Global Alliance for Disaster Risk Reduction & Resilience in the Education Sector

Towards Safer School Construction

A community-based approach

United Nations Educational, Scientific and Cultural Organization

ARUP

Save the Children

GFDRR Global Facility for Disaster Reduction and Recovery

risk RED risk reduction education for disasters

CASE STUDY

Some key principles in practice:
Trade-offs in post-disaster response

Country: Haiti

Organisation: Save the Children

Hazards: Earthquakes, flash floods, high winds

Summary: Reconstruction in the wake of the 2010 Haiti earthquake was extremely challenging, spanning many years and hundreds of organisations. In the complex and shifting post-disaster context, the international humanitarian organisation Save the Children was tasked with providing school buildings to get children off the streets and back into school. Amid conflicting pressures of time, resource constraints, internal organisational mandates and relations with the Haiti government, Save the Children made difficult trade-offs to complete their mission using community-based principles.

Country and hazard overview

In 2010, a devastating earthquake struck Haiti, damaging or destroying 80 percent of schools around the capital city Port-au-Prince. Nearly 250,000 people were killed, and one-third of the population displaced. Most documents from the past 204 years of Haitian governance were buried under rubble. Land tenure was almost impossible to determine and the Haitian MoE was overwhelmed by the crisis, despite good coordination. In this extremely difficult context, Save the Children – who was co-leading the Education Cluster with UNICEF while working alongside other NGOs and the MoE – rushed to respond.

Returning children to the classroom was the most pressing goal for Save the Children from both educational and child-protection perspectives. Aiming for immediate relief amid the post-disaster turmoil required Save the Children to make difficult trade-offs. Pressures from key stakeholders pushed and pulled the school construction program, sometimes in opposing directions.

A laudable success

The Education Cluster was run by Save the Children and UNICEF. Together, they coordinated the efforts of approximately 100 organisations.

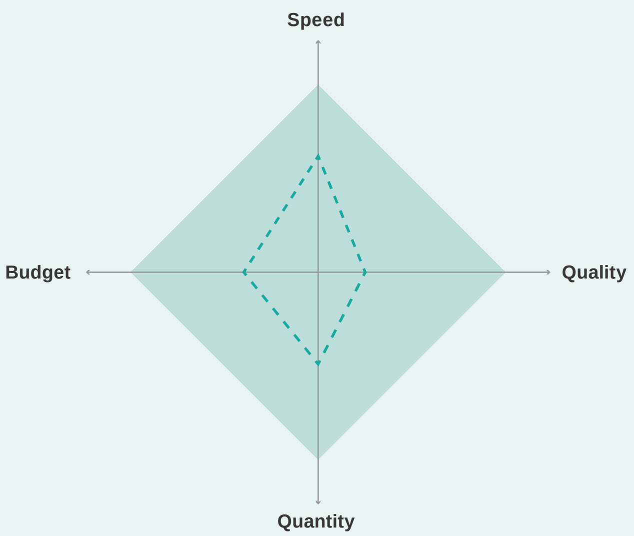
Collectively, the Haiti Education Cluster established more than 1,000 temporary learning spaces, trained more than 10,000 teachers in psychosocial support for children, facilitated the return to school of more than 1 million students, and undertook cholera-prevention activities in 20,000 schools.

Save the Children alone constructed at least 100 schools, helping thousands of children get off the street into their successful education programming that followed. Surveys indicate that community members were extremely grateful for Save the Children's efforts.

Key decisions or trade-offs:

- **Speed versus quantity.** Construction speed and cost versus building lifespan – to build semi-permanent or permanent?
- **Quality versus speed.** A consistent design for better compliance to safety standards and streamlined construction versus design diversity for increased functionality and tailoring to specific site characteristics.
- **Cost versus quantity.** Higher costs of site-specific design versus the economy of scale that comes with a consistent design template.
- **Quantity versus quality.** Breadth of school construction versus depth of community engagement – creating community "ownership" versus building more schools.

These conflicting considerations can be conceptualised by the project diamond: prioritising time, cost, quantity or quality can only be achieved at the cost of other factors.



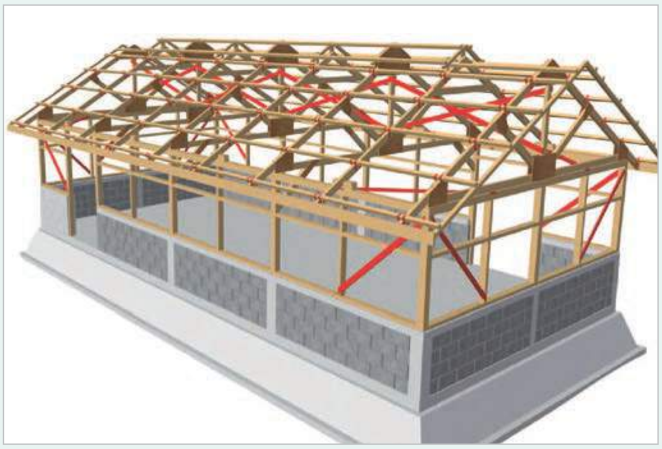
Many of the key trade-offs were made at the design stage, which in turn dictated the programmatic decisions that followed. Save the Children opted for a standardised school design and a semi-permanent structure in an attempt to optimise donor expectations for an immediate response, speed and cost.

A semi-permanent lifespan was seen as a middle ground. Donors were less inclined to lend money for permanent structures when the country was in the emergency and immediate recovery phase. Save the Children had its own goal to build a certain quota of schools and were contractually obligated to achieve those numbers. The Haitian MoE was also requesting temporary, immediate construction. Even as they drafted the design, they recognised that some building elements, in particular the plywood cladding, would require maintenance and replacement.

The semi-permanent school design was approved by the Haiti government through a protracted process, meaning the first schools were completed in June 2011 and the last schools in early 2013, three years after the earthquake. Initially, the short-term strategy made sense, but navigating the economic and political environment took so much time that the original argument for speed decayed. This left Save the Children with two key lessons about trade-offs in construction lifespan: the staff needed a shared definition of 'semi-permanent', and a well-communicated plan for upgrading schools to permanent structures when they degraded.

Ensure technical oversight and engage as partners

Many school construction projects functioned well with the standardised building footprint, while some required compromise to achieve sufficient classroom numbers. In the latter cases, school administrators made ad-hoc changes, some of which compromised safety and classroom function. A five-way memorandum of understanding (MOU) was established in an attempt to mitigate these changes. The MOU provided written agreement of roles and responsibilities of each stakeholder in advance, including school staff, MoE, Save the Children, the municipality and the local Parent-Teacher Association (PTA).



Schools were all single-story with 190-cm-high reinforced concrete skirt walls. The walls were topped with timber framing and clad with plywood. Corrugated metal was used for the roof. Graphic: Save the Children.

Because only a narrow gap existed between school buildings, the school staff cut doors into the gable-end walls of the buildings. The ad-hoc change removed bracing designed to help the building resist earthquakes and hurricanes. With doors only at the end of the long row of classrooms, building evacuation was also serious compromised. Photo: Bill Flinn.

When the site could not accommodate three standardised school building blocks, on-site engineers were able to improvise effectively, designing a staggered arrangement without compromising safety. Photo: Bill Flinn.

Both successful and unsuccessful examples of design modification show that technical management can make a huge difference in school safety. Having a suite of approved design alternatives can be a good option when on-site technical capacity is low, providing the site manager with reasonable flexibility. Further trainings and quality control can then be used to bolster the technical capacity of these local site managers. However, if further training is not possible, designs can be modified effectively if both qualified engineers and architects are on-site regularly.

Develop capacity and bolster livelihoods while building a culture of safety

To build community capacity and place disaster risk reduction at the forefront of all decisions, Save the Children formed Safer Construction and Disaster Risk Reduction Teams at each site. The process involved creating a detailed construction manual, posters of key concepts and models of rebar bending and lapping. They also held training sessions with builders and taught risk-analysis workshops to the school PTA and community members. Even with those strong steps, building risk reduction capacity during a humanitarian response was challenging.

Posters and a detailed training manual in Creole were used to communicate building schematics, material quality and the construction process. These materials were developed with the intention of helping Haitian engineers with on-site instruction. However, this communication style was not always in-sync with how local builders understood information. The team had more success with color-coded physical models showing the proper placement of steel reinforcement bars. Another challenge was that although training taught local contractors to identify high-quality sand and gravel, they often chose to purchase cheap, low-quality goods.

Significant training also was required to achieve the desired quality of construction. During site visits in the pilot phase, local engineers saw apparent high-quality construction but did not always have sufficient training to understand when external building elements were misleading. For them, if the required building elements were present then it passed the test but they did not always realise the quantity and placement of these elements was paramount in Haiti's high seismic and hurricane risk environment. For example, the lack of roof gable braces and sparse nailing patterns on timber frame connectors were not seen as problematic when they should have been.

While teaching local engineers about hazard-resistant design was a clear necessity in Haiti, additional benefits might have been gained by including skilled tradespeople, as well as other community members, in the earliest stages. These individuals could have assisted in some aspects of quality control, providing the double dividend of safer construction and increased community awareness on hazard-resistant construction techniques. Though it may seem unlikely that the community would spot what engineers would not, effective training from structural engineers with extensive knowledge on seismicity can increase community knowledge, aptitude and practice of safe design.

The community's long-term interest in the safety of their students might have provided extra motivation to ensure the school met top safety standards. Perhaps, just as valuable as a safer school, a more aware community may have increased demand for safer construction. Though the results may have been diffuse, the long-term impact would have been more important than any single building.

Design choice challenges

The construction typology of the school buildings was predominantly timber frame, while the modern vernacular of urban Haiti is reinforced concrete frame and concrete block. Haitians, after seeing heavy concrete walls crumble on friends and family, were fearful of rebuilding with masonry. This influenced Save the Children's initial design choice. However, those initial fears slackened over time, potentially warranting a design shift.

The construction of the concrete skirt wall provided some opportunity for training in hazard-resistant techniques, but the timber framing on the upper portions provided significantly fewer opportunities for Haitians to learn new techniques they could apply in their own homes. Learning opportunities would have been enhanced if masonry walls had been full height. These changes would not have significantly increased costs and may have dramatically increased the school's lifespan.

Key takeaways

The Save the Children experience in Haiti highlights the importance of applying key principles in safer school construction, and the challenges that come with this process. They were able to ensure the oversight of technical aspects and engage communities as partners to achieve and maintain safer schools on many sites. They were also partially able to develop the skills and awareness of local contractors and community. Supporting a culture of safety and building on local knowledge, however, proved more challenging during this complex humanitarian response.

- Periodically review decisions about the tradeoffs between 'time, quality, quantity and cost' to ensure the program remains relevant to shifting post-disaster reconstruction contexts.
- Where technical construction capacity is low but hazard risks are high, consider using visual and practical teaching approaches rather than printed guidance to engage local workers.
- Make the dissemination of risk reduction principles a deliberate goal of both private and public reconstruction projects.
- Look to lessons leant in other sectors – such as health and hygiene promotion and community-based shelter reconstruction – for effective education and behavioral change strategies that may be applicable to post-disaster safer school construction.

Students during a Disaster Reduction Drill at a school in Leogane Haiti. This school was built with Save the Children's support using innovative yet simple techniques that make it more hurricane and earthquake-resistant. Photo: Susan Warner/Save the Children.

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CASE STUDY

A decentralised approach to school construction

Country: Indonesia

Organisation: Ministry of Education, Ministry of Public Works, Ministry of Finance, World Bank

Hazards: Earthquakes, floods, landslides, high winds, volcanic eruptions, tsunamis

Summary: From 1999 Indonesia began decentralising almost all sectors of its government. By giving power to local authorities, it began to address the complex geography, cultural diversity and multiple hazards to which it is exposed. The Ministry of Education and Culture gave funding and decision-making power directly to school management and committees, even tasking them with managing school construction. Although the government is still struggling to provide an appropriate funding mechanism and enough technical support, many school communities have already constructed new school buildings or rehabilitated existing buildings in this decentralised political environment.

Country and hazard overview

In Indonesia, earthquakes, volcanic eruptions, tsunamis, floods, droughts and landslides are prevalent. Since 2000, the country has experienced three earthquakes with a magnitude greater than 8.0. Tectonic movements also make 76 of Indonesia's 150 volcanoes highly active and Indonesia's history includes a series of disastrous eruptions that have killed hundreds of thousands of people and affected global weather patterns. Flooding is also a perennial issue. These diverse and prevalent hazards place about 75 percent of Indonesian schools at risk to natural hazards.

School construction: From centralised to a community-based approach

Around 60 percent of Indonesian schools were constructed in the 1970s and 1980s in a massive Presidential Instruction (Inpres) Program funded in full by the government. Understanding of the building codes and hazards was low and corruption was rampant, leading to poor site selection and construction quality. Nevertheless, access to basic education significantly improved and enrolment was boosted.

Recognising the monumental challenge of building, operating, maintaining, repairing and retrofitting schools in various states of disrepair across thousands of islands, the government decentralised education management down to the community level in 1999. One year later, the central government established a block grant called the School Operational Fund with support from the World Bank, allowing school management and committees to directly receive and manage funding provided by the national government.

To actually give power to the school management committee, the Ministry of Education and Culture (MoEC) and the Ministry of Finance gave each community the responsibility to manage the School Operational Fund. As a block grant, the funding was flexible. It allowed the committee to spend money as they saw fit. It was also allocated based on the number of students – if enrolment increased, the funds to that school would increase.

The school management committee was flexible and consisted of a principal, treasurer and small group of democratically elected community members. These community members typically came from the immediate area but could be drawn from surrounding neighbourhoods or elected for special purposes. This system, in conjunction with the block grant, was intended to allow the school committee to operate as the school implementing unit.

Addressing school vulnerability to hazards

After learning that 75 percent of 258,000 schools in Indonesia are in disaster risk areas, the government launched programs specifically to increase technical assistance for disaster risk-reduction education. They also adopted regulations to increase the hazard-resistance of school infrastructure.

Even though the government knew about some of the problems with school buildings, they did not know specifics. To address this, the MoEC contracted a private company to determine the extent of damage and disrepair of Indonesian school buildings. Considering geographic and logistical challenges, the government allowed school committees to perform basic damage assessments that were then vetted at the district level. After years of surveys, the government learned that one-third of the total schools – more than 89,000 – fell into the heavily damaged and medium damaged category.

Without the capacity to address the diverse damages as a central agency, in 2011 the Ministry of Finance changed the existing Special Allocation Fund (DAK) – previously used for purchasing computers or textbooks – to help maintain education buildings. They drastically increased the portion of the budget allotted to physical expenditures and allocated funds according to damage level and student enrolment. School management committees could use these funds to build new schools or repair existing ones as they saw fit.

Challenges to this approach

Construction was a new responsibility for the school management committees. They had to hire their own contractors and sub-contractors to help them build new schools or retrofit existing ones. While committees did receive some assistance from a MoEC engineer to oversee a project, they did not always have the capacity to implement construction projects nor the appropriate knowledge to prioritise school safety. As a result, DAK funds have been spent returning buildings to their original condition, rather than improving structural components to make them safer.

According to an Indonesian report prepared for the World Bank, decentralisation of school construction increased ownership and decreased costs. In situations where school communities were already oriented to disaster risk reduction principles and where school principals took the lead in construction, school quality increased. However, the government is still working through some challenges related to safer school construction.

- **Technical oversight.** The government has not created an appropriate technical advisory system and school communities often lack the funds to perform rehabilitation and hire a technical consultant. Even if consultants are hired, they often lack the appropriate information to build hazard-resistant design according to local building code bylaws.
- **Public sector coordination.** In Indonesia, the MoPW is responsible for writing and enforcing the building codes, including the design review and construction inspection of schools. Unfortunately, local public works offices are given the same amount of funds regardless of the number of schools in a district. With so many diverse infrastructure tasks to supervise they rarely perform thorough checks – especially if the school is single story. In addition, public works officials rotate between departments to reduce corruption, but with the fast turnover rate officials rarely develop sufficient experience for thoroughly overseeing school projects.

  Under the current DAK fund, the responsibility to finance the supervision of school projects rests on local governments. Because local governments finance the supervision, each unique local political economy can influence the construction costs, potentially compromising quality assurance and safety.

  Noticing these funding and capacity issues, the MoEC provided a special portion of money for quality supervision for each school. Currently, this fund is only applicable for school construction directly financed by the MoEC and not for construction using the DAK fund.
- **Construction speed.** To compound these challenges, the speed at which school management committees must spend DAK funds has pressured school communities to implement projects faster than they are capable. Special allocation funds must be completed in three months to receive another allocation of money across all sectors. Other departments relying on DAK funds for education materials may pressure schools to finish their work within the three-month funding window so the funds for their sectors will not be delayed.

Community-based school construction policy at the national level is possible, but creating incentives that produce safer schools is a complex and lengthy process. In Indonesia, the decentralised approach may be the only opportunity to reach all communities. At the same time, decentralised construction and repair may be, in some cases, of substandard quality. And in Indonesia, where natural hazards are frequent, new vulnerabilities are especially dangerous.

Key takeaways

- Decentralised methods in regions with diverse contexts allow localities the freedom to address their unique needs.
- Even though school management committees can address their own needs well, they may not be immediately capable of managing a construction project.
- Oversight must remain a top priority even if schools management committees are given greater autonomy in construction.

Democratically elected school management committees may use funds to construct new schools or retrofit unsafe ones. The country is working to developing effective systems for providing technical support to local school management committees.
Photo: GFDRR.

The evolution of a community-based approach

The need for community involvment in all stages of safer school construction may lessen as societies develop safer construction practices. When governments have the capacity to build schools safely, their role in providing education and safer schools to their constituents is paramount. However, even when safety is ensured through strong codes and robust construction oversightmanagement, community involvement in school construction remains valuable.

- When local school management committees and broader stakeholders are part of school project planning and design, the schools better reflect cultural norms and community aspirations. Communities also better understand how their schools perform during natural hazards.
- When communities are invited to participate in safer school construction, the process can prompt discussion about disaster risk reduction and be a venue for alerting communities to the changing state of knowledge about hazard exposure. Local communities may find out about newly discovered seismic faults, sea level rise, increased severity or frequency of cyclones brought on by climate change, or how land-use patterns have altered flood plains. Safe school construction provides a local and immediately tangible focus for these conversations.
- Safer school construction also supports a diffused knowledge about the hazard-resistant infrastructure. While few local households may apply safer school construction techniques to their own homes in communities with mature construction industries, community involvement helps maintain the existing culture of safety.
- Broad awareness of and involvement in safer school construction projects also helps maintain the political will needed for funding school maintenance and retrofits, and the safe construction of new school buildings – even if these projects come with costs.

As a strong culture of safety emerges, community involvement in safe school construction becomes part of the wider process of a transparent, democratic and participatory community development process. It becomes one aspect of a resilient community.

A training session for local construction workers. Photo: Save the Children.

CASE STUDY

Fostering demand for safer schools

Country: Nepal

Organisation: National Society for Earthquake Technology-Nepal

Hazards: Earthquakes

Summary: Nepal has a history of destructive earthquakes but until recently had done little to protect its infrastructure and housing. Then, the National Society for Earthquake Technology-Nepal (NSET) began a host of projects to raise national awareness through safer construction practices. Through community mobilisation, NSET started a public dialogue about the imminent threat of earthquakes and offered tools to the community to help them be more resilient. NSET encourages the community to connect with outside funding sources so costs are shared. In all projects, they work to identify which school projects are most likely to scale-up the program in their communities and protect more Nepali children and adults.

Update: *On April 25, 2015, Nepal experienced an M7.8 earthquake 77 kilometres northwest of Kathmandu. Because the earthquake struck at noon on a Saturday, few were inside the thousands of classrooms that collapsed. Tragically, some teachers were attending teacher training sessions and were killed. At the time of printing, a full education sector damage assessment had not been completed. Early assessments indicated over 10,000 classrooms were fully damaged and upwards of 90 percent of schools damaged in some districts.*

Country and hazard overview

Nepal is beset with high seismic activity. They have weathered four major earthquakes in the last 100 years, which have claimed more than 11,000 lives. In 1934, the Nepal-Bihar earthquake claimed 8,519 lives and caused massive devastation to Nepali infrastructure and housing. Extending all the way to 1250 CE, the seismic record suggests earthquakes of that size occur approximately every 75 years. If historical trends continue, another earthquake is imminent. Smaller and more frequent earthquakes serve as constant reminders of the looming threat.

Mobilising communities

NSET were pioneers of community-based safe school construction in Nepal. In 1993, the organisation consisted of just a few people and little more than an idea. They wanted to build awareness about earthquakes and other natural hazards from the children up, and at the same time use a school construction project to bring about earthquake-resistant construction practices.

Mobilising communities to build safer schools can require lengthy engagement and trust building. A mix of low risk-awareness, limited government capacity and limited resources drove NSET to focus on finding sites for a few successful projects. Their aim was to ensure the government, as a key stakeholder, repeatedly saw community-based safe school construction projects as an effective means to protect children, provide education, teach masons new skills and, by extension, protect Nepali people and vital infrastructure investments.

School selection criteria

High community commitment

Potential for publicity

Replicability

Enrolment

Feasible socio-economic condition

Availability of construction materials

Potential for training

Selecting a school was done with care. For example, in Nawalparasi District, all of the district's 239 schools were surveyed to see which schools needed new classrooms. The number of available local masons was assessed, along with the socio-economic condition of all communities and the available construction materials. Through an analysis of these quantitative factors, NSET made a shortlist of around 20 schools.

The most resource-intensive and time-consuming part of strategically selecting a site was determining which communities would most benefit from a project. It was decided the benefit would be higher in communities that did not even know they were particularly vulnerable or that their vulnerabilities were preventable. Benefit would also be high in communities where local contractors or masons failed to follow earthquake provisions mandated by the building codes because they could not read the codes. NSET was more likely to choose these communities, but only if they showed potential for sustained community engagement.

Community engagement began with town hall meetings where community members were invited to learn about hazards and earthquake technology. At first attendance was low, but as the few attendees chatted with their families over dinner, tea and at other gathering points, involvement increased. Potentially saving children from harm in the next earthquake proved an effective conversation piece.

Once the initial novelty of the information wore off, sustaining the interest and commitment of the community's stakeholders was a challenge. NSET, along with community members, organised shake table demonstrations to continue conversations and demonstrate the effectiveness of hazard-resistant construction.

Shake table demonstration

Shake table demonstrations are now widely used for teaching school communities and local masons about the effectiveness of earthquake-resistant technology. Typically, two one-tenth scaled models –that look like the local school – are placed side-by-side on an apparatus that partially simulates the movement of real earthquakes. Although the external design of both models is the same, one of the models has earthquake-resistant features and one is a replicate of current building practices. As the table vibrates, the community simultaneously witnesses the potential destruction of their own building, while they are given hope through the model that withstands the quake scenario.

Out of all the schools surveyed in the Nawalparasi District, Kalika Secondary School was finally chosen. Community members were low- to middle-income, meaning there was potential for donation from the wealthier community members and deep interest in a safer school. The local government was also an eager partner.

In Nepal's Nawalparasi District, NSET engineers answer questions at a shake table demonstration. Onlookers learn their traditional building may collapse in earthquakes, but that small changes in their construction practices can save their schools and their lives. Photo: NSET.

Funding and retrofitting

NSET requires communities to gather almost all the funding required for a school construction project. Challenging as that may seem, their exacting method for choosing communities helps make sure that community demand is very high before initiating the project. However, they do not leave schools to operate alone.

At the Kalika Secondary School, NSET facilitated the formation of community-based organisations (CBOs) that would spearhead school retrofit activities. NSET representatives accompanied the funding CBO to request donations from the community and district-level government offices. Again, in the company of an NSET representative, the CBO went to the steel manufacturer asking for a tax-deductible donation, which would be part of the steel company's corporate social responsibility. As those negotiations began, NSET started to mobilise in-kind contributions of sand, boulders and bamboo that would eventually be necessary in the construction project. After developing a presence in the area, they were also able to secure some funding from a local NGO to support the project.

NSET also maintained a consistent presence during construction. NSET engineers remained on the construction site throughout the process, providing on-the-job training for local masons. Trainings were not only focused on how to construct for earthquake safety, but on why the changes produce safer school buildings.

After training masons, and tearing down one of the school buildings, a new three-story building was completed in 2010. Since then, around 60 percent of the construction completed by the trained masons has included earthquake-safer technology. NSET has seen masons tear down sections of their work when engineers point out deviations from the safer methods.

Challenges to this approach

Communities often resisted new construction practices at first. The initial scepticism made financing especially difficult. Constructing a high-quality building was expensive, and NSET wanted the school to either contribute directly or be involved in gathering funds from other sources. Garnering the support and demand for the project took time before community members were willing to plunge into the project and provide time-consuming support. However, after decades of work the region, Nepal's MoE now fully supports the community-based approach (see *In context: Working towards a culture of safety* in the *Post-Construction Stage* section).

Key takeaways

- Although adequate mobilisation can be time consuming, it can make drastic differences in project feasibility and procurement.
- Allocating a large proportion of resources to project selection can be useful when project goals include a focus on scaling-up.
- Raising community awareness through demonstrations and public forums can generate invaluable conversations.
- Shake tables are a particularly powerful tool for creating community interest and demand for safer construction.
- If communities lack the resources to build a school, and they lack the skills to gather the funds from outside sources, implementing agencies can facilitate conversations with public and private groups that may be willing to make donations.

CASE STUDY

Rapid visual assessment for retrofitting

Country: El Salvador

Organisation: UNESCO, University of El Salvador, University of Udine, Italy

Hazards: Earthquakes

Keywords: VISUS, rapid visual assessment, information communication technology, government, retrofit, triage, training

Summary: Before school retrofitting or reconstruction programs can begin, weak buildings need to be identified and prioritised, and retrofit or replacement designs calculated. Rapid visual assessment is typically the first step in this process. In El Salvador, UNESCO and two universities piloted a tablet-based rapid visual assessment tool. The project assessed 100 school buildings in 10 days and built the capacity of government officials, professionals and engineering and architecture students along the way. For many, the pilot was their introduction to building assessments and the fundamental principles of seismic-resistant design.

Country and hazard overview

El Salvador is both populous and seismically active. In 2001, two earthquakes struck, causing landslides and damaging 1,700 schools – more than one in three in the country. Ten years later, many school buildings remain in disrepair, in sites that leave them vulnerable to earthquakes and other natural hazards, or they do not comply with seismic building codes.

School buildings in El Salvador are mostly one story of confined or reinforced masonry. Although some buildings were traditionally constructed from adobe (mud brick), it has not been used for schools after many children and a teacher died during an earthquake in 2001.

When existing school facilities have not been built to withstand hazards, they need to be identified and strengthened. In contexts like El Salvador, where resources are insufficient for a full detailed assessment of every school, a rapid visual assessment can quickly collect proxy data from a brief site visit. From these assessments, the MoE can develop school retrofitting programs based on a triage action plan that prioritises the weakest buildings and those with the most students first. Detailed assessments can then determine whether school facilities should be retrofitted or replaced.

Using rapid visual assessment

Rapid visual assessment approaches have been developed in many countries. These assessments do not empirically determine the structural integrity of a building. Instead they rely on proxy data to determine fragility.

Originally, the proxy data was collected by engineers after earthquakes or other hazards. Noting the intensity of the hazard, they recorded the damage to buildings and organised the results by the building typology and other defining characteristics. Over time, enough data was collected to be able to predict damage based on a visual assessment of a building's characteristics and the expected strength of the hazard.

Rapid visual assessment only provides a general prediction of damage. After the rapid visual assessment is conducted, engineers still need to perform in-depth assessments to develop appropriate retrofit designs, but only for those identified during the rapid assessment for an in-depth analysis. This strategy reduces the cost of doing in-depth assessments for every school.

Planning school retrofits through rapid visual assessment

Faculty and students of a Salvadoran engineering program, along with researchers from the University of Udine in Italy, pilot-tested the VISUS tool as a rapid visual assessment methodology in 2014. VISUS is an expert-based methodology that organises and collects rapid visual assessment information for school facilities through a tablet-based application. It then uses collected data to judge the overall safety of school facilities. VISUS has been designed to quickly aggregate data through photographic evidence and prioritise the most appropriate action for achieving school safety based on risk and cost. These actions are listed as nothing, repair, retrofit or replacement.

Even though El Salvador has a relatively robust university system, civil engineering students are not required to take courses in evaluating existing buildings for seismic safety. For one month, VISUS developers from the University of Udine in Italy, together with UNESCO personnel, communicated with a Salvadoran professor who spearheaded the pilot project. He provided pictures from previous earthquakes and information detailing the technical aspects of typical school construction in El Salvador. Over time, this initial contact snowballed into a steering group, which maintained the project throughout its lifespan.

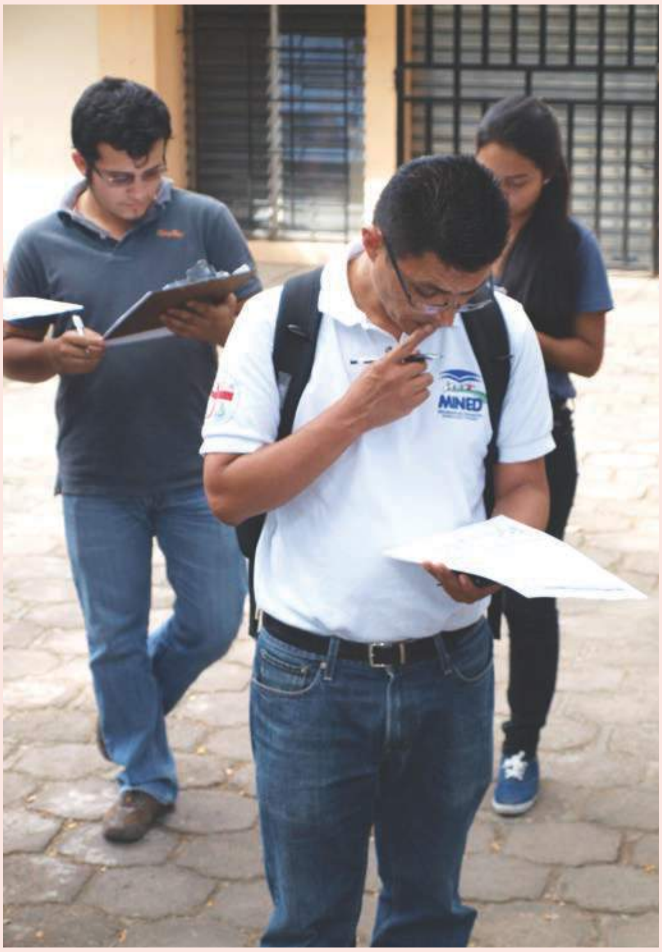
After establishing a base of operations at the University of El Salvador, the VISUS developers trained more than 60 people to perform the assessment, including personnel from the MoE, Engineers Associations and a small team of 15 students and 8 professors. The first half of the three-day training was in the classroom learning the concepts of rapid visual assessment and the VISUS tablet application for collecting data. In the latter half of the training, the trainees got hands-on experience in the field. A day was added for evidence-based photography so experts could verify the team's assessments after the fact.

The VISUS pilot project assessed school buildings in the departments of San Salvador, La Libertad and La Paz. Ultimately five groups of three university students and a professor visually assessed 100 buildings in 10 days. The VISUS evaluation of the school took as little as a half an hour and occasionally as long as three hours. When school staff were available to guide the team, the evaluation process was much faster.

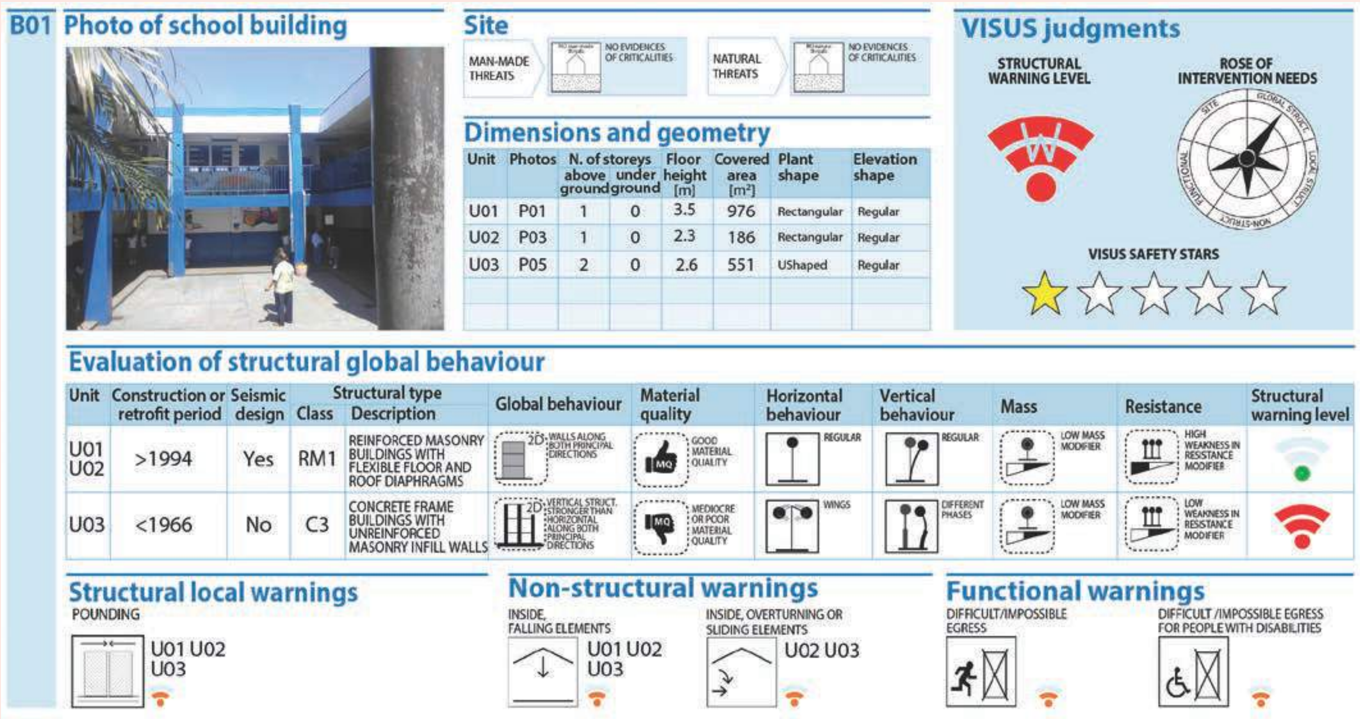
The VISUS methodology could be divided into three broad chronological sections: characterisation, evaluation and prescription for school safety upgrades. Teams used tablets to photograph structural and non-structural characteristics of schools and then match what they saw to a set of pre-defined alternatives. The methodology related each alternative to different damage levels the school would likely experience in an earthquake.

The newly trained surveying team did not always have sufficient expertise to correctly perform the matching. However, the photo documentation was sent to a scientific committee who vetted on-the-ground data, filling in any gaps in experience. This double-checking helped verify the congruence of the collected data. An algorithm then rated school building on a 1-5 star system ranked by risk and retrofit cost.

VISUS was able to effectively train and immediately rely on local students and professors for site visits because of its rigorous review protocol. By producing detailed and functional pictorial evidence, the oversight could be exported off-site, increasing speed and reducing costs.



Personnel from the MoE, engineering associations, students and professors of civil engineering practice rapid visual assessment of school buildings to determine which are most vulnerable to earthquakes. Photo: Jair Torres/UNESCO



A summary view of the rapid visual assessment of a school building with three blocks – Unit 1, 2 and 3. Using a series of screens to compare the unit to photos of different building typologies and characteristics, the team has categorised the units, considering global building behaviour, material quality, horizontal and vertical behaviour, building mass and lateral resistance. The tool also asks teams to assess non-structural and functional issues. Following a rapid visual assessment, VISUS engineering experts review field assessments and the accompanying photographs to ensure accuracy.

Challenges to this approach

In the pilot stages, the tablet was not fully functional in the field. Rather than allowing the users to assess the safety of the facility as issues were discovered, the tablet-application forced the user into a rigid linear progression of the five sections of the VISUS method. Realising this problem, teams quickly began recording the information on paper and enter the data once they returned to university. The pictorial comparisons provided in the application were still essential, but the tablet application needed modification to be fully functional in the field.

Rapid visual assessment is only the first step. The work in El Salvador identified school buildings that were likely to be the weakest, and because the VISUS tool was used, it provided initial estimates for retrofitting or replacing them. Yet even though the results of the pilot study are promising, the long-term impacts to Salvadoran schools are still unknown. The MoE and other actors still need to fund retrofitting and replacement. Engineers still need to complete detailed assessments, including sampling materials from the schools and testing their strength, before creating retrofit or replacement designs. And of course, the work then needs to be carried out.

Designed in Italy, VISUS focuses on structural typologies common in southern Europe. Applying this technology to other contexts requires adaptation. The tool needs to be expanded to include traditional building materials like adobe. It also needs to respond to a broader range of hazards to be applicable in other contexts. Currently, the team is conducting other pilot applications in Laos and Indonesia. This requires adapting the tool to entirely new building types and hazards – including floods, tsunamis and high winds.

Key takeaways

- Retrofitting programs can improve the hazard resistance of existing unsafe school buildings.
- When resources are limited, rapid visual assessment tools help quickly identify the weakest schools and the schools with the most vulnerable students.
- Local engineers may have little formal training in methods for assessing existing structures for vulnerability to hazards.
- Partnering assessment experts with local universities can build the capacity of engineering students, faculty and government officials.

CASE STUDY

Sustainable design: Building from the ground up

Country: Republic of Ghana

Organisation: Sabre Charitable Trust, Arup International Development

Hazards: High winds, earthquakes, extreme temperature

Keywords: environmental sustainability, functionality, research, building trust, Ghana

Summary: Sabre Charitable Trust and Arup International Development incorporated local building materials and design preferences into kindergartens for Central and Western Ghana, paying special attention to sustainability principles. Through prolonged research and community interaction, the team created a design that used both modern preferences for concrete and local materials to create safer schools.

Country and hazard overview

With a rapidly growing population, Ghana's education sector has struggled to keep pace with demand. Nearly 30,000 public sector classrooms are in need of major repair and the country has a shortage of nearly 10,000 kindergarten classrooms.

In the country's decentralised system, the process of constructing schools often begins with a community parent teacher association (PTA) or elder petitioning the district assembly or district line ministry. The government body will then seek funds for construction, either from their own coffers or by identifying a development actor willing to fund or even oversee a school construction project.

Communities typically contribute to the building of public schools, providing in-kind labour, materials, or cash to support a hired contractor. Community elders may also attempt to monitor construction to ensure contractors meet contractual obligations, but safety remains a concern given the technical nature of construction.

One common problem is when the contractor fails to properly attach roof trusses to the building frame. Many schools have lost their roofs when high winds blow across the region; similar damage can result from seismic tremors present in the south of the country.

School construction: Incorporating sustainability principles into design

In 2008, Sabre Charitable Trust teamed up with technical experts from Arup to design and construct safe, affordable, replicable, maintainable and environmentally sustainable kindergarten buildings that met the needs of communities living in the central and western regions of Ghana.

In the design process, the first step was in-depth research about vernacular design and the local construction skills.

The design team ensured the materials were not just local, but also readily available, even checking in the local markets to see first-hand what was for sale. They also aspired to 'build from the ground up', meaning they were literally attempting to pull resources from the earth and incorporate them into the school building.

When local building practices and conventional materials were not likely to produce a safe building, the team turned

Innovative façade made using pivoting bamboo shutters to allow optimum amount of natural light and ventilation. Photos: Arup & Sabre Trust.

to research. They tested local building materials, focusing on the strength and durability of local soil-based materials. Some communities used soil to produce bricks but the quality of the soil and fabrication process varied. These and other local practices needed to be informed by tested engineering options that increased safety and durability.

Challenges: Perceptions of local materials

Convincing communities to build with soil and other local materials proved challenging. In Ghana, communities wanted to use concrete and other materials they associated with development. Building school buildings completely out of natural and local materials, and following vernacular practices, put the school at risk of being seen as undesirable. Rather than disregarding the community's notion of progress and pushing local materials for the sake of environmental sustainability, the team had to build trust over time.

The community saw some value in vernacular design but also wanted modern materials. The team opted for a compromise in material choice consisting of a concrete frame, with traditional materials like bamboo and stabilised soil blocks used as infill walls.

At first, the prospect of building with mud seemed dismal to community members. But after being trained on how to manufacture the blocks properly, which included sifting the soil and mixing it with locally available stabilising agents like portland cement and pozzalana, the community members saw the outcome as an improvement. The improved soil blocks became more desirable and proved stronger than the local concrete blocks. In addition, going through the entire process of design and fabrication gave the community a vital sense of ownership.

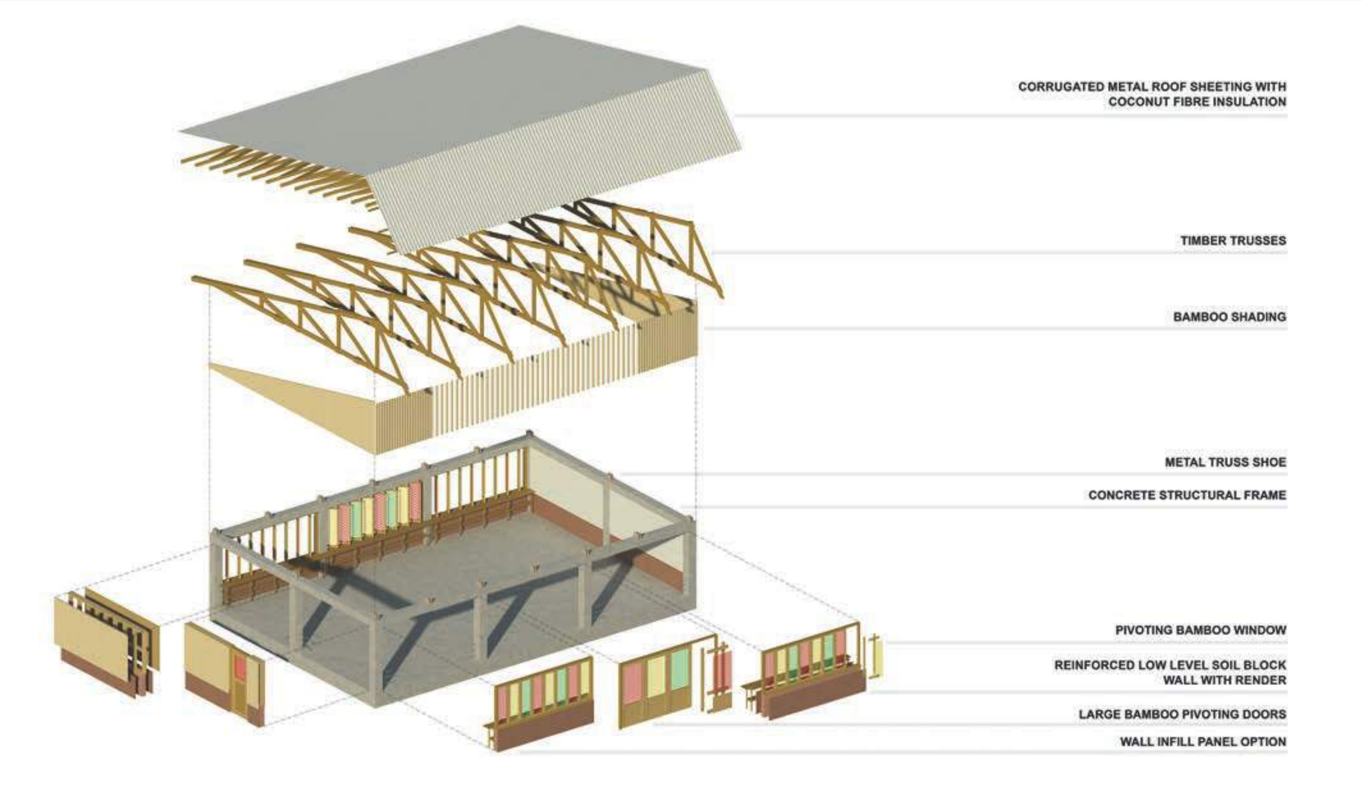
By using a concrete structural skeleton designed to resist seismic loads, infill walls could be made from renewable and locally sourced materials. This design feature and the concrete frame's modular form ensured the design was scalable and replicable. Locals were already erecting concrete frames, but the construction quality was poor. This provided an opportunity to increase local skills in creating vital structural components for future infrastructure.

The concrete was made from using locally sourced pozzolana – a mix of clay and palm kernels – as a 30 percent substitute for portland cement. Using locally available materials for the infill walls also increased the sustainability of the building and made it easier for communities to contribute to the construction process and do routine maintenance. The durable concrete frame is designed to bear the force of shaking, high winds or other hazards. This provided the team with an opportunity to use different or new materials for the works without fear of compromising safety.

Design specifications did not only focus on sustainable material choices. The design team went to great lengths to design the building for functionality. They created classroom layouts to meet performance-based criteria for daylight, temperature and acoustics. This provided a high-quality learning environment without the need for external energy. Every building element had at least two functions so that no materials were wasted and add-ons were unnecessary.

Key takeaways

- Be sure the design team has done in-depth research into local building materials, processes and aesthetics.
- Understand the gaps in safety that may exist in traditional building techniques or current practices.
- Develop sufficient trust to show communities they can improve and refine traditional building techniques.
- When appropriate, draw materials from the natural environment. Be sure to extract at a sustainable rate.



SECTION III: DESIGN

CASE STUDY

Training masons to build seismic-resistant schools

Country: India

Organisation: India's national and state governments, UNDP, World Bank

Hazards: Earthquakes

Keywords: cascading training, rural and remote oversight, community oversight, large-scale

Summary: In 2006, the Uttar Pradesh State Government in India sanctioned a hazard-resistant design for a massive school construction project that aimed to build thousands of schools at the same time. At the time, there was government capacity but local capacity was low, creating a good opportunity to institutionalise a community-based approach. There were too few engineers to be present across thousands of construction sites and many of the schools were remote. This emphasised the need for community involvement.

Because thousands of schools were being built simultaneously, construction oversight was challenging. But the state government saw it as an opportunity to raise the capacity of thousands of communities through cascading training. By 2007, the state government, in partnership with UNDP and with a loan from the World Bank, constructed almost 7,000 seismically safe schools and 82,000 additional classrooms in Uttar Pradesh.

Country and hazard overview

The Indian subcontinent presses into the Eurasian tectonic plate in the north, causing India – along with other nations in the region – to have experienced many small and a few devastating earthquakes during the last century. After witnessing the pattern of earthquakes and other natural hazards that resulted in a series of abrupt but predictable disasters, SEEDS began working with communities, technical universities and government authorities in 1994. They helped communities retrofit unsafe schools and adopted strategies for reducing losses from future crises, using schools as a catalyst for community-wide change.

State-wide school construction program

In 2004, the Uttar Pradesh State Government was planning a massive school construction project in response to the widening education gap. At this time, the UNDP Disaster Risk Management Program (DRMP) as well as the Education for All (EFA) initiative were both underway at a national level. Some UNDP and MoE officials saw the school construction project as a chance for disaster risk reduction and decided to teach the MoE and state government about safer schools.

Influenced in part by devastation in the 2001 Gujarat earthquake – in which 15,000 schools collapsed – and two historic earthquakes in Uttar Pradesh, the state government decided to change their existing school design, which lacked earthquake safety measures. Under the DRMP the Indian Government created the position of National Seismic Adviser who was responsible for updating the existing design. Uttar Pradesh contained multiple levels of seismicity, but given the large scale of the project, the government decided to create a design suitable for the highest earthquake probability in the state.

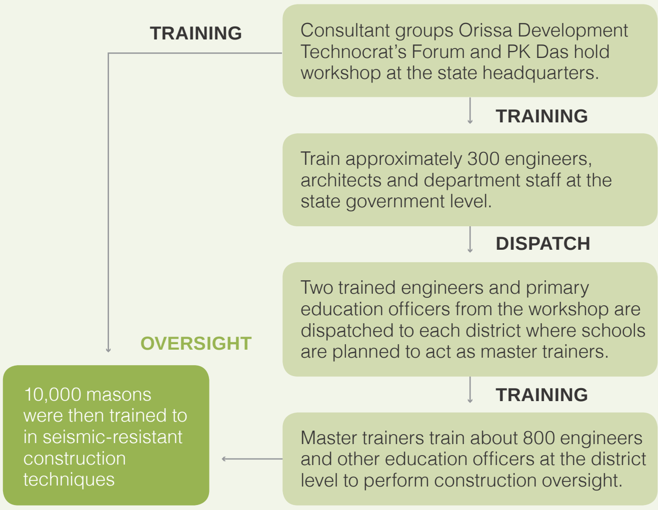
The National Seismic Adviser changed simple features in the school design to increase its seismic resistance. These included:

- Moving doors 60cms from vertical joints.
- Adding rebar to tie foundations and slabs together.
- Placing three horizontal 'earthquake' ring beams that circumscribe the walls (at the foundation, below the window, and above the window).
- Increasing the proportion of cement to sand and stone blast in the foundation.

After determining the changes would add an additional 8 percent to construction costs, the MoE entered a year of negotiations with the World Bank to increase their long-standing loan that had supplemented national and state funding for EFA. With funds in hand, the easy part was over. Now the state needed to train masons to build safer schools.

Challenges: Training masons and inspectors in safe school construction

In 2005, the MoE and MoPW organised a massive cascading training program to teach hazard-resistant construction techniques to their government engineers. These engineers then taught or supervised thousands of contractors and masons at the district level. Amid other DRMP activities, it took a few years to complete the training. In the process, the state government had to deal with a lack of knowledge and the staggering breadth of construction.



When Uttar Pradesh changed its school design to incorporate seismic-resistant features, the state needed to train masons in the new practices. Five-day trainings that included practice on a mock building taught one or two masons for each new school site how to construct earthquake ring beams in the walls. These trained masons then spread the knowledge to other masons on the construction site. Photo: Sanjaya Bhatia.

UNDP hired the consultants ODFT and PK Das to lead five-day trainings for masons in communities where new schools were to be constructed. The first portion of the training was a lecture to introduce masons to hazard-resistant construction and show them new techniques for earthquake safety. The latter portion of the training was the application of all-new, hazard-resistant construction techniques on a mock building, giving the masons a chance to translate the abstract theory into tangible practice. The mock building was only constructed to the window level and was left in the community as a reference for masons to recall what they had learnt. During the training, masons were paid their daily wages. Because of the scope of the project, only one or two masons were trained for each school construction site. However, they were able to pass their newly acquired knowledge to other masons working with them.

Tight quality control

Construction was overseen by trained engineers and implemented by the trained masons. Masons and a school oversight committee knew the stages that required engineering inspection, the criteria for approval, and the tests that would be conducted to ensure quality. Engineers monitored the masons as they poured the foundation, casted earthquake ring beams and placed the roof.

Yet with so much knowledge transfer over such short time, the Uttar Pradesh Government knew the application of the new techniques would be inconsistent and would need further oversight. To solve this problem, the team created a wordless manual with very simple pictorials to show villagers what should be present at the foundation and sill levels. The manuals also showed community members how to determine the quality of cement. Then, the village head was issued pre-stamped postcards with a checklist of poor construction practices. If there was no problem, the village head would send nothing back. But if the government received a postcard, it would immediately send a trained inspector to determine whether a mistake had been made.

Through this method, many errors were caught early, and several buildings were actually torn down after finding irreversible mistakes. If the constructor simply made a mistake, it was corrected. However, if the responsible party was corrupt, the constructor was blacklisted from future government construction projects.

By 2007, the state government had constructed 6,500 seismically safer schools and 40,000 additional classrooms. Programs of this scale only manifest when countries are attempting to fill large gaps in access to education. Even though programs on this scale are rare, they can be an opportunity to infuse new knowledge about hazard-resistant construction principles into communities and government agencies.

Key takeaways

- Countries addressing education gaps can institutionalise hazard-resistant construction into their rollout.
- Cascading training is an effective model for spreading new, hazard-resistant construction techniques to skilled tradespeople.
- During training, new construction techniques need to be tuned to the literacy level of skilled tradespeople
- Training programs should include hands-on practice so skilled tradespeople can apply new concepts.
- Postcard monitoring systems can supplement traditional construction inspection in rural and remote school communities.

CASE STUDY

Leveraging for comprehensive school safety

Country: India

Organisation: SEEDS, Nayang Technical University, Ministries of Education and Public Works, Temasek Foundation

Hazards: Earthquakes, flash floods, landslides

Summary: This project was created to sensitise communities in earthquake-prone regions of India by engaging the community, partnering with the local government, training engineers and masons, and providing necessary retrofits to schools. Although the number of retrofitted schools was low, SEEDS spent more than a year in each community in an effort to change the culture as well as increase the safety of the school building. Newly trained local masons retrofitted schools while engineers provided oversight during the process.

Country and hazard overview

The Indian subcontinent presses into the Eurasian tectonic plate in the north, causing India – along with other nations in the region – to experience many small and a few devastating earthquakes in the last century. After witnessing the pattern of earthquakes and other natural hazards that resulted in a series of abrupt but predictable disasters, SEEDS began working with communities, technical universities and government authorities in 1994. They helped communities retrofit unsafe schools and adopted strategies for reducing losses from future crises, using schools as a catalyst for community-wide change.

Creating a culture of safety

In a retrofit pilot project spanning the three Indian provinces of Himachal, Gujarat and Assam, the NGO SEEDS used the retrofitted schools as focal points to organise the community around comprehensive school safety. They especially focused on Pillar 2 – school disaster management. Each state is in a moderate to high seismic risk zone and has a history of disasters.

To effectively build community buy-in, SEEDS held basic orientations at schools to create awareness about comprehensive school safety. These orientations were a necessary primer before retrofitting but were also necessary for explaining the school community's role in school safety even after the retrofit was complete. The school community would be responsible for operating and maintaining the retrofitted building, performing non-structural mitigation and regularly conducting school disaster management activities. In conjunction with mason training and other mobilisation activities, this phase often took six months. SEEDS expected the school retrofit and the school disaster management activities with the school communities to serve as a channel for promoting a culture of prevention and preparedness in the local community.

The retrofit of schools in Shimla, India is part of a broader comprehensive school safety approach. After retrofitting is complete, the school and wider community engage in a mock drill to test their preparedness. Photo: SEEDS.

After a school was retrofitted, SEEDS facilitated trainings in disaster preparedness for community members, school staff and students. The trainings included search and rescue, fire safety, first-aid, safe evacuation and mapping contingency plans. Students were also trained in 'duck, cover and hold' methods in case of earthquakes and safe evacuation. Special training was also provided to school staff to create a school disaster management plan. Together, the school retrofit and the accompanying 'soft' activities with the school community were expected to serve as a channel for promoting a culture of prevention and preparedness in the local community.

SEEDS then formed school disaster management task forces based on the trainings, which were divided into functional groups. These were search and rescue, first-aid, fire response, and a group to connect with the local government offices. The task force members included representatives from local leaders, parent-teacher associations and school clubs.

Establishing a Joint Action Plan

After the school community became aware of disaster risk reduction principles, SEEDS established a Joint Action Plan, which connected the school task force with the larger community. They performed outreach to ensure the wider community knew the school could be a gathering point in a flood, earthquake or other sustained hazard. By strengthening this connection, SEEDS was attempting to ensure the community benefited from the training and disaster management planning at the school.

Even though the school was likely to operate as a safe haven and school task forces would take leadership roles during a disaster, SEEDS also taught communities emergency preparedness skills and basic hazard knowledge in case the school became incapacitated.

The Joint Action Plan was designed to help the task forces react to disasters as well as proactively protect children during their routine interactions with school. One proactive measure included consistent updates for parents on the whereabouts of their children. Disaster or not, if a bus was late, parents were sure to get a call explaining why.

For the school communities, the experience culminated with a large mock drill where the school, fire department, the hospital and local government played the part they would function in a real emergency. SEEDS identified mock earthquake drills as the most useful exercise for students, staff and communities to check their preparedness levels. They encouraged the local government to mandate the mock drill to ensure everyone participated.

After being given a predetermined signal, students responded with 'duck, cover, and hold' as they had been taught during the disaster preparedness training. They then evacuated the school buildings following the practice of 'don't run, don't push, don't talk, don't turn back'. Students left the building by class and organised at a set assembly point.

Realistic conditions involved certain students that were 'trapped' in the school or generally missing. The Search and Rescue task force then had to respond by finding the missing people and providing aid. If the missing students were injured, they would be connected with the hospital. It was not just the adults that role-played. Students also practised their response skills, identifying damaged buildings, rescuing each other, performing first-aid and putting out fake fires. The mock drills were both realistic and exciting.

The biggest challenge for the students was to evacuate quickly and to establish coordination among the task forces. However, they became more efficient through multiple practices of the mock drill.

Overall, the process of engagement, retrofitting and practising mock drills took a full year. On completion of the project SEEDS handed the project details – including the disaster management plan, guidelines for retrofit and other project details – to the local education department for implementation in other schools. The governments in several provinces have adopted the initiative for wide-spread replication.

Key takeaways

- Safe school construction should be integrated into a comprehensive school safety program.
- Non-structural mitigation is an integral part of Comprehensive School Safety, and a part in which students and staff can actively participate.
- Safe school construction projects provide impetus for engaging communities in school disaster management.
- School mock drills, especially when coordinated with the wider community, can provide good opportunities for practice and affirmation of a culture of safety.

In 2011, officials from Shimla's police, education and public works department meet with the SEEDS project manager during an advocacy workshop. Photo: SEEDS.