting with an architect or structural engineer during the design process will help to estimate further costs.

Please see Appendix 3 for references on performance objectives and performance based design

4.3.3 Key Points to consider

- ✓ Fostering Community Ownership: Ideally all buildings would be constructed or retrofit to meet the highest performance objective, but this is often not technically possible, nor financially feasible. To reach consensus on the performance objectives, it is essential that the process be transparent, in which all groups involved understand the cost and technical constraints. Giving the school community a central role in determining the hazard resistant capacity of their school buildings can greatly enhance their sense of ownership.
- ✓ If a large number of new and/or existing schools are to be considered, you may want to set provisional performance objectives at an early stage in the process. This will be useful for budget planning purposes. Care should be given to ensure all partners understand the provisional nature of the performance objectives. Due to financial or technical design constraints it may be necessary to settle for a lower performance objective. Performance objectives should only be finalized during the design phase.
- ✓ The retrofit of existing schools to performance objectives higher than that of life safety can be costly and time-consuming. It is advisable to establish a performance objective of life safety for retrofit projects until structural assessments have been conducted and mitigation measures and associated costs have been proposed. If it is determined that a school building is to serve as a safe haven, it may be more economical to construct a new building on-site.
- ✓ Schools, commonly large and public buildings, are often used as shelters, both during and after violent storms. The provision of shelter is an important service the school can provide to the community. When planning such a service, it is essential to consider how school operations will continue when longer term community shelter is needed. In some cases, separate structures are created to serve both as shelters and temporary schools in the aftermath of a hazard event. For guidance on space usage for permanent schools and multi-purpose shelters used as schools, please see: http://www.ineesite.org/uploads/documents/store/Space_Planning_of_School_Buildings_and_Multi-Purpose_Shelters.doc.

4.4 ADOPTING BUILDING CODES AND RETROFIT GUIDELINES

What is the objective of this step?	To identify a set of building codes or retrofit guidelines that provide technical design and implementation guidance on making a school more resilient to hazards.
What is the purpose?	Building codes provide standards which define how to design and construct or retrofit a building to resist hazards of a specified magnitude and frequency. The design team will use these building codes to ensure that the school building meets the designated performance objectives for a given set of hazard characteristics. Building codes rarely address the challenges of strengthening existing buildings that do not meet existing standards. A set of retrofit guidelines, that details tested techniques to enhance the hazard resilience of a building, will help guide the design of an effective retrofit solution.
How does this step relate to others?	The building code may inform the suitability of a building site (Step 4.5). The building code will be used to determine appropriate hazard resistant requirements of a new school building which meet the performance objectives (Step 4.7). Retrofit guidelines will provide guidance on appropriate retrofitting techniques to increase the hazard resistance of an existing school (Steps 4.6, 4.7, and 4.8). The building code will be used to assess the quality of construction (Step 4.8).

4.4.1 Introduction

What are building codes?

Building codes are a body of rules which specify the minimum requirement a building must meet to ensure the safety and well-being of its occupants. Some building codes may provide detailed instructions that stipulate particular methods and materials, while others may only provide standards of varying specificity (See section 4.6.3 for discussion of prescriptive versus performance-based code). Not all building codes include standards for hazard resistant buildings.

Retrofitting and building codes

Although structural principles within a building code may be established to apply equally to the construction of new buildings and the retrofit of existing ones, building codes, by and large, are oriented to new construction. If guidance on retrofitting does exist, it may often be unclear and rarely provides the detailed criteria and instruction necessary to practically and economically retrofit a building.

What are retrofit guidelines?
Retrofit guidelines consist of detailed descriptions of techniques which can be used to make a building more resistant to the effects of a hazard. These techniques will vary based on the type of hazard and on the building typology. To meet the performance objectives designated for a given school building, the structural engineer must evaluate and adapt these techniques where appropriate.

4.4.2 How do you do it?

1. Determine if an applicable building code exists

Does a building code exist?
Building codes may be defined and enforced at a national, regional or local level. In many countries, such as the United States and India, it is the responsibility of state, district, or local governments to adapt a building code and enforce it. In such cases a national code may exist, but may not be enacted into law. In some countries a building code may not exist, or may exist, but not be enforced.

If a building code exists, does it accurately address hazard-resistant construction?
Not every building code specifies standards to construct a building capable of resisting hazard forces. You will want to carefully evaluate the code to determine whether the appropriate hazards are addressed.

It is equally important to determine how recently the building code has been updated. Effective building codes are continuously updated as scientists gather more detailed information on the characteristics of hazards and the effects they have on structures. In 1984, an earthquake of magnitude, 6.4

PERU—new standards

Between 1966 and 1996, 50% of the buildings damaged by earthquakes in Peru were educational facilities. Most of the damage was due to the poor lateral strength of short columns.

In 2003, a committee of professors and university students created an addendum to the building code to address this problem and to designate schools as essential facilities.

Due to the new addendum, buildings retrofit and newly constructed have evaded this structural failure.

Source: http://www.preventionweb.net/files/761_education-good-practices.pdf

INDIA–Government enforces nationwide adherence to national building code for school construction

In the case of India, construction regulation falls under the jurisdiction of state and union governments. Due to the failure of 27 state and union territories to meet appropriate fire safety requirements within their schools, the national government enacted a law that enforced a nationwide adherence to the national building code for all public and private schools.

Where measures prescribed by the building code are not met, responsible officials are subject to disciplinary action.

Source: http://eledu.net/?q=en/node/1474

shook the West Valley College gymnasium in California. Although built to the Uniform Building Code, instruments in the gymnasium's roof showed that it was so flexible that a slightly stronger earthquake could have caused extensive damage and potential harm to occupants. Because of this, the building code was revised in 1991 (USGS, 1996).

Does the building code specify requirements for locally-available and familiar building materials?
If the building code is prescriptive in nature, it may stipulate the use of specific building materials and methods. If the building code does not accommodate the use of locally-available materials, it may be worth reviewing other building codes as the procurement and delivery of materials can be both costly and time-consuming.

Is there any national or local guidance on retrofitting relevant building types?
Some building codes do provide useful guidance on retrofitting existing buildings that have been designed and constructed to meet building code standards. Additionally, national engineering societies, disaster management organizations, non-profit organizations, and universities may have developed retrofit guidelines appropriate to local building typologies.

2. If a suitable building code or retrofit guidelines do not exist, adopt or develop them.

If the official building code does not address hazard resistant construction or retrofitting, other sources, such as engineering institutes and professional associations, disaster management organizations, NGOs, and donor organizations may furnish, or recommend, an applicable building code or set of retrofit guidelines. Counterparts in other nations exposed to similar hazards may possess applicable codes as well. As part of a national action plan for safer schools, the government of Haiti has developed standards for safe school construction based on the Caribbean Building Code.

Other potential sources are insurance companies, trade unions or associations, vocational schools, engineering schools, as well as international and national industries.

Retrofitting guidelines are hazard and building type specific. Many are publicly available and can serve as valuable resources for determining appropriate techniques and developing context specific guidance training builders.

Please see Appendix 3 for references to resources on building codes and retrofit guidance

4.4.3 Key Points to consider

- ✓ Although nationwide institutionalization of hazard-resilient building codes can be a powerful tool to enhance school safety (see case study), where building codes are not enacted or enforced, the more immediate goal should be to identify and adopt appropriate building codes to meet the demands of safer school construction. Ministries of education can set standards for schools which enforce compliance to a set of building codes. Through the adherence to these codes and the inclusion of national and local architects, engineers and inspectors, schools can serve as examples strengthening the argument for national reform.
- ✓ Building codes can be prescriptive, performance-based or some mixture of the two. Prescriptive building codes provide detailed specifications, including materials and methods, required to meet safety standards. Performance/Objective-based codes are comprised of designated performance standards. The justification of how a given design meets these performance codes is the responsibility of the architects and engineers submitting the design. Table 5 lists some of the benefits and drawbacks of these code types. In many cases, both prescriptive and performance-based codes are used. Where the prescriptive code poses constraints and qualified engineers and architects are involved, performance

Table 5: Benefits and drawbacks of Prescriptive and Performance-based Code

Code type	Benefits	Drawbacks
Prescriptive Code	✓ Provide detailed instructions ✓ Require less engineering capacity	✓ Limit design possibilities (restricted building materials and practices)
Performance/ Objective-based Code	✓ Allows for innovative designs (materials, technologies, and methods approved by structural engineer). ✓ Commonly accompanied by more prescriptive compliance documents, suggesting appropriate methods and materials	✓ Requires greater engineering capacity for design approval and quality assurance

4.5 ASSESSING A SCHOOL SITE

What is the objective of this step?	To conduct a detailed assessment of site-specific hazard characteristics and any conditions that make a site more or less vulnerable.
What is the purpose?	The purpose of conducting site-specific hazard assessment is to uncover the interactions between local hazards and a particular environment in order to: ✓ select a site that accommodates the performance and functional objectives of a new school ✓ identify potential site modifications to reduce the vulnerability of an existing school
How does this step relate to others?	When retrofitting schools, an assessment of the existing school site is conducted in concert with the detailed assessment of the existing school buildings (Step 4.6). When constructing new schools, hazard characteristics and site conditions will inform the design process (Step 4.7).

4.5.1 Introduction

A school building's capacity to protect its occupants relies not only on the effective design of the structure, but on the environment in which it is built. A building designed and constructed or retrofit to meet hazard resistant standards may offer little protection to its occupants if it rests on a particularly vulnerable site.

Why is site selection important?

Landslides and mudslides: For hazards such as landslides and mudslides, reducing school risk is achieved by minimizing exposure to the moving mass through site selection. When exposure to a landslide or mudslide cannot be avoided through site selection, measures must be taken to reduce the likelihood of occurrence and the area affected. This involves modifying the site and its surrounding areas through measures such as slope stabilization strategies, drainage system development, or retention wall construction.

Figure 6: River floods a school after 2008 Typhoon Frank, Philippines

Floods: In the case of flooding, the selection of an adequately elevated site may eliminate a school's risk of flood damage or loss. When a suitably elevated site does not exist, modifications to the site such as adding fill to elevate the building and creating floodwalls or drainage systems can reduce potential damage and loss.

Earthquakes: Site assessment is essential when building or retrofitting schools in seismic zones. Although nothing can be done to decrease the magnitude, likelihood or affected area of an earthquake, measures can be taken to ensure that site characteristics such as soil composition do not amplify earthquake loads on a building. Careful site assessment will also help to identify secondary hazards triggered by an earthquake which can induce damage and loss, such as falling objects and liquefaction.

Windstorms: The likelihood of an extreme wind event is beyond human control, but the intensity can be reduced by selecting sites with natural wind barriers. Site assessment is crucial to identify secondary hazards, such as wind-borne debris, as well as conditions which may increase the intensity of an extreme wind event.

The school site also plays an important functional role in the teaching and learning environment. A location accessible to all children, located close to the community it serves, and with sufficient space for outdoor play can enhance learning opportunities. A good site assessment considers not only the safety level a school should provide, but also a site's capacity to meet functional requirements of a school.

4.5.2 How do you do it?

1. Identify who will conduct assessment

Land use planner: Where zoning laws and land use plans exist and are up to date, a planner will identify areas, such as flood plains or high risk landslide zones, which are unsuitable for construction.

Qualified Engineers: A qualified structural engineer must approve a site before it is selected for the construction or retrofitting of a school. Soil type, elevation, gradient, and vegetation are but a few characteristics of a

INDONESIA—"Fair but far"

Save the Children's (SC) Tsunami Rehabilitation and Reconstruction program Aceh and Nias, has 58 school buildings and built 68 new 'Safe and Child Friendly' school buildings. Upon a community and government request for the construction of a new safer school in a village of Aceh, SC sent a team to assess the proposed school site. A preliminary survey of the location found that the site was an unsettled area and a 15 minute walk on poor trails to the nearest village. When queried, the community leader explained that the primary school would serve four surrounding villages and therefore the site was located equidistant from all of the villages. After negotiation with the neighboring villages, one village was chosen to host the school. A suitable site, centrally located in the village was selected and the school built.

Courtesy of SC -USA/Construction Quality and Technical Assistance Unit

site and its surroundings which can influence the intensity and likelihood of a hazard event. Loose sub-soils in a seismic zone amplify the forces that an earthquake exerts on a building. The likelihood of a landslide increases when a mountainside is stripped of it stabilizing vegetation due to logging or farming. These influences and many others, all change how a hazard event will affect a building and what measures must be taken to minimize potentially damaging effects. The approving engineer may recommend the consultation of other specialists to perform specific tests.

School or education sector representatives: The representation of school district officials, teachers and students from nearby schools, or other education sector representatives will ensure that the appropriate functional school requirements are effectively considered in the assessment.

Local Residents: An equally important role in the site assessment process is played by local residents. They can provide detailed information on land use, topography, climatic effects, and other factors which influence a site's vulnerability. With a minimal investment in training and appropriate supervision, youth and adults in the community can assist in gathering hazard data through interviews or careful measurement of hazard indicators. Their role in assessing a site can serve as a valuable hands-on learning experience, engaging them to reflect on their risk and the measures which can be taken to reduce it.

2. Create site assessment guidance materials

Guidelines/checklist for preliminary site selection (for new construction)

The provision of land for school construction, particularly in rural areas, is often the responsibility of local government or the community. When local governments or communities are unaware of the many factors influencing a site's suitability, the land proposed may be unsuitable or, at worst, may increase a school's risk of damage and loss.

As many of the criteria do not require extensive technical expertise, providing guidelines and/or training to local residents or officials can assist them to propose school sites which pose less danger and are better suited to teaching and learning requirements.

Guidance materials may already exist in the form of school construction standards. Rwanda's Ministry of Education has developed a set of national standards and guidelines for 'Child Friendly' school infrastructure which includes criteria for school site selection. Many international organizations and education sector NGOs provide similar guidance. Section 5 of these guidance notes provides some very basic suggestions on selecting sites in hazard zones.

Please see Appendix 3 for references to various resources on school infrastructure standards

Strategy: Fostering Community Ownership

Participatory risk mapping is one of many activities designed to engage a community in the various assessment processes. These activities, when coupled with new knowledge, empower individuals to:

- ✓ Identify local hazards and their characteristics,
- ✓ Detect vulnerabilities within the school and its community,
- ✓ Recognize their capacity to reduce those vulnerabilities, and
- ✓ Contribute essential local knowledge and skills to the school construction or retrofitting effort.

Please see Appendix 3 for references on participatory hazard assessment activities.

Site assessment tool

The development and piloting of a more detailed site selection tool for use by the site assessment team will help to organize the collected data for future decision-making. This tool serves to:

1. Justify the site selection.
2. Identify site specific hazard sources and characteristics
3. Identify potential secondary hazards, their sources and characteristics
4. Identify site vulnerabilities
5. Propose and justify mitigation measures
6. Discuss logistical implications for construction.

⚠ **It is important to note once again that the final selection of a site must be approved by a qualified structural engineer with hazard-specific expertise or experience.**

3. Conduct site assessments

A site assessment begins with a review of the existing risk assessments and the provisionary performance objectives. The existing risk assessments will provide a baseline from which to determine site specific hazard characteristics and vulnerabilities. The performance objectives will serve as key standards for determining a site's suitability. A school intended to serve as a shelter or safe haven may require additional criteria for assessment.

Figure 7: Creating Hazard Maps - Caribbean Disaster Management Project

Photo Courtesy of and copyright to JICA. Retrieved from : http://www.mofa.go.jp/POLICY/oda/white/2005/ODA2005/html/honpen/hp102010000.htm

Site-specific (micro level) hazard assessment

The characteristics of a hazard may vary greatly from site to site. For each hazard a site faces, the magnitude, likelihood of occurrence, and affected area must be determined so as to ensure that the designated mitigation measures assure the level of safety designated by the performance objectives. In general, sites in high risk areas will require more detailed studies. Consultations with geological and hydro-meteorological experts will help to determine the extent of studies required. For more regularly occurring hazards such as seasonal floods, much of the information required can be provided by local residents. Historical records and accounts by landowners, local residents and officials will provide valuable indicators of past events which will help to determine the local hazard characteristics.

Whether considering new construction or retrofit, a soil investigation should be conducted to determine the soil bearing capacity and the water table level. Other ground-related tests, relevant to identified hazards should also be conducted (e.g. pore-water concentration in mudslide zones).

Site vulnerability assessment

It is not within the scope of these guidance notes to propose detailed guidance on identifying those features which make a site more or less vulnerable to hazards. Criteria for determining a site's vulnerability vary greatly depending on hazard types, topography, geological and climatic conditions, land use, and the existing built environment. However, Table 6 lists several generic questions a site assessment should consider.

Table 6: Site vulnerability considerations

Site vulnerability questions	Sample sub-questions
What site characteristics make a site more or less vulnerable?	✓ Is the sub-soil sufficiently dense to prevent liquefaction due to an earthquake? ✓ Is the water table deep enough to prevent water-logging and ensure timely drainage? ✓ Do natural wind blockades exist to diminish wind loads on school buildings? ✓ Has the slope been stripped of vegetation by logging or farming, thus making it more susceptible to a mudslide?
Would the site and surrounding area expose the school to secondary hazards?	✓ Are there any industrial facilities or chemical plants which might accidentally release toxic materials during a flood? ✓ Are there nearby vulnerable structures which might fall and potentially damage a school in the event of an earthquake? ✓ Has the site experienced storm surge flooding during coastal wind events?
Is the site easily accessible?	✓ Can effective and safe evacuation routes be established for the entire school population, including those with special needs? ✓ Can emergency response personnel access the school during or after a hazard event? ✓ If a school or school building is to serve as a shelter or safe haven can the population access it?
What will be the effects of future development at the site and in surrounding areas?	✓ Is there sufficient space for future expansion without increasing the school's vulnerability? ✓ Will future land use or development in surrounding area pose greater risks to the school?

Please see Appendix 3 for references to various resources on site assessments in hazard prone areas

Determine if the site meets functional school requirements (for new construction)
Even the least vulnerable site may not be suitable if it does not meet the functional requirements of a school. Pay careful attention to any factors which might enhance or limit access to the prospective school facilities and the quality of teaching and learning.

Please see Appendix 3 for references to various resources on school site selection

Propose mitigation measures for consideration during the design process.
While at the site, it is advantageous to discuss potential mitigation measures. Key considerations for mitigation measures are technical feasibility, resource availability, sustainability, cost and time. It is advisable to solicit proposals from representatives across the com-

munity. Indigenous measures, when appropriate, are often cost-effective and sustainable (see case study on indigenous flood mitigation measures in Papua New Guinea).

4. Evaluate existing building types and local building capacity

Hazard-resistant design that is based on known and locally available materials and local building capacity has the potential to:

- ✓ Minimize initial costs - The use of locally available materials is typically less costly and builders are already familiar with many of the properties and applications of these materials.
- ✓ Increase sustainability – School buildings are more likely to be maintained when the skills and materials required to do so exist locally.
- ✓ Be taken up by local builders for application in local residences and other buildings.

In order to determine whether existing materials and technologies (i.e. how the materials are used) can be incorporated into the hazard resistant design of a school and to assess local building capacity, you will need to evaluate:

- ✓ Properties of the materials, such as strength and durability to resist the forces of identified hazards. Desired building material properties will depend on the hazard and can be determined by a structural engineer.
- ✓ Capacity of building technologies to resist the forces of the identified hazards.
- ✓ Building practices and rationale for the use of building materials and technologies. The reasons why builders and designers choose to apply particular methods or use certain materials may be due to cost, availability, technical know-how, cultural values, and sometimes misconceptions. These are valuable considerations which will inform the school design and can provide a baseline for developing local builder capacity.

4.5.3 Key Points to consider

- ✓ A clear and shared understanding of the relative importance of hazard-resistant requirements and school functional requirements will help to negotiate the various compromises you will need to make when assessing a site.
- ✓ Where land typically serves as a community's livelihood, it may be the least valuable piece of land that is donated for the school. Quite frequently it is also the least accessible and the least suitable site with respect to local hazard characteristics. In addition to providing guidance to a community on choosing suitable sites, it may also be necessary to consider compensatory measures when suitable sites may serve as someone's livelihood.
- ✓ Awareness-raising - Sharing the results of the site assessment with the local population is an excellent awareness-raising opportunity which may foster continued

engagement in the school construction/retrofitting process.

- ✓ Including local builders in the preliminary and more technical aspects of site assessments may be a good training opportunity. These builders may eventually be responsible for the retrofit/construction and maintenance of the school buildings. Establishing relationships early in the process will facilitate future collaboration.
- ✓ Vernacular building practices and materials, sometimes regarded as inferior, "can tell us how people in the past confronted the problem of creating structures in which to live and work under the influence of adversities such as shortages of wood, stone, or clay, and threats such as wind, water, and, of course, the most extreme threat of all – large earthquakes" (Langenbach, 2000). The use of vernacular technologies has a number of advantages, but poses many challenges as well.

PAPUA NEW GUINEA—Indigenous flood mitigation measures

Living alongside the banks of one of PNG's major rivers, the Singas community is constantly under threat from flooding.

The community had been told to move their settlement away from the river banks to higher ground in the hills, as part of a 'top-down' solution to their problem of flooding. However, they never moved. The river was valuable for their livelihood, they were close to amenities, and they had resided there for years, coping with previous floods. The Singas community manages their risk in the following ways:

1. They build large mounds of rubbish over a period of time, cover these mounds with soil, and stabilize the soil with plants. Atop the mounds, they build houses on stilts made from local wood. The Singas construct their houses during the dry season to allow the buildings to settle before the rains arrive.
2. High elevation areas are located and marked as safe areas to which the community can evacuate.
3. The Singas have hand-dug drainage systems which divert flood waters away from fields and other important assets.
4. Vegetation is planted around homes to further stabilize the soil.

Source: http://www.unisdr.org/eng/about_isdr/isdr-publications/19-Indigenous_Knowledge-DRR/Indigenous_Knowledge-DRR.pdf

Advantages	Challenges
Locally available resources decrease cost	Rarely represented in building codes
Culturally relevant buildings increase ownership	Evaluating production characteristics to ensure compliance with building code can be time-consuming
Existing skills minimize training needs and cost	

4.6 ASSESSING THE VULNERABILITY OF EXISTING SCHOOL BUILDINGS

What is the objective of this step?	To conduct a detailed vulnerability assessment of the structural and non-structural components of an existing school in a hazard prone area.
What is the purpose?	A detailed vulnerability assessment of the school facilities is conducted to: ✓ Identify the buildings' vulnerabilities with respect to local hazards, ✓ Determine whether to retrofit or reconstruct the buildings, and ✓ Propose appropriate retrofit strategies to enhance the buildings' hazard resistance.
How does this step relate to others?	Figure 2 on page 22 illustrates the larger workflow of the assessment, planning, design and implementation of a retrofit effort. The process begins with preliminary assessments for prioritization (see step 4.2), followed by a site assessment (see step 4.6) and detailed structural assessment and ending with the design, planning and implementation of the retrofit measures (see steps 4.8 and 4.9). Note, the site assessment (step 4.6) and the detailed structural assessment can be conducted simultaneously.

4.6.1 Introduction

In order to accurately estimate the risk of an existing school and propose effective mitigation measures, a thorough vulnerability assessment of the structural and non-structural components of a school's facilities is required.

4.6.2 How do you do it?

1. Identify who will conduct the building assessment

Qualified engineer: The expertise and experience of a qualified structural engineer is required to coordinate the assessment, determine necessary tests, and propose potential retrofitting strategies.

School community representatives: Involving the school community, specifically students and teachers who use the building regularly, will help to identify how specific components were intended to be used and, more importantly, how they are actually being used. Likewise, school communities can furnish drawings and descriptions of schools which identify: damages induced by previous disasters, visible indications of weakness (e.g. cracks, dampness, etc…), and a history of issues, maintenance and repairs.

Local builders: Often, a building's deficiencies may not be visible. Local builders can provide valuable insight on the quality of materials and techniques used to build the school. In

Figure 8: Earthquake induced cracking on this school in Rwanda

Courtesy and copyright of UNICEF Rwanda

addition, the identification of school vulnerabilities and potential mitigation strategies can be an excellent training opportunity, particularly for those builders who will participate in the retrofit implementation.

2. Establish criteria to determine whether to retrofit or reconstruct

The primary purpose of conducting a detailed structural assessment is to determine the potential weaknesses of the building and identify the most appropriate measures to strengthen it. In some cases, relatively few measures will be required to meet the performance objectives. In other cases, the conditions of a building might require a costly and time-consuming solution to increase its hazard resistant capacity. Where the cost and time reach a given threshold, reconstruction may prove a more effective and efficient solution.

Cost and time may not be the only criteria upon which you base this decision. The Istanbul Seismic Mitigation and Emergency Preparedness (ISMEP) project, partially funded by the World Bank, considers four criteria when determining whether to retrofit or reconstruct a school: financially affordable, economically justifiable, technically feasible, and socially acceptable (Presentation at INEE Global Consultation, April 3, 2009). Three of these criteria are elaborated below.

Cost: Cost is commonly the deciding factor in determining whether to retrofit or reconstruct. The aforementioned ISMEP project set a cost threshold to facilitate their decision-making. If the cost to retrofit the building was over 40% of the cost to reconstruct, the school was demolished and rebuilt (Presentation at INEE Global Consultation, April 3, 2009). In addition to materials and labor, you may want to consider several other related variables when estimating and comparing costs.

- ✓ Reconstruction may require demolition of the building and the removal of rubble
- ✓ The cost of a building includes both capital and recurring expenses. In comparing cost, be sure to calculate the recurring expenses, such as maintenance and repair, both for a retrofit and reconstructed school.
- ✓ If other school renovations are to coincide with retrofitting, these costs should be considered.

Social acceptance: If the safety benefits of retrofitting a building are not understood, this option may not be considered desirable by the school community. Awareness-raising activities amongst the broader school community and the inclusion of school and community representatives throughout the building assessment may help to cultivate a better understanding of the advantages of retrofitting. Support may also be raised when other identified repairs or renovations to the school are undertaken along with the retrofit measures. Some buildings may have a high cultural or historical value and it may not be socially acceptable to replace them. In such cases, extra cost and effort may be justified to save these schools from demolition

MYANMAR—School serves as model

A joint Save the Children UK/Development Workshop France Safer School Project (SSP) in Myanmar focuses on clusters of villages. The project objectives are to develop skills and risk reduction techniques within the communities by using school retrofit projects as models.

A public two-day participatory hands-on workshop is held in a host village to identify causes of cyclone damage to buildings and demonstrate ten techniques to strengthen buildings. Students draw pictures of their strengthened school based on these techniques and local leaders, builders and other participants discuss strengthening measures to be applied to the schools. After the workshop and with the supervision of two trained engineers and an architect, local builders from each community apply these strengthening techniques to the school buildings. An opening day celebration is hosted and a bamboo model structure is used to demonstrate how communities can strengthen their homes and other buildings.

Individuals from villages without a school requiring retrofitting have even attended, in hopes of learning how to strengthen their homes.

The SSP found that through risk and resource mapping, school-going children, working children and adults are able to determine what resources they have available to them. All of the villages in which these activities were piloted have referenced the school as a resource. Now the communities see it as a (physically) safe learning environment and a place of refuge. Combining the strengthening of schools with children's involvement in risk reduction provides a holistic approach to assisting communities feel more confident and safe in their village.

Source: http://www.dwf.org/blog/documents/SSP_DWF_Myanmar.pdf

Technical feasibility: The detailed structural assessment will determine the technical feasibility of retrofitting the building. Factors for consideration are the level of damage, the quality and condition of materials and building components, and whether the building type can be retrofit to an acceptable level of safety.

3. Develop assessment materials and training for school community

Community assessment tools and training

A minimal investment in training and awareness-raising will help to ensure wider public support amongst the school community. The use of school and community-led vulnerability assessment tools can be an excellent way to gather valuable information about the school buildings, their history, and use, while cultivating a growing awareness of local hazards, vulnerabilities, and the local capacity to reduce risk.

Please see Appendix 3 for references on school, community and child led risk assessment tools

4. Conduct detailed assessment

The detailed vulnerability assessment is conducted to identify the specific deficiencies of the school facilities and surrounding environment with respect to the relevant hazards.

Determining vulnerability categories: The vulnerabilities of a school will differ based on the types of hazards and their expected intensities and frequencies of occurrence. Vulnerability categories should address the conditions of the building, its components and materials, the foundation, the ground composition, site characteristics and potential hazards posed by the surrounding environment.

Identifying deficiencies: Deficiencies are those characteristics of the school facilities or site which prevent the school from meeting the performance objectives. For each vulnerability category, visual assessments and tests, determined by the structural engineer, are conducted to identify the specific deficiencies. Soil analysis, compression strength tests, and concrete composition analyses are a few examples. University engineering departments with appropriate testing facilities may be excellent potential partners during the school vulnerability assessment.

Propose retrofit strategies to address deficiencies and meet hazard safety objectives: While at the site, it is advantageous to discuss potential retrofit strategies. Key considerations are technical feasibility, resource availability, sustainability, cost, and disruption of school services. Retrofitting strategies proposed by local builders and school communities can provide new perspectives based on valuable knowledge of local hazards, building materials and methods, and usage of the school facilities.

Identify other necessary repairs and renovations to improve teaching and learning environment: When conducting the detailed vulnerability assessment, it is important to consider not only the hazard resistant capacity of a structure and its environment, but the functional capacity as a learning environment. Functional features and their importance should be identified for both structural and non-structural components.

Please see Appendix 3 for references to various resources on school infrastructure standards

Investigate capacity and constraints to implementing a retrofit plan: In addition to assessing the conditions of a structure with respect to relative hazards, the team should also identify any capacities or constraints which will influence retrofit activities. Such constraints and capacities should include, but are not limited to, site accessibility, local availability of required retrofit materials, and local building capacity. See section 4.6.2.4 for further detail on assessing building materials and local builder capacity.

4.6.3 Key Points to consider

- ✓ Awareness-raising: One of the greatest challenges to retrofitting efforts is a lack of understanding of the excellent results it can produce. One very effective means of conveying the benefits of retrofitting is through demonstrations. Mini shake-tables have been used effectively in Nepal to demonstrate the effects of an earthquake on ordinary buildings and earthquake resistant buildings. See Figure 9.
- ✓ Awareness-raising: Structural and site assessments can be valuable learning experiences for school communities. Clearly indicating and explaining the weaknesses and strengths of the school buildings can provide useful criteria for evaluating homes and other buildings within the communities. The creation and dissemination of pictorial guidelines that illustrate these vulnerabilities and feature simple strengthening measures can help to spread hazard resilient building practices from the school into the community and have been effectively applied in construction support programs in Nepal (NSET), Vietnam (DWF) and China (Build-Change). For an example of such guidelines, see Figure 10. Other examples can be found in Appendix 3.

Figure 9: Shake table demonstration during National Earthquake Safety Day in Kathmandu, Nepal

Photo courtesy of and copyright of NSET, Nepal

Figure 10: Making Schools Safer from Future Eartquakes Poster–Earthquake Safe Communities in Nepal by 2020

Courtesy National Society for Earthquake Technology - Nepal (NSET)

4.7 PREPARING A NEW SCHOOL DESIGN OR RETROFITTING PLAN

What is the objective of this step?	To design a new school or retrofitting plan that satisfies the performance objectives and school design criteria.
What is the purpose?	Hundreds of years of scientific research and testing have resulted in a much greater understanding of the forces of nature and how structures can be built to resist them. The purpose of designing a hazard-resistant school or retrofitting plan, is to utilize this knowledge to create structures more capable of resisting the powerful forces hazards exert on buildings.
How does this step relate to others?	This step will produce the design, estimated time and costs, and all necessary documentation required to begin the construction or retrofitting of a school (Step 4.8).

4.7.1 Introduction

The design of a new school or retrofit plan is the culmination of all the assessment and planning undertaken. It is both a process of creativity and negotiation. The many tradeoffs required to produce an acceptable design will benefit from:

- ✓ An uncompromising intent that all design requirements and considerations are understood by all parties;
- ✓ A willingness to compromise to reach consensus; and
- ✓ An open environment that encourages the proposal of new and different solutions.
- ✓ An ongoing effort to ensure the wider school community is aware of the design considerations and is well represented throughout the process.

4.7.2 How do you do it?

1. Determine roles within the design process

The design process involves three functional teams:

- ✓ Management team
- ✓ Execution team
- ✓ Quality assurance team

The role of the ***management team*** is to define the school design requirements, manage the overall design process, and provide the assessment reports, building code, and any other physical, technical and financial resources. As the design process is the realization of the envisioned school, the management team should include representatives of the various stakeholder groups, particularly the school communities.

The role of the ***design team*** is to define the design criteria, (based on the performance objectives, the assessment results, and the building code) and design the structural and

architectural plans. The design team is also responsible for the preparation of construction documents, inspection guidelines, operating standards, and maintenance procedures. The design team, at a minimum, should consist of a certified architect and a structural engineer.

The role of the ***quality assurance team*** is to ensure that the design criteria and the preliminary and final plans meet the required performance objectives and the building code requirements. The quality assurance team should consist of at least one structural engineer familiar with the building code and possessing design experience with respect to the relevant hazards.

2. Compile and analyze design considerations

During this decision-making phase, the architect, structural engineer, and management team discuss the measures necessary to meet the performance objectives as well as the school functional considerations.

Review performance objectives, assessment reports, and standards

A careful collaborative review of the performance objectives, assessment data, and the appropriate site or structural assessment reports will facilitate the establishment of the final design criteria. During this review the design team should identify any general constraints or opportunities identified in the assessment reports and posed by the building code or retrofit standards.

Performance Objectives: The performance objectives are the ultimate safety criteria which the design is intended to achieve. The performance objectives and their justifications should be thoroughly discussed and agreed upon by all those participating in the design process. Site, structural, financial, resource or other constraints may necessitate a revision of the performance objectives. All performance objectives must, at a minimum, protect lives.

Assessment Data: The hazard characteristics and site and structure vulnerabilities provide the information necessary to effectively apply the building code and retrofit standards in order to meet the performance objectives. Any mitigation measures proposed in the site or structural assessments should also be discussed.

Building Codes and retrofit guidelines: The design and quality assurance teams should be familiar with the appropriate sections of the building code or retrofit guidance. If these pose important constraints to other design factors, the management team will need either to reprioritize the design requirements or work with the design team to identify an alternative solution.

Design Life: An essential criterion when designing a building is its intended lifespan. Design life is the projected period in years for which a building is expected to meet the designated requirements if proper use and maintenance are ensured. A common design life is 50 years. The designated design life of the building will influence the selection of appropriate building materials and technologies and the capital and recurring costs.

⚠ **SIMPLICITY!** Complicated designs are much more difficult to ensure structural integrity and tend to cost a lot more. Simple designs require less builder training and engineering expertise, they are more easily maintained, and they demonstrate techniques that can realistically be transferred to houses and other local buildings.

Some particular considerations when designing retrofit solutions

A retrofit plan, unlike a new school design, must take into account the conditions and characteristics of an existing building and the demands of integrating new components into its structural system. As the existing system may not have been constructed to meet building codes, retrofitting plans should begin with the minimum performance objective of life safety, and only when feasible should other performance objectives be considered.

As it may not be possible to accurately assess the resistant capacity of all of a building's materials and components, the development of effective retrofit solutions may rely largely on the design team's experience and judgment in applying appropriate techniques. This is particularly the case when retrofitting buildings to resist earthquake forces.

Therefore, consideration should be given to other design criteria, but no safety measure should be forfeited at the cost of incorporating other non-safety related features. At the same time, repairs and renovations which meet identified needs of the school community and enhance the aesthetic quality of the building, without jeopardizing its safety, can help to foster community support for retrofitting.

Define design criteria

Defining the design criteria is a decision-making process in which the performance objectives and all other criteria are prioritized and considered with respect to cost, feasibility and any other constraints. It is the responsibility of the management team to define the design criteria. It is the role of the design team to provide initial guidance on the technical feasibility, estimated cost and potential timeframe necessary to meet the proposed criteria. A transparent discussion of expectations, constraints and opportunities will help to foster constructive participation throughout the design and implementation stages. Figure 11 outlines several key design criteria to consider.

Figure 11: Key design criteria for consideration

Capacity of skilled workforce: Designs incorporating hazard resistant features that build on existing workforce skills and employ familiar and accessible materials can be more easily adopted by local builders. When builders understand the added value of these features, hazard resistant technologies can become a marketable skill and be applied beyond the school. In addition, school maintenance is more sustainable when the required skills and materials are locally available.

Please see Appendix 3 for references on alternative building materials and hazard resistant design

Availability of materials: In addition to facilitating future maintenance of a building, specifying locally available materials in the design can greatly decrease the cost of transporting materials to remote school locations. Transport costs may be so high that it becomes preferable to simplify the design in order to employ local materials and still meet the performance objectives.

Teaching and Learning: Safer schools are not just shelters, but functioning learning environments. Any school space should reflect the pedagogy embraced and stimulate learning and teaching. A review of current teaching and learning practices and careful consultation with school personnel, students, and education specialists will help to identify these requirements. This may also be an opportune time to discuss design implications on new education initiatives, such as multi-grade or double shift pedagogies which may not benefit from more traditional designs built to accommodate a teacher-centered learning style. For retrofit plans, understanding these requirements will help you to identify mitigation measures which comply with these requirements. Non structural components such as furniture, chalkboards, laboratory and sports equipment should be considered. Where school infrastructure standards exist, they can provide valuable design guidance.

Please see Appendix 3 for references on design criteria for teaching and learning environments

Cultural Values: School buildings that reflect a community's values or identity are less "foreign". "Familiarity" of a building may not only enhance community ownership of the building but improve the learning environment.

Latrines and Drinking Water: Schools should be designed to have latrines and drinking water accessible to the entire school population. Consideration should be given to ensure that latrines remain functional and do not pose a secondary hazard in the event of flooding. Separate latrines should be designed for males and females.

Access & Evacuation: Depending on the hazards to which a school is exposed, appropriate response procedures may entail evacuation of the building. The sudden onset of an earthquake or flash flood can cause panic, especially if appropriate response training has not been conducted. This

Continues

Figure 11: *(Continues)*

can lead to unpredictable behavior and potential blockage of an exit. A design rule of thumb is that each space should have a minimum of two evacuation points. It is equally important to ensure that these exits lead away from potentially dangerous environments and are accessible to individuals with special needs.

Accessibility for Special Needs: Design requirements should include accommodation for all students, school personnel and visitors including those with visual, audio or mobility impairments. Features such as door widths, walkways and ramps should be designed to accommodate all members of the school population and provide "barrier-free" access to the learning environment and evacuation to safety.

Please see Appendix 3 for references on inclusive school design

Internal Environmental Factors: Physical discomfort is a proven obstacle to learning. Attention should be given to internal temperature and lighting when choosing construction materials and positioning windows and doors. If electrical lighting or temperature control systems are to be installed, these must be detailed within the plans and meet the performance objectives.

Environmental Impact: Certain building technologies and materials can contribute to the deterioration of the environment. Much of the risk of landslides can be contributed to uncontrolled logging on mountain slopes, and development of many coastal areas has resulted in the deterioration of sand dunes that serve to deter erosion. Consideration should be given to the source, composition and expected life span of building materials as well as the energy efficiency of the design.

Conflict zones: In conflict areas, schools may be targeted for large or small-scale attacks. In many areas, school children are abducted from schools and forced into military service. Schools in these areas should be designed to protect students from abduction and attacks and consideration given to creating a less conspicuous structure.

Future School Development: If the future development of schools is envisioned, this must be reflected in the design and positioning of school buildings. Special attention should be given to ensure sufficient space between buildings

3. Review existing plans (for new construction only)

A good point of departure for developing appropriate designs is the review of existing school designs. Within the collection of designs may be found one or more designs which meet, or require only a few modifications to comply with, the building codes and school functional design requirements. Beyond the government there are a broad number of entities which contribute to the education sector through the construction of schools. It may be worth collecting these plans as well.

4. Develop a design

Schematic, or concept, plan

From the defined design criteria, the structural engineer and architect develop a plan which defines how the design criteria will be met. If certain criteria cannot be met, justification for their exclusion should also be furnished. This plan should not focus on details, but provide a broad overall understanding of the design and include an overall cost estimate. For retrofitting efforts, it is preferable to provide several potential solutions with respective cost and time estimates.

⚠ *Funding:* If funding for implementation has not yet been secured, it is typically at this stage that a plan is developed to solicit funding. In 2009, the government of Haiti received a 5 million dollar grant for emergency school reconstruction. One of the key deliverables is a National Action Plan for Safer Schools. This plan, developed by the Ministry of National Education and Professional Training, in collaboration with other partners, will serve to secure future funding for wider scale school construction and retrofitting (World Bank, 2009).

It is presently outside the scope of this document to discuss strategies for acquiring funding. However several references to resources can be found in Appendix 3.

Please see Appendix 3 for references on financing safer schools

Full detailed Plan

Once the schematic design is approved by the management and quality assurance team, a detailed design plan is created. The quality assurance team must approve each structural and non-structural component of the design, and rigorously review the materials and methods specified to ensure these meet the designated performance objectives. An updated and detailed estimate of costs required to implement the design should also be prepared.

Figure 12: Seismic Resistant School with safe play area in Aceh, Indonesia

Photo Courtesy and copyright of SC-USA/Construction Quality and Technical Assistance Unit

5. Create construction documents

Essential to the design process is the development of documents to guide the construction, supervision, use and maintenance of the school building. The following documents should be prepared:

Construction/Retrofitting guidelines: The construction or retrofitting guidelines provide detailed instructions on the materials to use and how they are to be used to meet the design specifications.

Inspection guidelines: The inspection guidelines define the stages at which inspections should be conducted and the criteria for approval.

Operational manual: The operational manual indicates how a building should or shouldn't be used (e.g. maximum capacity) in order to ensure it functions as designed. Included within the operational manual should be instructions on preventing damage and loss due to non-structural components of the building (e.g. book shelves, desks, etc…)

Maintenance plan: The maintenance plan determines how and when the building and its components should be assessed and replaced or repaired.

6. Define a schedule and sequence of work (for retrofitting or reconstruction).

As retrofitting and reconstruction can potentially disturb normal school operations and expose students to construction hazards, a work plan should be developed with school officials to minimize disruption. Several strategies that have been tested are:

- ✓ Scheduling work outside of operating hours, such as during evenings, weekends and school breaks.
- ✓ Rescheduling school operations to accommodate work
- ✓ Transferring students to neighboring schools
- ✓ Erecting transitional school structures

If extensive work is required to retrofit a larger school, an incremental approach can be taken. Incremental retrofitting is the process of dividing the work into manageable stages over a longer period of time (FEMA 395, 2002). These stages can be prioritized; identifying more vulnerable elements for initial treatment. Although this strategy does minimize disruption and spread costs out over a long period of time, it does require longer term planning and is not recommended for highly vulnerable buildings.

Please see Appendix 3 for references on retrofitting

4.7.3 Key Points to consider

✓ Make the school construction or retrofit into a permanent learning experience for the community

From assessment to future maintenance, each phase of a hazard resilient school construction or retrofit project provides powerful learning opportunities that can serve not only the school, but the broader community. Suggested below are several strategies to engage the school and community

- Identify school principal or other school-based individual as designated bridge to make the school construction process a learning process for all stakeholders in the local community, including children, parents, staff, local government and the local skilled workforce, in particular.
- Use blow-up illustrations of design options to involve school community in design decision-making
- Hold public meetings to ensure that broader school community understands the design considerations and their concerns are represented during the design decision-making.

These learning experiences should continue through the construction or retrofit implementation. Additional strategies are highlighted in Section 4.8.3.

✓ Inspection guidelines, construction documents and detailed plans can be used to develop training programs for builders, engineers, and the school community.

Safer Construction of temporary schools for early recovery efforts: Ensuring that vulnerabilities are not replicated

Temporary, or transitional, schools are needed when there are no safe alternative teaching and learning facilities available. They often accommodate large numbers of children, enabling them to return to school as quickly as possible while permanent solutions are explored. While they are an 'emergency provision', measures must still be taken to ensure that temporary shelters do not pose a further risk to children and teachers.

Challenges

Temporary schools, established in the immediate aftermath of an emergency, may face additional risks. For instance, where an earthquake has occurred, buildings in the surrounding areas are more fragile and continually impacted by aftershocks.

The availability of materials and the skilled capacity to assess potential sites and design safer temporary shelters is often limited. Those usually responsible and technically skilled in providing shelter are often consumed with attending to the shelter needs of the wider community.

General considerations when siting, designing and constructing temporary schools

The principles that guide the establishment of temporary and permanent schools are much the same, and these Guidance Notes can and should be utilized to strengthen safer construction of temporary schools in early recovery efforts. However, there are additional considerations for temporary schools that must be taken into account to enhance the safety of those who use them.

Site:

- ✓ School is at a safe distance from the construction of the permanent structure/building works.
- ✓ The distance between the school and the community/care givers is not too far and will not increase chance of separation. Ideally the school should be located within the community or near other Child protection/recreation activities.
- ✓ After a disaster, it is especially important that children feel safe in the temporary structure and surrounding environment

Structure:

- ✓ The temporary structure can be easily and quickly dismantled if relocation is needed.
- ✓ A school committee knows how to quickly dismantle the school and re-erect it in an alternative location if needed, without putting anyone's safety at risk.
- ✓ As temporary schools may provide service throughout various seasons, the structure should be easy to adapt to different climatic conditions.

Who to consult:

- ✓ Local authorities (including Ministry of Education)
- ✓ Teachers
- ✓ Parents
- ✓ Children
- ✓ Community
- ✓ Local skilled workforce
- ✓ Representatives from other sector-specific disaster assistance initiatives (including sector coordination groups and/or clusters on water and sanitation, logistics, shelter provision, health, etc…)

Please see Appendix 3 for references to resources on temporary/transitional schools

Figure 13: Temporary Schools of Timber and Corrugated Iron, Pakistan

Copyright: USAID/Kaukab Jhumra Smith

4.8 ASSURING QUALITY OF CONSTRUCTION AND RETROFIT WORKS

What is the objective of this step?	To construct a new hazard resilient school or retrofit an existing school to higher safety standards.
What is the purpose?	To assure careful adherence to the engineered design during its realization in order to achieve its capacity to resist damage and better protect lives.
How does this step relate to others?	This step is the manifestation of the planning, assessment, and design processes outlined in the preceding steps.

4.8.1 Introduction

When buildings that have been designed to meet hazard resistant standards fail, the most common cause of the failure is a poor quality of implementation or deterioration due to inadequate maintenance. Reasons for low quality implementation are poor, non-transparent management, insufficient supervision and inspection, and inadequate building skills. Inadequate maintenance of school facilities is most commonly due to a lack of necessary funding and/or local skilled resources. In order to realize the performance objectives defined for a new or retrofit school, each of these potential issues must be considered and strategies identified to prevent them.

4.8.2 How do you it?

1. Develop, document, and apply well-defined terms of references

Defining and clearly communicating terms of references for all processes and procedures will facilitate an efficient work flow and prevent any misunderstandings which could jeopardize the quality, or even completion of the project.

The following items should be clearly-defined, discussed and understood by those responsible for the management of the overall project, the supervision and inspection of work, and the execution of work:

- ✓ Roles and responsibilities
- ✓ Communication and accountability channels
- ✓ Project deliverables and liability
- ✓ Schedule of work and payments
- ✓ Quality assurance mechanisms
- ✓ Monitoring and evaluation system

A well designed monitoring and evaluation system can greatly assist project managers to quickly identify any unexpected obstacles or conflicts that will require a change in the project terms of references. Proposed changes should be documented and reviewed by all parties.

2. Identify and implement mechanisms to ensure transparency

Strategies that ensure transparency of management and procurement processes and make project information publicly available, not only limit potentially corrupt practices, but can instill public confidence in the project and support a community's sense of ownership. Strategies to ensure transparency may include:

- ✓ Project budgets, financing and procurement decisions to be discussed publicly and displayed on village information boards;
- ✓ Community-based independent committee to oversee contracts and implementation;
- ✓ Journalists, NGOs and students could be invited to audit procurements;
- ✓ The establishment of an anonymous complaints mechanism which channels them to project authorities (Kenny, 2007).

3. Develop and provide training for builders

There are many approaches to providing skills training in hazard resistant building techniques. How these trainings are designed and conducted will depend on the existing capacity of the skilled workforce, the scale of the overall project, and the training resources available. Information collected on the existing capacity of builders and the construction/ retrofit guidelines will guide the development of a training program.

Learning by doing

The most effective training approaches include extensive hands-on components in which new techniques are demonstrated and training participants practice these techniques under the guidance of experts.

Large-scale trainings

The National Society for Earthquake Technology (NSET) in Nepal has conducted large-scale trainings for masons (see adjoining case study). Due to the success of these efforts, a mason exchange program was designed with the Indian NGO, SEEDS. Nepali masons were sent to Gujarat, India to peer-mentor local masons in earthquake resistant practices.

Figure 14: Masons learning hazard resilient building practices in Uttar Pradesh

Nepali NGO and local government train skilled tradesmen

NSET, the National Society for Earthquake Technology, partnering with local authorities and the Lutheran World Federation, trained 601 masons, carpenters, bar benders and construction supervisors in earthquake safety construction techniques. The theoretical and hands-on trainings took place over a period of five months.

As a result, participants from Kathmandu and five other municipalities formed working groups to enhance and promote their new skills and train other professionals in their respective municipalities. Municipality authorities presently support the working groups and consider the initiative an important milestone towards the goal of increasing the use of building codes.

Source: http://www.nset.org.np/nset/php/trainings.php

Figure 15: Seismic Retrofit of Indonesian school

Copyright of UNCRD SESI Project

These trainings combined both theory and practice for an effective technology transfer (NSET, 2007).

Local on-site training

In this common approach, local builders are hired to carry out the school construction or retrofit works. Their training occurs on-the-job under the supervision of the project engineer and other skilled builders. Save the Children's Tsunami Rehabilitation and Reconstruction program - Aceh and Nias, which has retrofit 58 school buildings, used an on-the-job cascading approach. Save the Children engineers supervised and trained five national engineers and 30 local skilled tradesmen during the retrofit of two model schools. Once completed, one engineer and six builders were sent to each of five other schools to carry out the retrofitting works and train builders from those school communities (Shrestha, 2009).

Providing some form of certification, nationally-recognized or otherwise, that notes a builder's capacity to perform hazard-resilient building techniques can provide local builders with an advantage when competing for future work.

Please see Appendix 3 for references on builder skills training

4. Ensure compliance to the design requirements

Supervision

However simple the design may be, regular supervision of the work by a qualified engineer must be incorporated into the work plan. Well-detailed construction/retrofit guidelines can aid trained builders in meeting the design requirements, but unexpected obstacles will arise and require guidance. This is especially true for retrofitting efforts, where the conditions of older buildings must be accounted for. Engaging an on-site, qualified structural engineer to supervise all work is a highly recommended approach. When this is not feasible, regularly supervisory visits at each new stage of work should be scheduled to ensure good building practices.

Inspections

Effective inspection requires that inspectors be trained engineers possessing a detailed understanding of the design, the building code, and the performance objectives. It is advisable that inspectors are engaged independently of the procurement process. One approach is that taken by the *Sarva Shiksha Abhiyan* (SSA) (Education for All project) of 2006-07, in which the Elementary Education Department of Government of Uttar Pradesh, India, trained two junior engineers of the Rural Engineering Service in each district to carry out supervisory and inspection functions while delegating the construction management to school principles and Village Education Committees (Bhatia, 2008).

To increase efficiency and effectiveness, inspections should be planned for the completion of a job of work, and prior to the next stage rather than at fixed periods of time. Documenting and reviewing the overall inspection plan with the construction managers and builders will help to prevent costly and time-consuming implementation errors. The plan should include the stages of work that will require inspection, the criteria for approval, and any tests required. All inspections must be documented and approved before further work is initiated and any modifications to the design must be approved by the design team and the school construction manager.

Third party monitoring

Experience suggests that third party monitoring systems add great value to an inspection program. School community audits can be very effective when community members are trained to recognize both weak and strong building practices. If a community audit body is to be organized, they will need to be given the authority to immediately stop any work if design requirements are not met. Another means of engaging the community in assuring project quality is by establishing a mechanism by which individuals can anonymously post complaints. For more complex designs, a technically qualified independent inspection body can be engaged to review, test and approve critical features of the design during its implementation.

5. Establish a school maintenance program

To ensure the school building performs as per its expectations during its design life and beyond, it is essential that a maintenance program is established.

A strong school maintenance program has three main components: organization, inspection, and maintenance plan.

> *Organization* – A basic organizational structure would include a general coordinator and individuals or teams responsible for particular areas of the school. If the school maintenance budget is insufficient to carry out the maintenance tasks, a fund-raising coordinator should also be identified. It is advisable to draw from students and members throughout the community to fill these roles.
> *Maintenance Plan* – The maintenance plan is comprised of the scheduling of inspections, the parties responsible, points of inspection and the corrective measures to be taken if an issue arises.
> *Inspection* – A final assessment at the completion of the construction or retrofitting works will serve as a baseline for all future inspections. If issues identified during regular inspections beyond the capacity of the maintenance team to address or if the building has undergone major changes (such as damage induced by a hazard event), a qualified inspector/engineer should be consulted (Bastidas, 1998)

The recurring cost of maintenance will vary on the design and age of the school and the availability of resources required to carry out repairs. In general, an annual maintenance budget should be between 1 and 2% of the capital cost. Embedding recurring maintenance costs into the school construction/retrofitting budget will provide the longer term support required to maintain a safe learning environment.
Quite commonly the school community is delegated the responsibility of maintaining the school facilities. It is advisable to review the maintenance and reporting tasks with the responsible community organization and, if needed, facilitate the establishment of roles, responsibilities, and documentation and reporting mechanisms.

The cost of rebuilding a deteriorated school is much greater than the cost of maintaining one.

Please see Appendix 3 for references to resources on managing building maintenance

4.8.3 Key Points to consider

- ✓ The construction or retrofitting of a school building is a valuable educational opportunity with the potential to further strengthen community ownership of the school and demonstrate hazard-resilient techniques that can be replicated in homes and other buildings. Following are several strategies to encourage interest, participation and enthusiasm amongst the community in learning how buildings can be made to resist hazards.
  - Organize public visits to the site in which explanations are given of the hazard resilient components of the building and simple retrofitting techniques are demonstrated can encourage replication of these techniques in houses and other buildings in the area.
  - Be sure that construction can be viewed from a safe distance with explanatory signs
  - Display photos charting the progress of the work and the development of the hazard-resistant school and displayed in a public space. Clearly identify all hazard resistant features.
  - Discuss with school community how these principles can be applied to other construction in the community.
  - Identify frequent dangers in local construction practices and involve students, teachers and engineers in identifying these and raising awareness in the local community about disaster resistant design and construction practices.
- ✓ Awareness-raising campaigns in surrounding areas can bring members of other school communities to view and learn how buildings can be constructed or retrofit to better protect their occupants.
- ✓ Beyond the engagement of skilled local builders, students, youth and adults can contribute by collecting, preparing and delivering building materials to the work site and providing labor. Apprenticeships can initiate new livelihoods for youth; instilling safer building practices in future builders. Schools built and owned by communities are much less likely to be left to deteriorate.

Basic Design Guidelines

This section of the guidance notes consists of a number of basic design guidelines with respect to the following hazards:

- ✓ Earthquake (to include notes on tsunami)
- ✓ Windstorms (to include notes on storm surge)
- ✓ Flooding
- ✓ Landslides
- ✓ Wildfires

For each hazard type, basic design guidelines will cover where appropriate:

- ✓ Site considerations and modifications
- ✓ Design & Construction
- ✓ Precautions for non-structural components
- ✓ Precautions for future development

For each hazard type, references to technical resources, design and construction guidelines, and case studies are listed in Appendix 3.

⚠ This section is meant solely to provide the reader with a very basic understanding of hazard resistant design principles applicable to load bearing wall and framed buildings. These are not intended to be used as building code as they do not provide detailed specifications. Furthermore, this is not an exhaustive list of potential mitigation measures as these will vary greatly depending on the site-specific hazards and building typologies. In addition, these are only indicators and should not be used as criteria to assess existing structures or to modify the design of new structures. Confirmation of the need to change the design or to retrofit requires review by a qualified structural engineer.

TERMINOLOGY

Load: A type of force which acts on a building or some element of the building. Dead loads consist of the weight of the building elements that a structure must support. The roof, for example, is a dead load. Live loads are other additional forces which act on a building. People using a building are considered live loads. The forces on a building caused by wind, water and ground shaking are also examples of live loads.

Load path: How forces on one structural component are subsequently transferred to other elements

Structural Components: Elements of a building which are designed to support any loads on a building.

Non Structural Components: Elements that are not part of the load-bearing system of the building. This may include false ceiling, fixtures, furniture etc

Wall bearing construction: In wall bearing construction, the walls support horizontal structural members like beams which support the roof or an additional storey.

Framed construction: In framed construction, a structural frame is built to support all other elements of the building. A framed building should be designed so that any loads on the building are transferred to the frame. Frames are made of structural elements such as columns and beams. In frame construction, walls do not carry any loads and are commonly called infill or curtain walls.

Robustness: Applies to a building's structural system. It's a structure's ability to withstand stresses, pressures, or changes in circumstance. A building may be called "robust" if it is capable of coping well in its operating environment due to any minimal damage, alteration or loss of functionality (Bhakuni).

Integrity: Applies to materials in use. Integrity is a term which refers to the quality of being whole and complete, or the state of being unimpaired (Bhakuni).

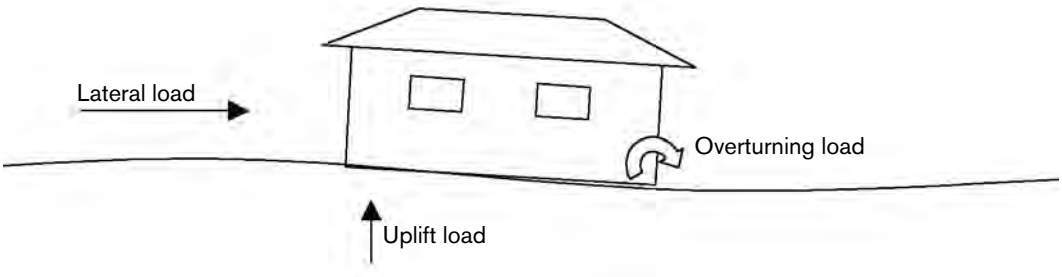
Stability: Applies to various building elements (such as columns, walls, beams, etc…) which maintain equilibrium for a building to stand (Bhakuni).

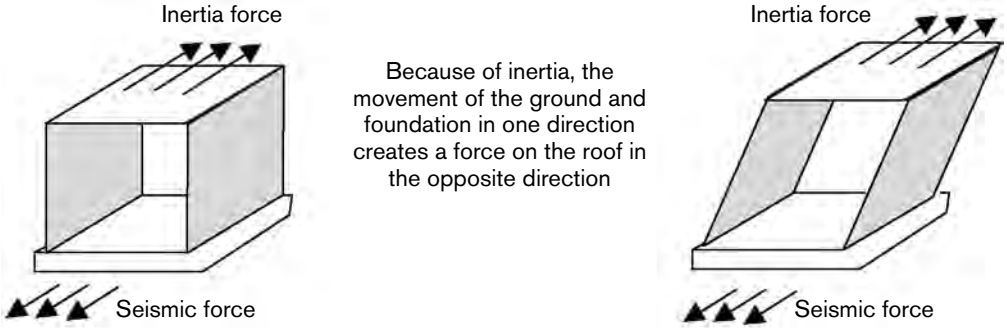
5.1 EARTHQUAKES (TO INCLUDE TSUNAMI)

An earthquake can be caused by the shifting of tectonic plates or by volcanic activity. Geographic areas which lie above the meeting of these plates are generally the most prone to earthquakes. The ground shaking is due to a wave-like force travelling through the earth's surface and its effects will vary based on the geological characteristics of a given area. This wave-like force may also cause other events. When the source of an earthquake lies under water, the force moving through the water can cause tsunamis, or tidal waves. The ground shaking on land can also induce other events such as landslides and shifting of various ground layers.

During an earthquake, the ground movement induces lateral, or horizontal, and vertical loads on a building. A lateral load is similar to the back-and-forth forces the driver of a vehicle will feel when he comes to a sudden stop or accelerates quickly. These forces cause the driver's body to bend forwards or backwards or to shift in place.

As the force of an earthquake causes the ground to move like a wave, the ground will also push up on one side of the building and force down the other side of the building creating an overturning load.





Earthquakes–Site Considerations and Modification

E1. Select site as far as possible from known earthquake fault lines.
E2. Select site that minimizes or prevents potential harm due to earthquake-induced landslides.
E3. Select site composed of firmest sub-soil available.

Softer sub-soils amplify ground motion which will be transferred to foundations and school structures. Weak sub-soils are susceptible to soil liquefaction. Soil liquefaction is a phenomenon which occurs when solid soils under pressure take on a liquefied state thus causing the ground to move. Soil liquefaction can damage foundations and even cause collapse of the foundation and the building.

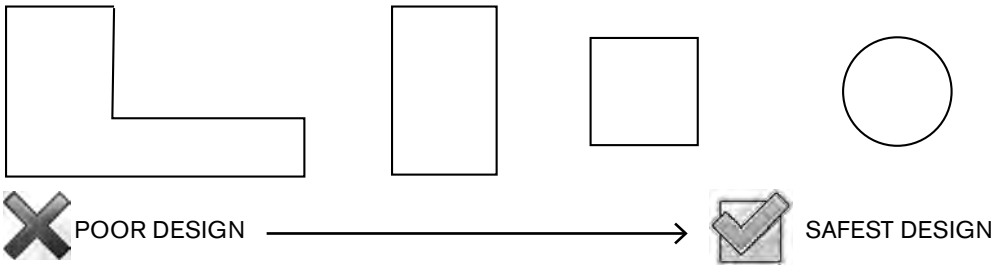
E4. Select site where ground water level is well below the foundation level
E5. Allow for sufficient space between buildings

It is important, particularly when constructing in urban areas, to allow for sufficient space between buildings. If separation between buildings is not considered, the ground shaking may cause the buildings to pound against each other and cause serious damage.

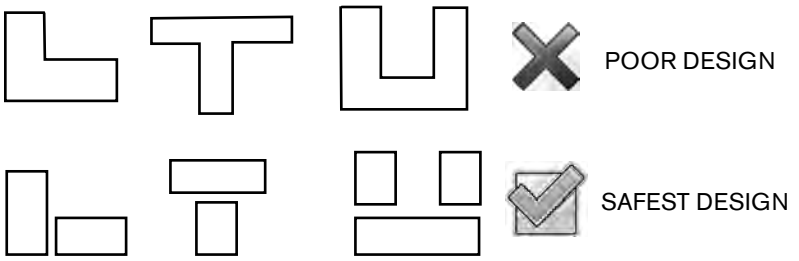
E6. In tsunami-prone areas, select site at elevation above that of maximum potential wave height.
E7. Identify potential evacuation routes and access routes for emergency services.
E8. Consider the proximity of structures in surrounding areas that may serve as a shelter for those displaced in emergencies.

Earthquakes–Design and Construction

E9. Design structural elements to be symmetrical and evenly spread over the plan of the building.

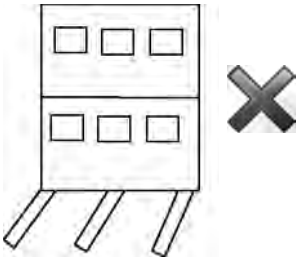


The asymmetry of structural elements can result in damaging 'twisting' forces. Structural layouts, such as U- and L-shaped buildings, amplify these twisting forces and their inside corners are particularly vulnerable to damage. These types of structures should be avoided. If such layouts are desired, it is preferable to design several distinct symmetrical buildings oriented in such a way as to produce similar results.



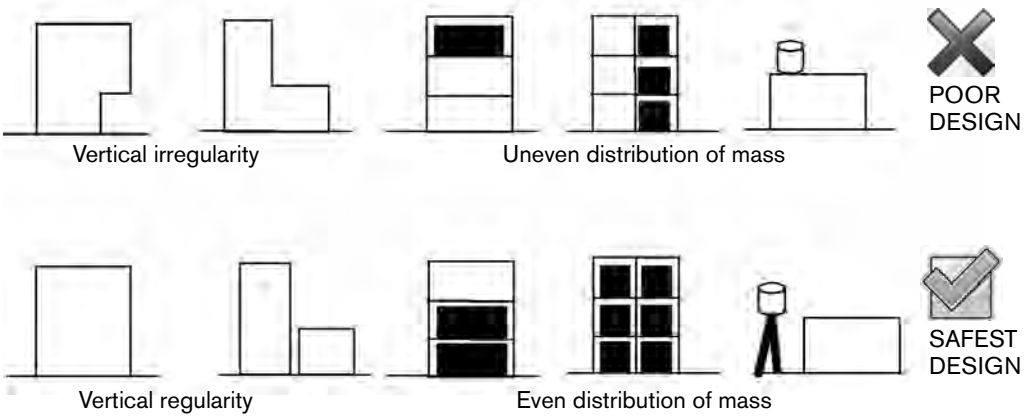
E10. Design building to be vertically regular with respect to lateral stiffness and weight distribution.

For schools with more than one storey, the capacity for the structure to resist lateral forces should be the same for each floor. A common cause of damage to multiple-storied buildings is “soft-storey” collapse. This occurs because the lateral stiffness or shear strength of one story, typically the ground level, is less than that of the upper stories.



When one storey is less laterally resistant than stories above it, it is more likely to collapse

An uneven distribution of mass at higher levels of a structure can also amplify the lateral load caused by an earthquake. Therefore lighter roofs are preferable and any heavy equipment such as water tanks, should, when possible, be located independently of the structure.



E11. Ensure all structural elements are securely connected together.

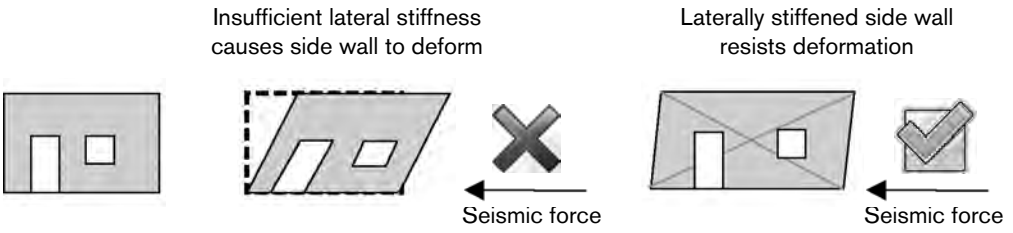
Connections between all walls, floors and roofs are crucial stress points and must be designed to be stronger than the connecting elements. This is particularly important where diaphragms are connected to shear walls and beams to columns. Each element of the box relies on the other elements and therefore they must be securely fastened to each other. It is equally essential that the structural system is firmly fastened to the foundation. If the building is not sufficiently secured to the foundation, it may shift or slide off.

E12. Design and build to resist lateral loads from all directions.

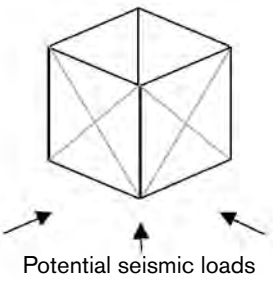
A rigid box is an ideal structural design to resist the lateral loads induced by an earthquake. This design is applicable to both bearing wall construction and frame construction. In bearing wall buildings, the walls, floors and roofs are the structural components which should be configured to form this box. In framed buildings, the columns, beams, and other frame members should be configured to form this box. Characteristics of this rigid box design will be discussed for both types of construction.

Bearing wall construction

In wall bearing construction, a wall that is parallel to a lateral load it is called a **side wall**. The lateral force on the side wall will place pressure on the top unless it is designed to resist the force. When a side wall is designed, built, or retrofit to act as a stiff, integrated whole which resists lateral forces, it is called a **shear wall**. The use of sufficiently strong mortar in brick or block construction is one means of enhancing a wall's lateral resistance.

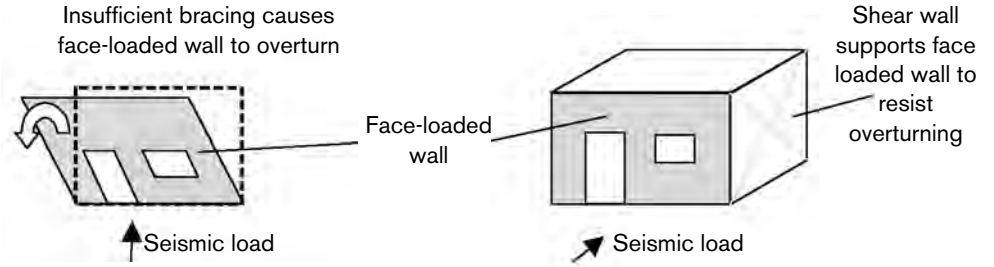


If this stiffness is insufficient relative to the load, the building will sustain damage and possibly collapse.



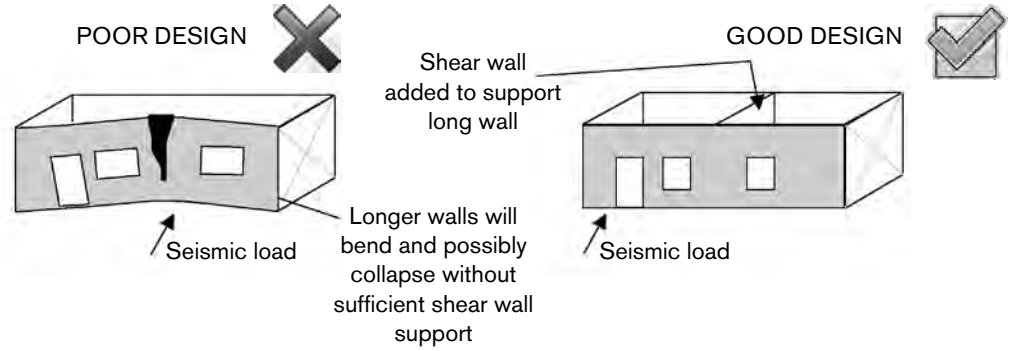
As the direction of these lateral loads cannot be predicted, the shear strength must be considered for loads from any direction. Therefore all walls should be designed to resist lateral loads.

A wall which is perpendicular to a load is called a **face-loaded wall.** A face-loaded wall responds differently than side walls. Face-loaded walls, unless securely braced from side to side and top to bottom, will overturn.



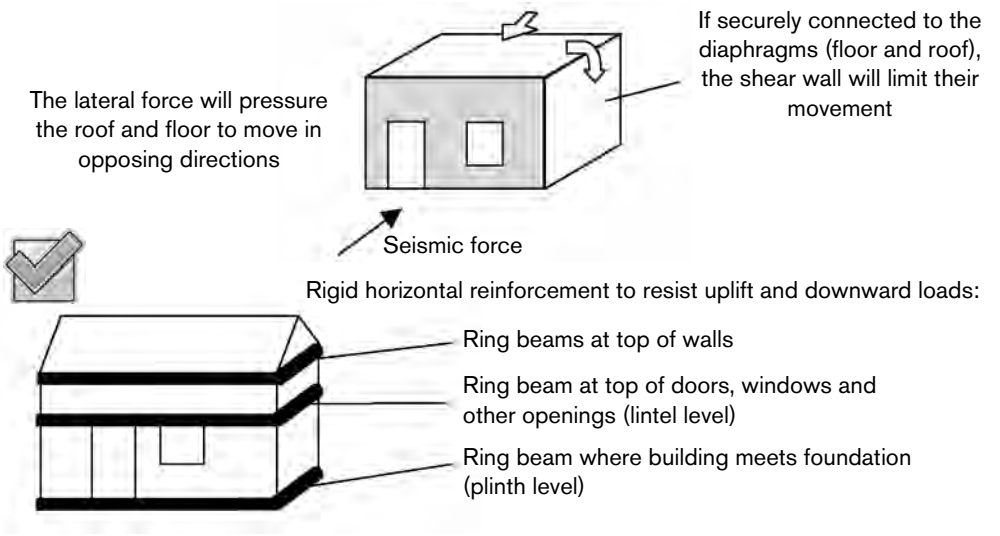
As shear walls help to brace face-loaded walls and stop them from overturning, the corners where they meet should be reinforced.

Long face-loaded walls will require additional interior shear walls to resist overturning or bending and eventual collapse.



Horizontal structural components which tie all four walls together such as a floor, roof, or upper storey are called diaphragms. Diaphragms further support a face-loaded wall and transfer the load down to the shear walls, or in the case of a floor, directly to the foundation or ground.

In wall-bearing buildings, rigid horizontal reinforcement that encircles the building can act to resist deformation and damage to a wall caused by uplift, downward and lateral forces (when tied to vertical reinforcement). Any system of providing this reinforcement must form a continuous ring around the building and must be securely fastened to all vertical structural elements (such as columns and reinforced corners).



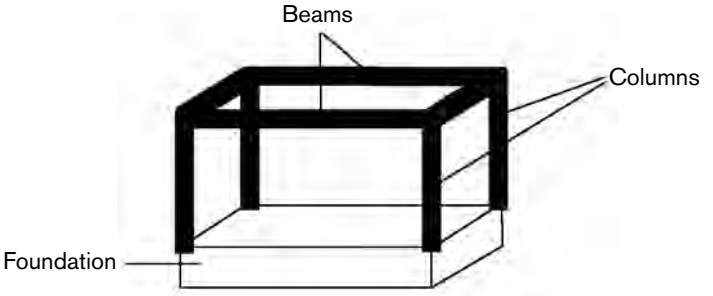
E13. To ensure that the load on a diaphragm is correctly transferred to the supporting walls, it must be rigid and act as a single element and **it must be securely attached to the walls**. An example of a rigid diaphragm would be a reinforced roof or a concrete slab floor. All walls should be securely attached to all diaphragms.

E14. Minimize openings in bearing wall construction

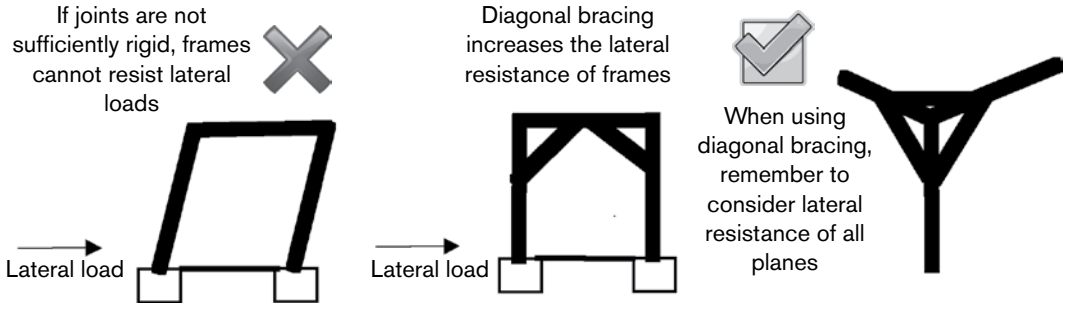
Shear walls should extend from the floor to the roofline. Openings in the wall, such as doors and windows, reduce a shear wall's resistive capacity (particularly in the proximity of corners). Reinforcement of door and window frames will strengthen these critical weak points. Minimize openings in diaphragms as well.

Frame construction

In frame construction, the columns and beams can be joined to create a box-like structure.

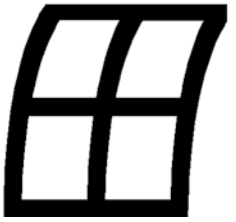


As the columns and beams joined together must resist the lateral loads, their joints must be made substantially rigid so as to maintain the box-like form. These joints are a critical point and must be securely fastened such that the joint is stronger than the structural members. Diagonal bracing can further increase the structure's lateral resistance



E15. Increase resiliency of structure through use of ductile technology and materials

Ductility is the characteristic of a structure or its components which allow them to bend or deform when under a given force. When a lateral force exceeds a structure's lateral stiffness, rather than immediately collapsing, a ductile structure will absorbe some of that force by deforming. Although damage will be sustained, more serious damage and possible collapse may be avoided. Certain steel reinforcement used in concrete construction acts to increase the ductile capacity of columns and walls.

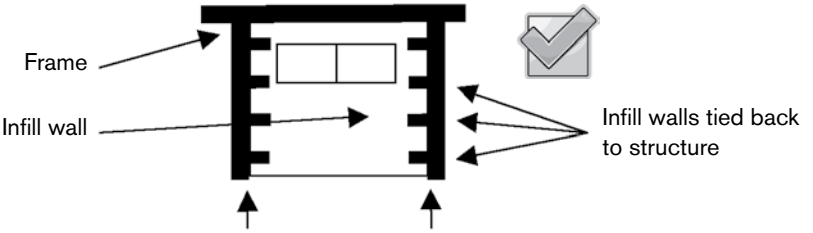


A correctly-designed ductile structure will deform before fracturing

Brittle materials, connections, and overall structures do not dissipate a load's energy and thus are more prone to fracture and collapse. It is important that the use of ductile materials and the design of ductile structures be approved by a structural engineer. Designed incorrectly, a ductile structure or structural component can result in extreme structural damage. Even ductile structures and materials will fracture when under the stress of larger loads.

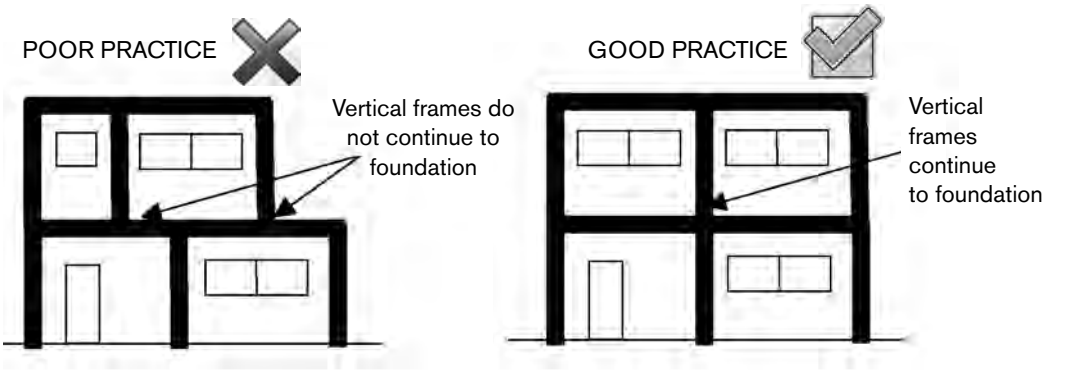
E16. Allow for expansion between structural columns and infill walls

In frame construction, walls, often called curtain or infill walls, do not bear any loads. Where columns and beams are designed to resist seismic loads, movement joints must exist between infill walls and frame to allow the two elements to move independently and prevent the wall from cracking. However, solid infill such as brick walls must be tied back to the structure to avoid a collapse which may endanger the occupants.



E17. Design all elements to transfer loads directly to the ground.

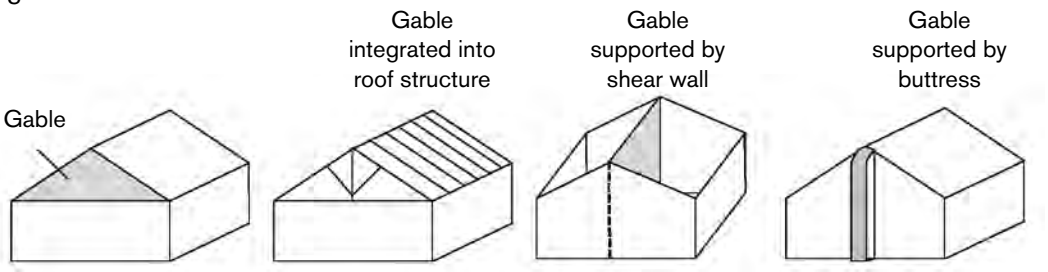
To reduce the damage caused by lateral loads, structures must be designed to transfer all loads directly to the ground.



Vertical framing that does not continue to the foundation is a critical weak spot.

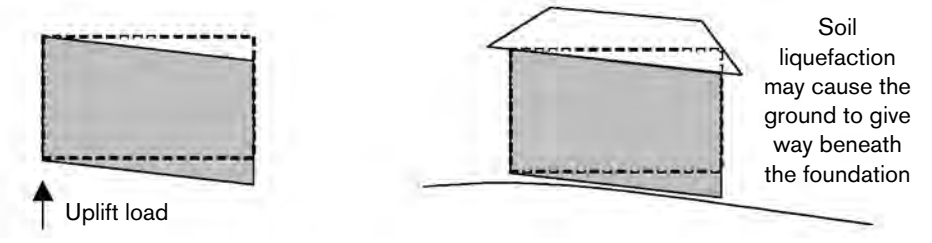
E18. Gable walls must be braced to their full height

Gables are the portion of the side of a building which rises from the bottom edges of the roof up to the ridge. In wall bearing construction, gables are called gable walls or gable ends. Gable walls require additional bracing to the full height of the wall in order to resist overturning. This might be achieved by fixing diagonal bracing between the gable wall and roof beams, designing a shear wall which supports the gable wall from within, or constructing a buttress.



E19. Design to resist uplift loads

Stiffness in shear walls or in a frame should also be designed to resist uplift loads as well as corresponding downward loads. If sub-soils are soft, soil liquefaction may occur causing the ground elevation to drop. If the foundation does not rest on solid sub-soil, part or all of the building may drop as well.



Earthquakes–Precautions for non-structural components

E20. Firmly attach exterior building elements to structural elements

Exterior components which cover the building (its windows and door frames and roof and wall coverings) must also be firmly attached to the structural elements in order to minimize detachment and possible damage to building or persons outside.

E21. Brace or secure interior non-structural elements of the building to structural elements.

Architectural elements such as ceilings, wall covering, and non load-bearing walls should be fixed securely to the structure to prevent them from falling or collapsing and causing damage, harm or loss.

Other infrastructure, such as electrical, gas and water supply pose a particular risk in an earthquake and can cause fire, gas leaks and electrocution. Consider containment, escape routes and isolated safe assembly points.

E22. Secure furnishings and other equipment which could fall and cause harm, damage or loss

A common and dangerous hazard induced by an earthquake is falling objects. All heavy furnishings or equipment, both inside and outside of the building, should be securely fixed to structural elements, or located independently of the building.

E23. Design staircases to resist earthquake loads

In multi-storey buildings, evacuation may require the use of stairways. To reduce harm and loss of life to those evacuating a building, staircases should be designed to withstand earthquake loads.

Earthquakes–Precautions for future development

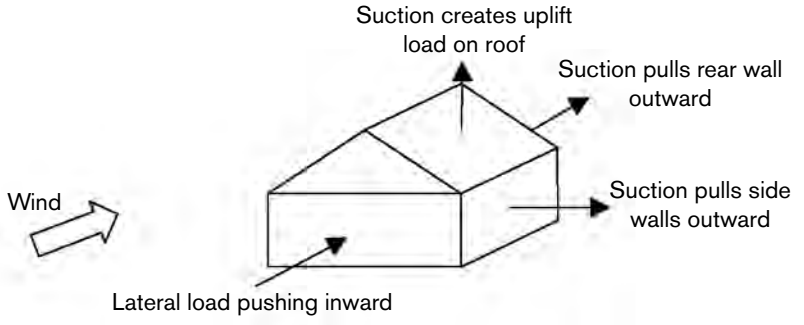
E24. If future development of site is predicted, space should be allocated on the school site so as to ensure sufficient separation between school buildings.

Please see Appendix 3 for references and hyperlinks to good literature, handbooks, guidebooks, etc.

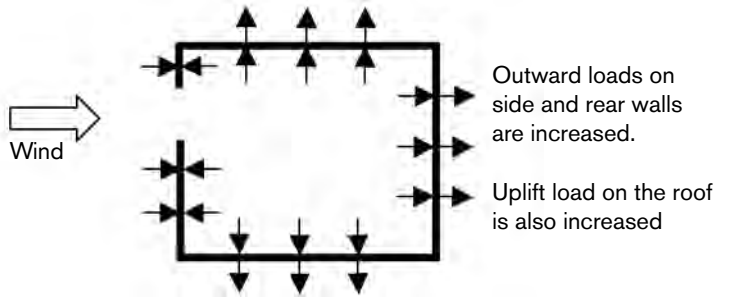

T

5.2 WINDSTORMS

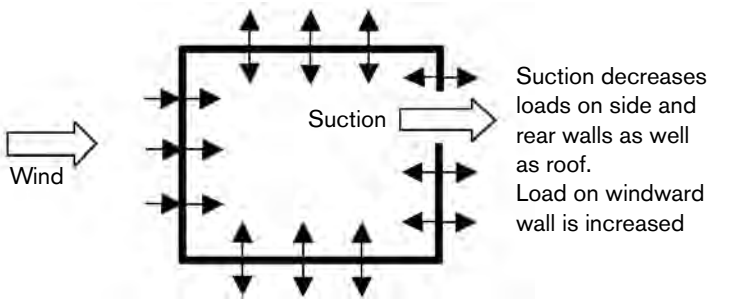
The forces of extreme winds due to cyclones (including tropical storms and typhoons) induce a variety of loads on a building. In a simple rectangular building, the side of the building facing the wind is subject to a lateral load. This lateral load pushes this side of the building inward. The wind blowing around the other sides of the building lowers the air pressure outside. This drop in pressure creates a suction force which pulls these walls outwards. The suction force of the wind over the building creates an uplift load on the roof as well.



These loads may be increased or decreased based on the pressure within the building. If more air is allowed to pass through the wall facing the wind (via broken windows, severed doors, and any existing openings) the air pressure within the building will increase. This increase in air pressure inside the building will force the walls outwards. This will increase the outward pressure already exerted on the side and rear walls and roof.



If more air is allowed to pass through the rear and side walls, the building is depressurized and air from within is sucked out of the building. This suction pressure pulls the side



walls, rear wall and roof inward. This inward force counteracts the suction force of the wind outside the building. Therefore the load on the side and rear walls and on the roof are diminished.

Wind is not the only force which acts on a building during storms. They are generally accompanied by heavy rains, storm surge and flooding. This can induce heavy damage on buildings and harm to people.

Windstorms–Site considerations and modifications

W1. Select site with minimum exposure to wind.

Natural wind blockades such as trees can decrease a buildings exposure to wind, but be sure that these are not so close as to fall and damage the building. When designing, allow for some loss of shielding capacity due to stripped leaves and branches.

W2. Decrease proximity of potentially unsafe structures and potentially damaging debris.

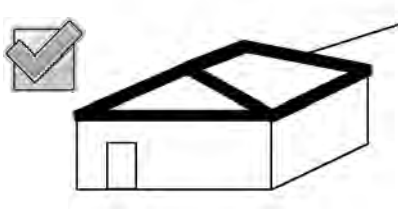
Nearby structures which have not been built to resist strong winds, or potentially damaging debris can act as missiles and damage the building.

W3. Select site at elevation greater than highest flood levels in prior storm surges.
W4. Consider site selection criteria for other identified hazards such as floods, landslides and earthquakes

Windstorms–Design and Construction

W5. Ensure foundation is sufficiently large and heavy to resist uplift force on building.
W6. Ensure foundation is designed, and at a depth, to resist erosion by potential storm surge.
W7. Ensure all structural elements are securely connected together and firmly anchored to the foundation. See E11.
W8. Design all elements to transfer loads directly to the ground. See E17.
W9. Reinforce connections where roof structure meets walls and where different roof surfaces meet

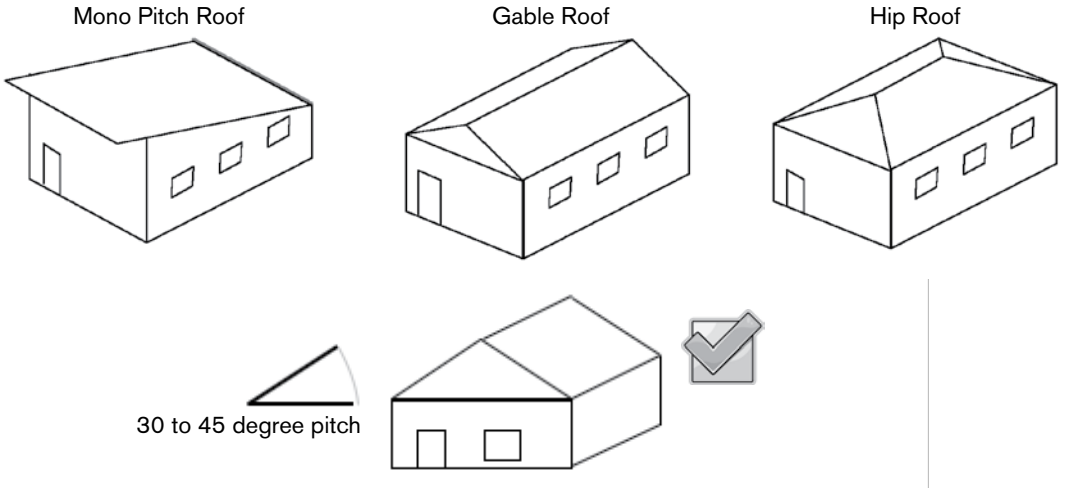
Uplift loads, created by the suction of passing wind are substantially greater where the roof meets the walls and where different roof surfaces are joined.



Roof perimeters and edges must resist greater uplift loads. They require reinforced connections

W10. Avoid very low and very steep sloped roofs.

Very low or very steep sloped roofs generally less resistant to wind forces. Although uplift loads will vary by type of roof (e.g. flat, mono-pitch, gable, hip), a general rule of thumb is to design a roof's slope to be between 30 and 45 degrees.



Where roofs of a greater or lesser slope are desired, additional fastening systems should be designed to resist uplift loads.

W11. Avoid wide roof overhangs.

Roof overhangs expose the underside of the roof structure to wind loads and increase the possibility of roof blow off.

W12. Minimize total height of building.

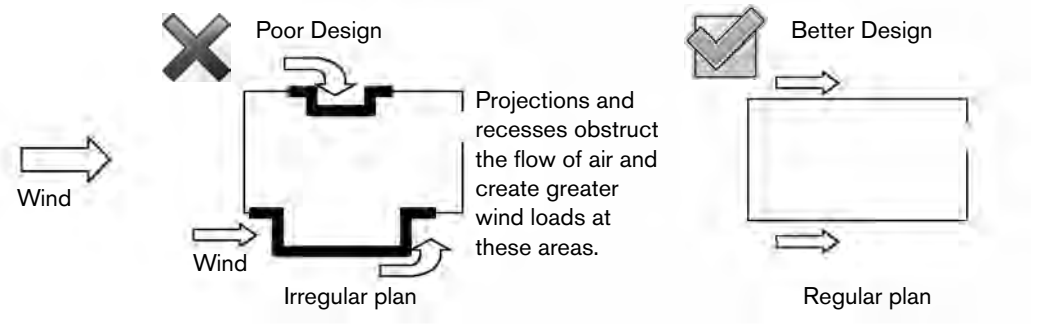
A lower profile building is inherently less vulnerable. Wind speeds increase with height above the ground level. A one-storey building is less likely to sustain wind damage than a two-storey building

W13. Reinforce corners and edges of all sides of the building.

In corners and along edges, wind speeds increase due to turbulence. This results in a greater load on those areas of the building.

W14. Minimize exterior surface irregularities.

Exterior surface irregularities (e.g. eaves, projecting floors, stair towers) create obstructions to the flow of the wind. Where irregularities are required, reinforce structural components and building envelope within those areas. Wind speeds increase in corners due to turbulence. This, in turn increases the load on that part of the building.



W15. Design and build to resist lateral loads from all directions.

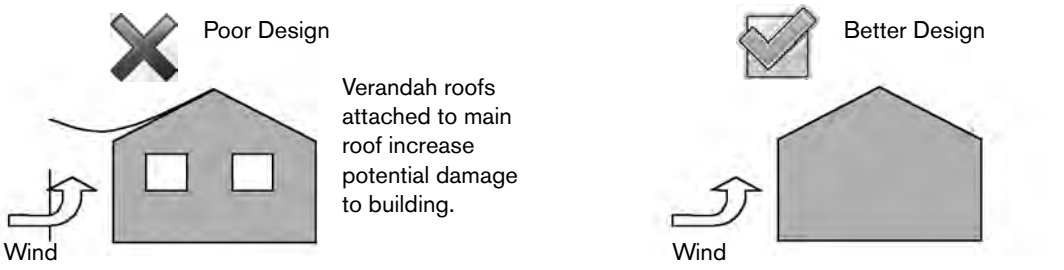
Windward surfaces of the building should be braced to resist being blown over. See E12.

W16. Minimize openings in bearing wall construction.

Openings weaken a shear wall's capacity to act as a rigid whole and effectively resist lateral forces on windward elements of the building. See E14.

W17. Verandahs and other transitional spaces should not have their roof structures as extensions of the main roof but should be structurally separate.

Because the undersides of these roofs are exposed to the wind, they are particularly susceptible to blow off. If these roofs are attached to the main roof, they increase the likelihood that the main roof will be torn off as well.



Windstorms–Precautions for non-structural components and other facilities

W18. Ensure building envelope is securely fastened to structure

Much of the damage resulting from a windstorm occurs once the wind penetrates the building. Wind can penetrate even the smallest openings and tear off roof or wall coverings. This can create openings in the building which expose the interior and building occupants to wind and water damage and increase wind loads on the roof and walls. Wall and roof coverings should be securely attached to the building structure with additional reinforcement at all perimeters.

W19. Design building envelope to resist damage by wind-borne debris.

Debris carried by the fast moving winds can act as missiles and damage the building. Roof and wall coverings should be designed of impact resistant materials.

W20. Design doors and windows to resist wind loads

Doors and windows should be fastened to reinforced frames with reinforced hinges and latches. Glass windows are particularly vulnerable as they can be easily broken by the wind or flying debris. Storm shutters on windows, doors and any other openings can reduce damage to the building interior if they are securely fastened to the building's structure. Pre-cut panels for windows and doors also work well. They can be stored on site and attached quickly when storms approach.

W21. Brace, support and/or attach interior components

Wind acting on interior building elements, furnishings, and equipment (e.g. ceilings, bookshelves, chalkboards, electrical and plumbing systems, and interior partitions) can cause damage to the building and its occupants. These should be attached to the structural elements of the building.

W22. Secure to the ground any exterior equipment and auxiliary structures which could be damaged or cause damage.

W23. If exposed to storm surge see section 5.3 for flood resistant measures.

Please see Appendix 3 for references and hyperlinks to good literature, handbooks, guidebooks, etc.

5.3 FLOODS

Flood damage to buildings may be caused by:

- ✓ Degradation of building materials due to initial and prolonged contact with water
- ✓ The forces of standing water, moving water, waves and floating debris on a building
- ✓ Erosion of ground on which the structure rests

Harm or death during a flood may occur when:

- ✓ Humans are trapped inside a building due to a lack of safe evacuation routes
- ✓ Deep or fast-moving waters cause drowning or harm due to floating debris

Measures to reduce damage, harm and loss during a flood fall into three basic categories: Elevating the building, creating barriers to prevent damage to the building, and wetproofing the building (allowing flood water to flow into building without causing substantial damage).

Floods–Site considerations and modifications

F1. Select site at elevation above that of expected flood levels.

The ideal solution to potential school flooding is to identify a site above the maximum expected flood elevation.

F2. Consider site selection criteria for other identified hazards such as floods, landslides and earthquakes.

When sites are exposed to multiple hazards, an ideal site with respect to one hazard may be a poor choice when considering another hazard. For example, the slope of a tree-cleared mountain may be well above anticipated flood levels, but may be susceptible to mud slides.

F3. Assess drainage systems and select site with best drainage potential.

The potential flood damage of buildings increases greatly with duration of exposure. A good drainage system may prevent higher flood elevations and prevent prolonged exposure to flood water.

F4. Select site with natural erosion deterrents such as trees and ground cover

Flood waters, especially faster moving water, can damage the site through erosion. Increased vegetation ground cover helps to hold the soil in place and minimize erosion.

F5. Identify access and evacuation routes.

If a school is built above the flood elevation, yet access routes are inundated, the use of the school will be affected. Evacuation routes are equally important to ensure people are not trapped in or on school buildings.

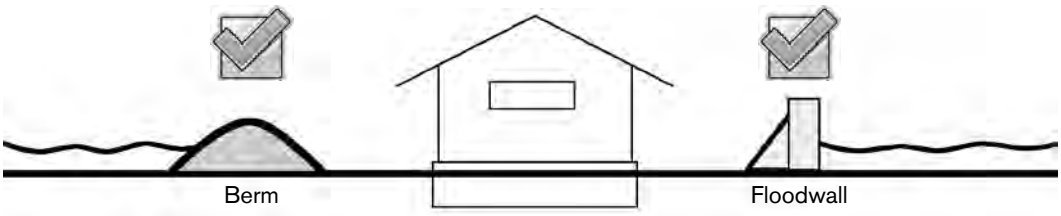
Elevating the building above expected flood level

F6. Add fill to raise site above expected flood elevation

Earthen fill can be added and properly compacted to increase the site elevation.

Constructing flood barriers

F7. Create earthen or concrete flood barriers on site or at source of flood



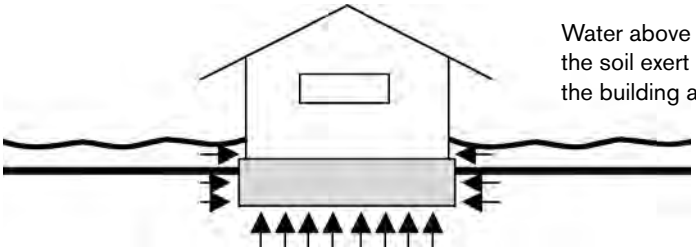
There are several different types of barriers commonly built to reduce flooding. Levees are commonly built along rivers and other bodies of water to prevent overflow. Berms, made of earth, and floodwalls, commonly made of concrete are built at the site. When considering flood barriers, it is essential to design systems for drainage if floodwaters overflow the barriers.

Floods–Design and Construction

F8. Ensure all building elements are securely fastened together and firmly anchored to the foundation.

As flood elevation increases the uplift load on a building due to buoyancy may cause the building to float off the foundation if not securely fastened. See E11.

F9. Design and build or retrofit building and building components to resist lateral loads.



Water above ground and within the soil exert lateral pressure on the building and its foundation

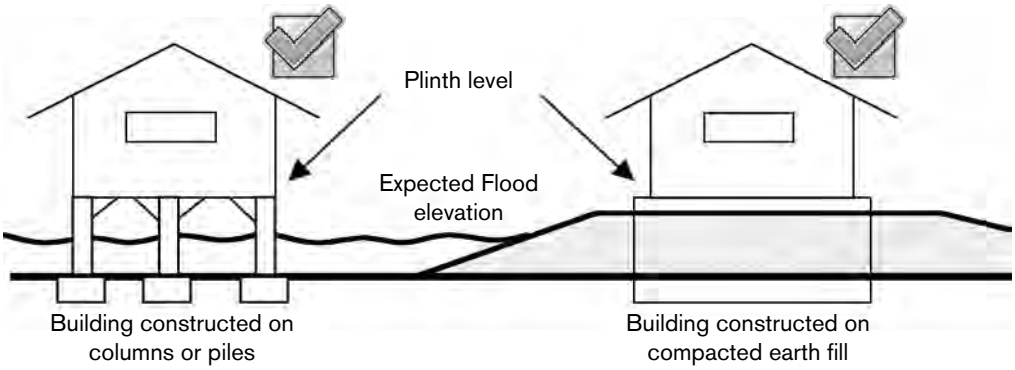
The forces of standing water (hydrostatic loads) and moving water (hydrodynamic loads) can create a very large lateral load on foundations and walls causing structural damage and collapse. See E12.

F10. If expected flood level is to meet building foundation, fill the foundation or design openings in foundation to equalize external and internal water pressure.

Elevating the building above expected flood level

F11. Design and construct shear walls, columns, or fill to elevate building

Designing a new building such that the plinth level rests above the expected flood level is an effective way to reduce damage caused by flooding. This may be accomplished by building on columns, piles, or compacted earth fill.



Any technique used to raise the building, must also be designed to resist the forces of standing and moving water and floating debris. Existing buildings can also be raised, although this solution can be costly and difficult. Raising masonry and concrete structures is particularly difficult and can easily damage the building.

Constructing flood barriers

F12. Create a waterproof building

Through the use of waterproof materials and technologies, it is possible to make the building itself a flood barrier. This method is commonly called “dry-proofing” and attention must be given to the building’s structural capacity to resist the pressure of standing or moving water. Dry-proofed buildings must be immediately evacuated as failure of this technique may result in catastrophic structural damage (FEMA 424).

Wet-proofing a building

F13. Maximize the use of water-resistant building materials.

Since the technique of wet-proofing allows the movement of water throughout the building, water resistant building materials should be used to minimize initial and long term damages.

F14. Design building such that water can quickly drain from all building components.

Building materials can quickly degrade when exposed for prolonged periods to water and moisture. Attention should be given to ensure that water can be removed from the building as quickly as possible. Additionally, measures must be determined to remove dampness from all structural and non-structural materials. Prolonged dampness may degrade materials and resulting mold or mildew may be a health hazard.

Floods–Precautions for non-structural components and other facilities

F15. Install electrical, mechanical and plumbing systems, and any other valuable equipment above the expected flood level.
F16. Ensure school toilet facilities are located above expected flood elevation and downstream and down slope of school facilities.

Flooding toilets are a secondary hazard potentially causing infection and disease.

Please see page Appendix 3 for references and hyperlinks to good literature, handbooks, guidebooks, etc.

5.4 LANDSLIDES (TO INCLUDE MUDSLIDES)

Landslide is a name given to a grouping of different types of events characterized by the mass movement of bedrock, earth, or debris when the force of gravity overcomes any forces stabilizing the slope. When the cohesiveness of these materials or the friction (which holds them in place) is increasingly diminished, the potential for this mass movement increases. This movement can occur at rates as slow as a few centimeters per year, or can be triggered suddenly and reach speeds of 120 km/hr.

Landslides, mudslides and other types of mass movement can be a result of water saturation of the soil layers, modifications made to the slope and its vegetative coverage, and earthquakes.

Three of the main types of mass movement are falls, slides, and flows.

Falls–Falls occur when fractures in rock outcroppings are weakened to a point where rock fragments break away and fall to the ground.

Slides–Slides occur when one relatively intact layer of material becomes separated and slides away (downhill) from another layer

Flows–Flows occur when unconsolidated soil, sediment and other debris becomes oversaturated with water and move down the slope in a fluid motion.

Most events are complex and involve two or more types of mass movement.

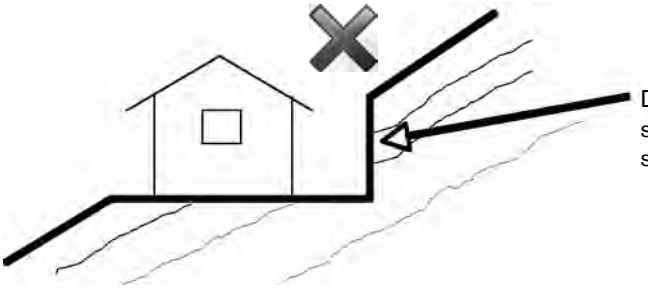
The majority of measures to reduce landslide/mudslide risk are interventions to stabilize the slope. Thus this section does not provide guidance on school structural mitigation measures. It is recommended within these notes that no new schools are constructed in

landslide/mudslide zones, and that existing schools should be carefully assessed by geo-technical engineers and preference be given to school relocation to safer sites.

Landslides - Site considerations & modifications

L1. Avoid sites on or at base of slopes in a land/mudslide zone.

L2. Avoid creating deep side cuts into a hill

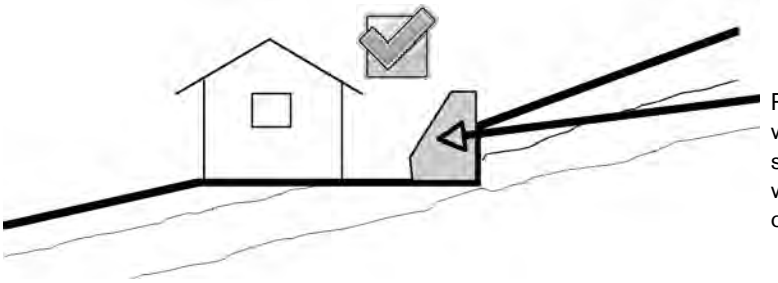


Deep cuts into a slope weakens its stability

Deep cuts on the slope decrease the stability of the ground above

L3. Construct retaining walls

Where shallow cuts must be made in **low landslide risk** areas, retention walls should be constructed to strengthen the cut slope



Retaining walls can help stabilize slopes weakened from cuts.

L4. Select site with adequate vegetation cover on nearby slopes

The roots of trees, brush and other vegetation help anchor the soil and subsoil on a slope. Trees may also act as a barrier to diminish the impact of less severe slides. The removal of trees and other vegetation from slopes increase the probability of a landslide/mudslide.

L5. Construct channels and drainage systems to decrease water level and divert drainage from site

Channels and other drainage systems can divert water out and away from the slope and decrease oversaturation of the soil that triggers mud and debris flows. Slope drainage systems should be designed by geotechnical specialists and care given that drainage paths do not pose other hazards.

For slopes at greater risk of movement, geotechnical measures can help to stabilize the slope. As these technologies require the detailed surveys by geologists and engineers,

vary greatly depending on the potential type of mass movement, and are typically large-scale longer term solutions, they are not addressed within this section. Further detail can be found amongst the resources referenced in Appendix 3

Please see Appendix 3 for references and hyperlinks to good literature, handbooks, guidebooks, etc.

5.5 WILDFIRES

Wildfires, also called bushfires, forest fires, or grass fires occur when combustible materials such as trees, shrubs, and grasses are ignited. Wildfires are most often ignited through natural means, although human activity, such as slash and burn agriculture and even arson, is also a cause of wildfires. There are many variables that influence the intensity, frequency, and affected area of a wildfire.

- ✓ The type and concentration of fuel, most commonly vegetation, will influence the spread of a wildfire.
- ✓ Climatic conditions, such as drought and heat waves can create conditions that facilitate the ignition or spread of wildfires.
- ✓ Wind patterns and speeds will also affect the direction and speed of the spread of a wildfire. Embers carried on the wind can even allow fires spread past rivers and other fuel-free areas (called "jumping").

Wildfires - Site Considerations & modifications

WF1. Plan school building in location where regular land clearance and maintenance of surrounding areas can be undertaken. Large grass areas or farm or woodland should be regularly cleared/cutback.

WF2. School sites should be at a minimum agreed distance to factories or other industries of high risk of explosion or vulnerability to fire (such as those that keep wood piles, flammable chemicals, and other fuels).

WF3. Consider investment in firebreaks (fuel breaks).

A firebreak is a river, a road or any other barrier of non-combustible materials that serves to arrest the further spread of fire. Firebreaks should be created at an adequate distance from the school buildings and be sufficiently wide so as to prevent the fire from 'jumping' the firebreak.

WF4. Create a fire-resistant space around all buildings

Remove any flammable materials within 30 meters of all buildings including combustible vegetation. If vegetation is desired, identify and plant low, fire-resistant species only. Any vegetation within this space should be sufficiently irrigated.

WF5. Ensure access areas are always clear

Gates, roads or any other points of entry or exit to the site should be kept clear of combustible materials to ensure access of emergency vehicles and evacuation of school population. This includes any combustible materials overhanging materials such as tree limbs.

WF6. Define an adequate and agreed minimum space between buildings

Planning sufficient space between buildings will reduce the likelihood of a fire spreading from one building to another

Wildfires–Design and Construction

WF7. Select fire resistant materials for all building envelope components

Wall coverings, roof materials, windows, and doors should not be made of wood or any other combustible materials.

WF8. Enclose all eaves

Eaves should be enclosed with fire resistant materials so as to prevent embers from blowing up under the rafters and igniting the roof from below.

WF9. Ensure roof fixtures are fire resistant

Any fixtures or openings within the roof, such as vents, exhausts or chimneys should be made of fire resistant materials and all openings covered with 1cm wire mesh to prevent entry of wind-borne embers.

Wildfires–Precautions for non-structural components and other facilities

WF10. Keep roofs free of all debris

Clear regularly from the roof any debris, such as dead leaves, that could potentially ignite.

WF11. Install fireproof shutters for the windows.

Design and build shutters of fireproof materials to cover windows. The intense heat of a wildfire will cause windows to break

WF12. Install an external sprinkler system on the building fabric, with an independent power supply for the pump

WF13. Do not store flammable materials on the ground floor of a multi-storey building.

Wildfires–Precautions for future development

WF14. There must be adequate and agreed minimum space to ensure that any new development meets the above recommendations.

Please see Appendix 3 for references and hyperlinks to good literature, handbooks, guidebooks, etc.

APPENDIX 1

Rationale for and Background to the Development of Guidance Notes on Safer School Construction

Safer School Construction: The Issue

In January 2009, the Center for Research on Epidemiology of Disasters (CRED) highlighted a spike in the number of people killed in natural disasters: the 2008 death toll of 235,816 was more than three times the annual average of the previous eight years. Moreover, it noted that the biggest losses, from Cyclone Nargis and the Sichuan tremors, could have been substantially reduced had schools been built more earthquake-resilient. The death of children and adults in these schools causes irreplaceable loss to families, communities and countries and life-long injury to millions of children around the world. Moreover, disasters continually destroy or damage school infrastructure, which is a great economic loss for a country; the cost of reconstruction can be a substantial burden on the economy. In addition to providing a space for children's learning, schools often serve as centers for community activities and constitute social infrastructure that is key in the fight against poverty, illiteracy and a disease free world. The Education for All and Millennium Development Goals cannot be achieved without the construction of safer and more disaster resilient education facilities.

Safer School Construction Guidance Notes: The Vision

The institutionalization of guiding principles for the construction of more disaster resilient schools has been identified by governments, international organizations, and school communities as a critical need for reducing, and ideally preventing, the devastation caused by natural disasters, illustrated most recently in China, Haiti, and Pakistan. Although there are many governments and organizations engaged in the construction, retrofit and repair of safer schools as well as the production of knowledge based on their experience and practices, there is presently no one reference point from which to easily navigate and obtain the appropriate technical knowledge and valuable insights gained from similar initiatives around the world. The development and dissemination of a tool compiling a series of recommendations and guiding readers to more technical and context-specific information is an important first step in a global effort to ensure that schools in disaster-prone regions are designed and built to best protect their inhabitants.

Therefore, the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) and the Inter-Agency Network for Education in Emergencies (INEE) are working together to facilitate a consultative process to develop Guidance Notes for Safer School Construction. These Guidance Notes will provide:

1. a set of suggested steps to consider when planning and implementing the construction, retrofitting and/or repair of safer schools

2. key design and construction principles to consider when building, retrofitting or repairing school structures for greater resilience to natural disasters
3. links to resources including designs, manuals, academic studies, case studies and other materials based on the experience and research of practitioners and technical experts around the globe

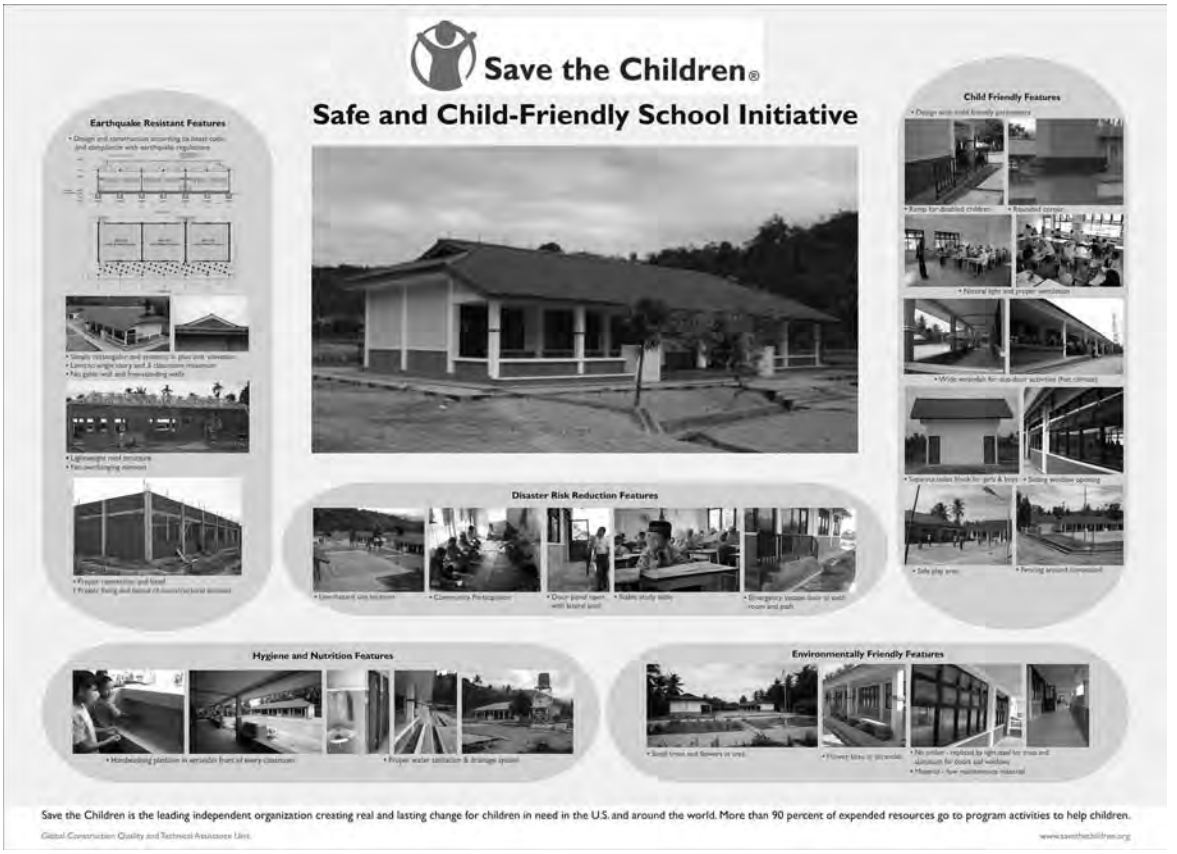
Guidance Notes on Safer School Construction: The Process

The Guidance Notes are being developed through a consultative process involving continuous input from a technical expert resource group as well as virtual and face-to-face consultations with education, disaster prevention, shelter design and construction stakeholders to ensure not only sound technical input but also that the tool is practical and user-friendly. Moreover, the Guidance Notes draw on material already available, which will ensure that the content is based upon concrete experiences, good practices and lessons learnt. Once finalized, the guidance notes will be produced, translated and widely launched in the second half of 2009 by the GFDRR and INEE in partnership with other networks and organizations. It is envisioned that these guidance notes will be an evolving document, which will be regularly revised to include new and appropriate research, insights and practices thereby maintaining its relevancy and usefulness.

For more details on the process as well as to access additional materials on safer school construction, please go to: www.ineesite.org/saferschool construction.

APPENDIX 2

Safe and Child Friendly School Buildings: A Save the Children poster



APPENDIX 3

Acknowledgements and Links to Additional Information, List of Documents Consulted

Acknowledgements

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tional; Dr Yasamin O. Izadkhah, IIEES; Russell Johnson, Architect AIA; Aygül L. Kabaca, INEE; Jane Kalista, UNESCO; Anup Karanth, Geo-hazards Society (GHS, India); Yalçın Kaya, Istanbul Seismic Risk Mitigation Project, Special Provincial Administration; Amir Ali Khan, National Institute of Disaster Management, Government of India; Dr. Frederick Krimgold, Disaster Risk Reduction Program at Virginia Tech; Hari Kumar, GeoHazards Society; Clement Lado, ICCO Sudan; James Lewis, Datum International; Shirley Long, Save the Children UK; Rachel McKinney, UNICEF; Maury Mendenhall, World Learning; H. Kit Miyamoto, Miyamoto International, Inc.; Solmaz Mohadjer, Teachers Without Borders; Michael Morrissey, Australian Agency for International Development; Martha Muhwezi, Forum for African Women Educationlists; Christina Tobias-Nahi, Islamic Relief USA; Amarah Niazi, Relief International; Susan Nicolai IASC Education Cluster and Save the Children; Sjoerd Nienhuys, Architectural Engineer; Audrey Nirrengarten, UNHCR; Øyvind Nordlie, Norwegian Refugee Council; John Norton, Development Workshop France; Omnia Abdul Aziz Nour, Reach Out To Asia (Qatar Foundation); Fahma Nur, World Bank; Adeyemi Ogunmefun, Commonwealth Secretariat; Kjersti Okkelmo, Save the Children; Khizer Omer, Aga Khan Planning and Building Service; Gary Keith Ovington, UNICEF; Mehmet Emre Ozcanli, Turkish Association of Seismic Isolation and EM-KE Construction Ltd.; Bishnu Hari Pandey, Earthquake Engineering Research Facility at the University of British Columbia; Karen Peffley, World Bank; Marla Petal, Risk RED; Garry de la Pomerai, COGSS DPE Safe School Construction Work group and UK Advisory Group for Natural Disasters; Marina Doris Lenus Ponnukone, War Child Holland Sudan; Krishna S Pribadi, Center for Disaster Mitigation at Institute of Technology of Bandung; Perrine Punwani, International Rescue Committee; Navaid Qureshi, IFC; Aloysius Rego, Asian Disaster Preparedness Center; Christel Rose, International Strategy for Disaster Reduction; Bente Sandal-Aasen, Save the Children Norway; Graham Saunders, International Federation of Red Cross and Red Crescent Societies and IASC Shelter Cluster; Dipan Shah, Society for Environment Protection; Hari Darshan Shrestha, Save the Children; Jo da Silva, Arup International Development UK; Ezra Simon, World Learning; Robin Spence, Structural Engineer and Emeritus Professor of Architectural Engineering; Jishnu Subedi, Nepal Engineering College; Martin Suvatne, Norwegian Refugee Council; Bathazar Tribunalo, Plan International; Zeynep Turkmen, Center for Disaster Management at Bogazici University; Cuneyt Tuzun, Bogazici University, Kandilli Observatory and Earthquake Research Institute; Dr. John Twigg, Benfield UCL Hazard Research Centre at the University College London; Claudio Osorio Urzúa, UNICEF; Carlos Vasquez , UNICEF; Dr. Carlos Estuardo Ventura, Earthquake Engineering Research Facility at the University of British Columbia; Cara Vileno, US Department of Labor; Nigel Wakeham, Architect; Jolanda Kryspin-Watson, World Bank; Dr David Week, Assai Pty Ltd; Ben Wisner, Benfield University Hazard Research Centre at the University College London; Patrick White, US Department of Labor; Sharon Wright, Independent Consultant; Can Zulfikar, Kandilli Observatory and Earthquake Research Institute at Bogazici University; Donna Chus, Gabrielle Apollon, Kelly Ogden-Schuette, SIPA, Columbia University.

LINKS TO ADDITIONAL INFORMATION

PLANNING

Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds
http://www.fema.gov/library/viewRecord.do?id=1986

Tools for Mainstreaming Disaster Risk Reduction: Guidance Notes for Development Organisations, (2007) By ProVention Consortium
http://www.proventionconsortium.org/themes/default/pdfs/tools_for_mainstreaming_DRR.pdf

INEE Minimum Standards, Analysis standards 3 (Monitoring) and 4 (Evaluation), (2004) INEE
http://www.exacteditions.com/exact/browse/436/494/2635/2/1

Handbook for Educational Buildings Planning Educational buildings and equipment (1988) UNESCO
By Almeida, Rodolfo
http://www.eric.ed.gov/ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED326985&ERICExtSearch_SearchType_0=no&accno=ED326985

School Construction in Developing Countries: What do we know? (2002) By Serge Theunynck
http://www.sheltercentre.org/sites/default/files/Theunynck%20(2002)%20School%20Construction%20in%20Developing%20Countires.pdf

Disaster Prevention for Schools Guidance for Education Sector Decision-Makers (2008) *UNISDR Thematic Platform for Knowledge and Education*
http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=7344

Disaster Risk Reduction begins at School (2008) *UNISDR Thematic Platform for Knowledge and Education*
http://www.unisdr.org/eng/public_aware/world_camp/2006-2007/case-study-en.htm

Safe Schools for the Community: Earthquake Resistant Buildings in India (2008) Sanjaya Bhatia
www.solutionexchange-un.net.in/drm/cr/res13100801.doc

Plan Hemisferico de Accion para la Reduccion de Vulnerabilidad del Sector Educativo a los Desastres By Pedro Bastidas
http://www.preventionweb.net/files/8016_Asuntospendientesdelaplantaedsica.pdf

Ensuring Safer Building Construction Practices in Sri Lanka By Geethi Karunaratne
http://www.adpc.net/audmp/rllw/themes/th6-geethi.pdf

Developing Building for Safety Programmes: Guidelines for organizing safe building programmes in disaster-prone areas (* Book from 1995, ISBN: 9781853391842) Aysan, Y et al.

School Buildings - Planning, Design and Management by A K Jain (JBA Publishers, ISBN: 81-89800-40-X)

ENGINEER TRAINING AND SAMPLE TERMS OF REFERENCE

SELECTED TRAINING MATERIALS FROM THE ATC/SEAOC 'ATC-48 BUILT TO RESIST EARTHQUAKES' TRAINING CURRICULUM

http://www.atcouncil.org/atc-48.shtml

Vulnerability Assessment of Shelters in the Eastern Caribbean Retrofitting By Tony Gibbs of Consulting Engineers Partnership Ltd.(For USAID, OAS)
http://www.oas.org/CDMP/document/schools/retrofit.htm

DRR Education and Awareness-raising
Child-Led Disaster Risk Reduction: A Practical Guide (2007) By Save the Children – Lynne Benson and John Bugge
http://www.preventionweb.net/files/3820_CHLDRR.pdf

Let our Children Teach Us! A Review of the Role of Education and Knowledge in Risk Reduction (2006) By Ben Wisner
http://www.unisdr.org/eng/task%20force/working%20groups/knowledge-education/docs/Let-our-Children-Teach-Us.pdf

Natural Disaster Awareness Tool Catalogue French Red Cross website with awareness raising tools classifie
http://pirac.croix-rouge.fr/index.php

Disaster Prevention for Schools Guidance for Education Sector Decision-Makers (2008) *UNISDR Thematic Platform for Knowledge and Education*

http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=7344

Reducing Vulnerability of School Children to Earthquakes By UNCRD
http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=4001

Integrating Disaster Risk Reduction into School Curriculum: Mainstreaming Disaster Risk Reduction into Education By ADPC
http://www.preventionweb.net/files/4006_ADPCEducGuidelineConsultationVersion3.1.pdf

Disaster Risk Reduction Begins at School 2006-2007 By UNISDR
http://www.unisdr.org/eng/public_aware/world_camp/2006-2007/pdf/WDRC-2006-2007-English-fullversion.pdf

DISASTER AWARENESS FOR SCHOOLS A resource guide for Caribbean teachers (2000) By Caribbean Disaster Emergency Response Agency
http://www.preventionweb.net/english/professional/trainings-events/edu-materials/v.php?id=6932

Firewise Generation
http://www.firewise.org/fw-generation/

Fire Safe: Teacher Resource for Years 3 to 6 By the Australian Country Fire Authority
http://www.cfa.vic.gov.au/teachers/resources/firesafebooks_firesafe.htm

Junior FireSafe: Teacher Resource By the Australian Country Fire Authority
http://www.cfa.vic.gov.au/teachers/resources/firesafebooks_junior.htm

Effective Education For Disaster Risk Reduction – Teachers Network
http://edu4drr.ning.com/

EARTHQUAKE PROBLEM: Do's and Don'ts for Protection By Department of Earthquake Engineering, University of Roorkee
http://www.nicee.org/uploads/D_D.pdf

RISK, HAZARD, AND VULNERABILITY ASSESSMENT AND MAPPING

FEMA Flood Hazard Mapping Resources
http://www.fema.gov/plan/prevent/fhm/frm_docs.shtm

Flood Hazard Assessment for the Construction of Flood Hazard Map and Land Development Priority Map Using NOAA/AVHRR Data and GIS - A Case Study in Bangladesh ( ) Md. Monirul Islam & Kimiteru Sado
http://www.gisdevelopment.net/application/natural_hazards/floods/floods002pf.htm

Hazard Mapping and Vulnerability Assessment
By Toshiaki Udono and Awadh Kishor Sah
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Measuring Mitigation: Methodologies for assessing natural hazard risks and the net benefits of mitigation: A scoping study By Charlotte Benson and John Twigg
http://www.proventionconsortium.org/themes/default/pdfs/MM_scoping_study.pdf

Multi-Hazard Disaster Risk Modelling and its Application in School Safety: Experience from Gujarat
http://www.schoolsafetyconference.org/Papers/General%20Papers/General%20-%20SEHAR%20IQBAL.pdf

Report on Natural Hazard Mapping and Vulnerability Workshop
http://www.oas.org/cdmp/hazmap/Grenada/atwell.htm#CaseStudies

A Guide to School Vulnerability Assessments: Key Principles for Safe Schools
By U.S. Department of Education
http://rems.ed.gov/views/documents/VA_Report_2008.pdf

Communicating with Owners and Managers of New Buildings on Earthquake Risk: A Primer for Design Professionals
http://www.fema.gov/library/viewRecord.do?id=1431

HAZARD DATA RESOURCES

UNEP GRID – Directory to Web-hosted hazard data sources
http://www.grid.unep.ch/activities/earlywarning/link.php

Project of Risk Evaluation, Vulnerability, Information & Early Warning (Pre-View)
http://www.grid.unep.ch/activities/earlywarning/preview/index.php

Munich RE Natural Hazards Assessment Network
http://mrnathan.munichre.com/

Global Risk Identification Program (GRIP)
http://www.gripweb.org/grip.php?ido=1&lang=eng

Global Risk Data Platform
http://www.grid.unep.ch/activities/earlywarning/preview/data/data_sources/index_data_sources.php

Dartmouth Flood Observatory –World Atlas of Flood Hazard
http://www.dartmouth.edu/~floods/Atlas.html

Pacific Data Center Asia Pacific Natural Hazards Information Network
http://www.pdc.org/mde/

Pacific Data Center Hazard Mapping Tools
http://www.pdc.org/iweb/products.jsp

Natural Disasters Data Book (2006)
http://www.adrc.asia/publications/databook/DB2006_e.html

BUILDING ASSESSMENT AND RETROFIT PRIORITIZATION

ATC-38 POSTEARTHQUAKE BUILDING PERFORMANCE ASSESSMENT FORM
http://www.atcouncil.org/pdfs/atc38assmtfrm.pdf

ATC-45 Field Manual: Safety Evaluation of Buildings after Wind Storms and Floods
http://www.atcouncil.org/ATC45.shtml

Seismic Evaluation of Existing Buildings, SEI/ASCE 31-03
https://secure.asce.org/ASCEWebSite/BOOKSTORE/BookDescription.aspx?ProdId=916

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http://www.concrete.org/bookstore/bookstore.htm

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http://www.asce.org/static/hurricane/journal.cfm/

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Resource Library
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INEE Resources Database
http://www.ineesite.org/index.php/resourcedb/

INEE_MS_Toolkit- Establishing a Safe Learning Environment
http://ineesite.org/uploads/documents/store/doc_1_INEE_tools_for_learning_space.pdf

National Clearinghouse for Educational Facilities (NCEF) Publications on School Safety and Security
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National Hazards Center Library Hazlit Database
http://ibs.colorado.edu/hazards/library/hazlit/NatHazSearch.php

Natural Hazards Center at the University of Colorado
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