58795

EAP DRM KnowledgeNotes

Working Paper
Series No. 22

Disaster Risk Management in East Asia and the Pacific

PROTECTING SCHOOLS AND HOSPITALS FROM NATURAL HAZARDS

By Matteo Ferrucci

THE NEED FOR ACTION

Evidence from past events in the East Asia and Pacific Region demonstrates that such critical infrastructure as health and educational facilities is heavily exposed to natural disasters. For example, the Wenchuan Earthquake, which affected China in 2008, impacted 52 percent of the health care centers[1] and damaged more than 14,000 educational facilities killing over 5,000 students[2]. In Myanmar in 2008, Cyclone Nargis damaged or destroyed nearly 75 percent of the health facilities and more than half schools in the area affected[3]. Super Typhoon Durian hit the Philippines in 2006 and damaged more than half of the schools in five different cities, costing US$20 million[4].

In this scenario, there is a growing necessity of preventing natural hazards from having such a devastating impact on critical infrastructure. Enhancing the resilience of schools and hospitals to natural disasters is a responsibility of all authorities and stakeholders involved and a priority for the Disaster Risk Management (DRM) agenda. Not only would lives and property be saved, but more effective emergency management will be enabled. In fact, schools and hospitals can serve as community shelters during a disaster or as a place to coordinate post disaster activities. Considering the critical role of schools and hospitals, priority should be placed on identifying and reducing the weaknesses of existing facilities and on improving the building standards for new construction. While damage and losses associated with extreme events may exceed a country's GDP, the implementation of mitigation measures aimed at improving the resilience of existing facilities provides a cost-effective preventive solution, generally limited to 4 percent of the initial investment cost.[5]

---

1 Source: www.unicef.org/china/reallives_10352.html
2 Source: WB Beijing Office, China
3 Source: www.unicef.org/infobycountry/media_49541.html
4 Source: Risk Red: Disaster-Resilient Education and Safe Schools: What Educational Authorities Can Do
5 WHO (2007) Disaster Risk Reduction and Preparedness of Health Facilities. A literature review Prepared by the WHO Kobe Centre, Japan

This working paper series is produced by the East Asia and Pacific Disaster Risk Management Team of the World Bank, with support from the Global Facility for Disaster Reduction and Recovery (GFDRR). The series is meant to provide just-in-time good practice examples and lessons learned from projects and programs related to aspects of disaster risk management.

THE WORLD BANK

GFDRR
Global Facility for Disaster Reduction and Recovery

IMPROVING THE SAFETY OF EXISTING FACILITIES

The objective of improving the resilience of existing key assets can be achieved through the development and implementation of a **disaster risk reduction (DRR) plan**. The plan identifies and prioritizes appropriate vulnerability mitigation measures aimed at strengthening the structural integrity and spatial safety of a facility.

Performing a risk assessment. The development of an effective DRR plan should start by assessing the causal factors of disasters and their relation to the building structure and site, a phase known as risk assessment. Risk assessment is the combination of (i) **hazard assessment** aimed at identifying the nature, location, intensity, and frequency of an extreme event through the utilization of multi-hazard or hazard-specific risk maps and (ii) **vulnerability assessment** focused on evaluating the degree of exposure of the construction site or the facility (or a sample set of facilities) to the identified threats. The nature of the vulnerability can be: (a) *structural*, attributable to the elements that are part of the resistant system; (b) *non-structural*, architectural components, mechanical, plumbing, and electrical items that provide utilities and services to the building; or (c) *functional*, on-site accessibility, availability of open spaces, equipment and supplies, and security and alarm systems. This is because, in order to avoid loss of function and secondary damage and to prevent injury during a disaster, in addition to strengthening the structure itself, it is also necessary to secure non-structural components and ensure the functionality of all services.

The structural vulnerability assessment comprises a preliminary vulnerability screening of the facilities at risk. It determines compliance with a set of standards or acceptable criteria and a detailed vulnerability investigation focused on evaluating structural and spatial weaknesses of the facility by means of quantitative techniques.

Identifying risk mitigation measures based on an acceptable level of performance. Interventions should be based on pre-defined risk reduction goals and objectives. In the case of critical facilities, risk mitigation measures are aimed at achieving an acceptable level of performance that promotes life protection, safe evacuation, and continuity of operations during a hazardous event (functional protection). This is particularly true in the case of hospitals, which are needed to be fully functional centers of emergency response and relief. For this reason, securing of non-structural elements is critical.

The degree of vulnerability mitigation to be achieved is based on the results of the risk assessment and on the level of performance desired, as well as on the resources and capacity available in the country.

According to the nature of vulnerability, mitigation measures can be divided into three categories: (i) *structural retrofitting:* aimed at improving the building's capacity to withstand the forces exerted by natural hazards: adding resisting elements, increasing strength/ductility, and improving connections between elements; (ii) *approaches that focus on spatial safety:* relocation of the building or its components, and restraining the mobility of furniture and equipment; and (iii) *strategies for functional vulnerability reduction:* ensuring safe access, continuity of water and electricity supply, warning systems, and safety equipment.

Preparing and implementing the DRR plan. The outcomes of the assessment process and the identified mitigation strategies should become part of a documented plan, together with other relevant information, such as timeframe for implementation, sources of funding, and compliance with existing building codes.

Prioritizing retrofitting interventions. When a large inventory of exposed schools and hospitals exists within a country or project area, prudent investing in retrofitting solutions should be planned over time and according to the resources available. The prioritization scheme should be based on the vulnerability assessment of each stand-alone facility and on cost–benefit considerations. The latter rely on weighted indexes that account for the relative importance of multiple aspects that contribute to overall risk. These include vicinity to the source(s) of risk(s), building age and material, and number of children/patients. The implementation of retrofitting solutions should be prioritized on a case-specific basis and the technical measures to be implemented and their costs–benefits subject to site-specific feasibility studies. One of the best arguments for demonstrating that safety in schools and hospitals can be achieved is to showcase experience from different countries that have completed or are undertaking critical facility protection projects. Box 1 describes an example of good practice in the prioritization of retrofitting interventions under a project funded by the World Bank, and Box 2 tells the success story of a Chinese teacher who staved off the mortal effects of the Wenchuan Earthquake in 2008.

Box 1. Retrofitting/Reconstruction of Public Facilities under the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (2005)

Under the Seismic Risk Mitigation for Priority Public Facilities component of a World Bank project, a total of 840 critical public facilities, including schools, hospitals, polyclinics, and schools dormitories, were shortlisted for retrofitting from a comprehensive building inventory prepared by the Istanbul Governorship Disaster Management Center (AYM). The selection process was based on such criteria as accessibility, year of construction, distance from fault lines, building capacity, and other relevant characteristics depending on the type of facility. A set of coefficients indicating the relative importance of each criterion was used to weight each factor involved in the selection process. When feasibility studies and cost–benefit analysis demonstrated the limited effectiveness of retrofitting or when a facility was anticipated to be particularly critical for emergency response, the structure was considered eligible for reconstruction.

Box 2. A Success Story: Angel Ye and the Sangzao Middle School[1]

The Chinese government estimates that more than 7,000 schoolrooms collapsed in the Wenchuan Earthquake. Nevertheless, there is a farming town in central China where all 2,323 students survived the earthquake. This was made possible thanks to the efforts of the school's principal, Ye Zhiping, better known by the locals as Angel Ye, who in the 1990s successfully pressed the county government for US$58,000 to retrofit schools. With the funds he was able to carry out risk mitigation works, including insertion of iron rods into the concrete columns and reinforcement of the balcony railings. These structural reinforcement measures, coupled with recurrent evacuation drills, explain why the Sangzao schools remained standing while unreinforced schools collapsed. For example, the Beichuan Middle School, located just 20 miles north of Sangzao, failed, killing 1,000 students and teachers.

1 The New York Times: "How Angel of Sichuan Saved School in Quake" http://www.nytimes.com/2008/06/16/world/asia/16quake.html

CONSTRUCTION OF NEW HAZARD-RESILIENT FACILITIES

In circumstances such as reconstruction after a major natural disaster or when the cost of reinforcement is higher than a predefined threshold, construction of new hazard-resilient facilities is required. In this case, risk can be mitigated by incorporating disaster risk reduction (DRR) principles into national construction standards aimed at minimizing the vulnerability of the assets and their occupants to natural hazards. In many developing countries, construction codes lack the technical soundness and rigor necessary to ensure adequate performance of the structure during an extreme event and do not capture the importance of site selection and emergency preparedness as major components of spatial safety. Moreover, an insufficiency of certification and accreditation of engineers, inspectors, and contractors coupled with lengthy permit approval processes (which could take over 200 days[6] in many developing countries) lead to corruption. On the contrary, the government should enforce building codes in a programmatic manner, incentivizing public institutions to build according to standards. In Madagascar's recent cyclone-resistant building regulations, for example, builders and inspectors are liable for potential disaster damages and losses, and community-based organizations are allowed to press judicial charges after a disaster.

While there are universal principles for hazard resilient construction (construction criteria are based on the probability of a natural hazard striking a given area), when planning for the reconstruction of key facilities, it is important to bear in mind local methodologies. Lessons learned from past events, such as the 2010 earthquake in Chile, demonstrate that non-engineered structures based on local building techniques like confined masonry or prefabricated steel-framed structures (see top photo on page 4) were largely undamaged and saved lives, despite the fact that they were located in areas with extensive damage.

6 Source: www.doingbusiness.org/ExploreTopics/DealingLicenses/

It is not only about the structure. Hazard-resilient construction is based on the combination of (i) structural integrity measures aimed at ensuring that the structure is capable of resisting the forces exerted by the natural hazard and (ii) spatial safety measures such as selection of a safe construction site and emergency preparedness and evacuation plans effectively integrated with early warning systems. Spatial safety approaches focus on such concepts as site development schemes, land use planning, and risk mapping.

Similar to retrofitting, hazard-resilient construction is based on the concept of performance-based objectives. In the case of educational and health facilities, given their need to remain functional and provide shelter during and after a disaster, the level of performance to be met should be higher than that of other facilities. This entails the adoption of more stringent design criteria and systematic implementation of inspection, maintenance, and monitoring procedures. Box 3 shows how California's being at the fore in seismic risk mitigation dates back to the 1930s.

While inadequacy of building codes is responsible for the majority of structural and non-structural damages, in some cases the key is the lack of enforcement and implementation monitoring. A significant increase in the code enforcement level can be accomplished by promoting a culture of risk knowledge and hazard awareness.

What about the people? Safe construction alone is not sufficient to prevent disasters. The concept of securing schools and hospitals must encompass crosscutting themes of disaster management like risk awareness and disaster preparedness in the school or hospital community. Education, training, and community participation are the key elements of capacity development, which in turn is a central strategy for reducing disaster risk. Risk awareness can be strengthened at an institutional level by enforcing building codes (see Box 4), creating initiatives to involve all societal sectors – from the community to local governments (see Box 5) – or establishing disaster education on a single facility basis. The latter encompasses the integration of disaster-related courses in the formal curricula, extracurricular informal education, teacher training, and dissemination of successful case studies. Such activities could range from the explanation of emergency preparedness and evacuation plans to basic first aid courses or special science or geography modules related to the mechanisms of natural

Box 3. California Field Act of 1933

Following the devastating Long Beach Earthquake, which destroyed or damaged a total of 230 school buildings, public awareness of seismic risk pushed the California State Legislature to pass the Field Act within 30 days of the quake. The core of the Act was the banning of unreinforced masonry construction and the requirement of factoring seismic loads into retrofitting of existing assets and construction of new facilities. The Act also supported the development of independent inspection and quality control procedures to be reviewed by qualified engineers and architects. The early benefits of the Act in terms of school safety were demonstrated seven years later when an earthquake larger in magnitude than the Long Beach Earthquake (the Imperial Valley Earthquake) caused negligible or no damage to buildings constructed after the Field Act. More importantly, since the Act has been in force, no compliant building has suffered partial or total collapse or caused the injury or death of a student or teacher. Moreover, the cost of repairing damage to schools in compliance with the Field Act has ranged from 10 to 100 times below repair costs for other schools.

hazards. In the case of hospitals, training programs for personnel are essential to ensuring that primary operations continue to function in the event of an earthquake (e.g., train the individual to operate emergency power-generating equipment in hospital facilities).

Box 4. Enforcement of Building Codes under the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (2005)

With the objective of strengthening the institutional and technical capacity of the Greater Istanbul Municipality and district municipalities to enforce building codes and compliance with land use plans, a set of subcomponents were planned and implemented as part of a well-defined strategy. The strategy for building code enforcement was based on the key findings of a study carried out during project preparation, which revealed that the lack of enforced building codes was attributed to gaps in the legal framework and inadequacy of certifications and public understanding. The strategy focused on public awareness campaigns, the development of a regulatory framework to better enforce building codes and increase compliance with land use plans, voluntary accreditation and training of engineers, and increased transparency in the issuance of building permits.

Box 5. *Shake Out – Get Ready!* Program in California

A culture of disaster risk reduction can be built through the implementation of disaster simulations and evacuation drills on a regular basis. While these activities are needed to test the effectiveness of the early warning and response systems, elevating them to educational and learning events is, in fact, important. An example is the *Shake Out – Get Ready* initiative recently launched by the State of California in partnership with organizations including the U.S. Geological and Survey (USGS) and Federal Emergency Management Agency (FEMA). It consists of having a simultaneous earthquake simulation drill across all social sectors, from individuals to local governments, in order to sensitize the population to seismic risk.

A MULTI-HAZARD APPROACH

Construction and retrofitting of key facilities should be conducted using a multi-hazard approach, both in the risk assessment and the risk mitigation phases. In risk assessment, this could be carried out by overlapping single hazard locations to produce multi-hazard maps, which in turn could be superimposed on maps containing schools and hospital locations. This would allow identifying priority facilities and appropriate cost-effective mitigation measures to be implemented.

In risk mitigation, a multi-hazard approach involves design consideration of the potential risks deriving from all natural hazards affecting an area. The resulting cumulative risk cannot be offset if only select hazardous events are factored into the design. Accounting for the full range of potential natural hazards in performance-based design will lead to greater effectiveness and cost-efficiency of the retrofitting or construction process.

HOW MUCH DOES IT COST?

A cost-effective solution. While natural disasters have been traditionally seen as unpredictable events and efforts of countries and donors have concentrated on post disaster reconstruction, scientific advances and the increased capability to predict and mitigate the impacts of disasters have shifted cost-effectiveness towards the pre-disaster side of the disaster risk management spectrum. The financial cost of mitigating the personal tragedies and economic repercussions of natural hazards is minimal when the society and the governing bodies are well informed and able to advocate for the proper techniques.

For example, a mitigation investment to improve the structural integrity of a school or hospital would increase total construction costs by no more than 1–2 percent. Considering that interventions aimed at reducing non-structural vulnerability would add an additional 2 percent for hospitals and 1 percent for schools, the total premium would not exceed 4 percent of the initial investment cost.

Ghesquiere et al. (2006) focused on the seismic probabilistic cost–benefit analysis of sample facilities (not limited to schools and hospitals, but also including administrative buildings and fire stations). The work suggested that retrofitting significantly decreases the Probable Maximum Loss (PML) for all types of buildings; in particular, the losses for schools were reduced from 30 to 4 percent of the asset value. For recurrent and less intense events like cyclones, the incremental benefits of investing in stronger codes may not necessarily outweigh the benefits derived from building new non-engineered facilities in areas that lack health or educational services.

With regard to new construction, the payoff for incorporating hazard resistance is enormous. The introduction of hazard resistant design measures in the construction of new facilities would increase costs by 5–24 percent, which is considerably low compared to the cost of reconstruction or damage repair after a major disaster. Even so, the most powerful argument in favor of improving the resilience of buildings is the societal benefit derived from a hospital or school that is safe and fully operational during a disaster.

REFERENCES AND KEY RESOURCES

Global Facility for Disaster Reduction and Recovery (GFDRR). Guidance Note for Integration of Disaster Risk Reduction in World Bank Health Sector Projects. Mimeo.

Global Facility for Disaster Reduction and Recovery (GFDRR). Guidance Note for Integration of Disaster Risk Reduction in Education Sector for World Bank Projects. Mimeo.

Ghesquiere, F., L. Jamin, and O. Mahul. 2006. *Earthquake Vulnerability Reduction Program in Colombia: A Probabilistic Cost–Benefit Analysis*. Policy Research Working Paper 3939. Washington, DC: World Bank.

Jha, A. 2010. "Mainstreaming Disaster Risk Management in East Asia Pacific." PowerPoint Presentation. Washington, DC: World Bank.

PAHO/WHO. 2003. Protecting New Health Facilities from Disasters: Guidelines for the Promotion of Disaster Mitigation. Washington, DC: PAHO/World Bank.

PAHO/World Bank. 2004. Guidelines for Vulnerability Reduction in the Design of New Health Facilities. Washington, DC: PAHO/World Bank.

Tanhueaco, R. 2010. Guidance Note: One Million Safe Schools and Hospitals. Geneva: United Nations International Strategy for Disaster Reduction - Asia and the Pacific.

WHO. 2006. Field Manual for Capacity Assessment of Health Facilities: Responding to Emergencies. Manila: World Health Organization, Western Pacific Region.

THE WORLD BANK

East Asia and the Pacific Region

The World Bank

1818 H St. NW, Washington, D.C., 20433

http://www.worldbank.org/eap

Special thanks and appreciation are extended to the partners who support GFDRR's work to protect livelihoods and improve lives: ACP Secretariat, Australia, Belgium, Brazil, Canada, Denmark, European Commission, Finland, France, Germany, India, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, UN International Strategy for Disaster Reduction, and the World Bank.