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School Construction as Catalysts for Community Change: Evidence from Safer School Construction Projects in Nepal

ABSTRACT

Organizations in Nepal have retrofitted weak school buildings using earthquake-resistant construction techniques for over a decade. Some of these safer school projects have been carried out as technical interventions only, while others have been embedded within programs of community engagement, masonry training, and oversight. Following the 2015 Gorkha earthquake, 12 school sites were assessed through visual inspection and a series of community interviews to understand the impacts of safer school construction projects on local perceptions and construction practice. Compared to communities that had received technical intervention only, or no intervention at all, communities that had experienced community engagement were more knowledgeable of earthquake-resistant construction techniques and reported more adoption of these techniques in housing construction. They also evidenced more trust in the school building, using it as shelter following the earthquake. Community engagement can amplify the benefit of future school retrofit and reconstruction projects, simultaneously building social and infrastructure capital.

Key words: Nepal, earthquake, school, retrofit, community engagement

Introduction

A few minutes before noon on Saturday April 25, 2015, almost all Nepalese public school children were thankfully nowhere near their classrooms. When the M7.8 Gorkha Earthquake struck, 14 districts across Western and Central Nepal experienced intense shaking (Nepal 2015a). As it subsided, surviving children looked around to see damaged and destroyed buildings, including schools, clinics, and housing. Their lives irrevocably changed.

As the Government of Nepal (GoN) began formally assessing damage, it became clear that impacts to the education sector were pronounced. Across the affected districts, 8,242 public schools were damaged in the earthquake with an estimated US$313 million in losses in the education sector alone (Nepal 2015b:79). Yet, the Gorkha Earthquake also struck a country with extensive experimentation with school retrofitting. Unlike most low-income countries, where school retrofits are initiated only *after* a devastating earthquake, Nepal had been retrofitting schools for nearly two decades, even without any major earthquake.

Past decades have seen the continued geometric rise of casualties and economic losses from natural hazard events. While absolute economic losses have been highest among wealthy nations, loss of life and relative economic losses have been concentrated in low-income countries, such as Nepal (UNDP 2004; World Bank 2004; World Bank 2010). In such countries, seismically induced damage to schools, including catastrophic collapses of fully occupied school buildings, has become a grave concern (Paci-Green and Pandey 2015).

The death of schoolchildren in collapsing school buildings is not a natural outcome of earthquakes. Over the several decades, research into the causes and consequences of disasters has pointed to the social roots of disaster (Wisner, Blaikie, and Cannon 2004). Rather than being the direct result of environmental forces, disasters are the visceral and visible outcomes of socio-cultural, economic, political, and historical processes that shape where and how communities live and engage with each other. Over decades and centuries, unsafe development processes have shaped the fragility of the built environment and expanded community exposure to hazards. Meanwhile, privatization pressures have reduced social safety nets and government capacity to respond to hazard events (Lewis

1999; Oliver-Smith 1994; Pelling 2003). The resulting increased vulnerability has often shifted the burden of natural hazard losses towards marginalized groups within a society — women, children, persons living with disability, ethnic minorities, and especially the poor (Green, Bates, and Smyth 2007; Gullette 2006; Phillips and Morrow 2008; Powell et al. 2006; Wisner, Blaikie, and Cannon 2004).

Efforts to address natural hazard losses through systematic prevention, preparedness, and mitigation fall under the broad framework of disaster risk reduction (UNISDR 2004). Such efforts deviate from more traditional emergency response and humanitarian aid, efforts that have been found to divert development resources towards disaster relief and even exacerbate long-term community vulnerability. Rather than address the disaster outcome, disaster risk reduction seeks to reduce underlying vulnerability to natural hazards (Schipper and Pelling 2006; Thomalla et. al. 2006). More recently, parallel and overlapping efforts to reduce disaster risk by drawing upon indigenous practices, enhancing community resilience through the strengthening of community capital, and integrating disaster risk reduction with climate change adaptation and poverty reduction have emerged. These approaches complement traditional disaster risk reduction strategies aimed at addressing systemic causes of marginalization (Aldrich 2011; Norris et al. 2008; Miles 2015; Manyena 2006; Mayunga 2007; Mercer et al. 2010; Vogel et al. 2007; see also Tierney 2015 and Saraçoğlu 2013 for excellent critiques of the resilience concept as a tool of neoliberal development).

The United Nations International Strategy for Disaster Risk Reduction (UNISDR), through the Hyogo and Sendai Frameworks for action, promotes and monitors national efforts at disaster risk reduction and community resilience. Within the education sector, UNISDR's global efforts have coalesced around the Comprehensive School Safety framework that focuses efforts on three overlapping components — safe school facilities, school disaster management, and disaster reduction and resilience education (Save the Children 2012; Petal and Green 2010; Green and Petal 2009). School retrofitting projects have been of particular importance in addressing the safety of school facilities in earthquake-prone regions. Within Nepal, a broad spectrum of governmental agencies, non-governmental organizations, and development partners have expanded efforts to reduce disaster risk by addressing all three pillars of comprehensive school safety. The work on pre-earthquake school retrofitting and earthquake-safe new construction has been particularly noteworthy as it is at the forefront of such work in low-income countries.

In 1999, the National Society for Earthquake Technology-Nepal (NSET), a non-governmental technical organization, began pioneering school retrofit projects to reduce the probability of school collapse in predicted moderate and large earthquakes. The concept of retrofitting was not new globally, but at the time, it was considered too costly and unproven for low-income countries like Nepal. NSET's initial retrofit project targeted unsafe schools for three reasons. Most importantly, safer schools projects focused on "children first," since children were a vulnerable population legally required to be in a public building for six hours a day. Secondly, schools were of great importance to communities beyond their obvious educational function. Loss of schools and students in them would have profound psychological impact to any community and damage a central element of social and cultural life. Thirdly, school buildings were believed to be relatively simple to retrofit, unlike other critical facilities like hospitals, bridges, or energy sector infrastructure. Being simple, schools could serve as an opportunity for local masons and residents to learn how to build safer housing using familiar construction materials (GFDRR and NSET 2012:13). The hope behind NSET's retrofitting projects was that schools and students would not only be protected from damage, but that local communities would learn from such projects and begin to apply safer construction practices in their communities.

The 2015 Gorkha Earthquake provided an opportunity to assess school retrofitting efforts in Nepal. In June of 2015, two and a half months after the Gorkha Earthquake, the authors conducted field assessments and interviews at 12 public school sites. The assessment compared schools that had been retrofitted or newly built as earthquake-resistant with schools built conventionally through the standard design and construction process that the Ministry of Education (MoE) had adopted (for assessment summary and recommendations, see Paci-Green, Pandey, and Friedman 2015).

This article focuses specifically on the question of whether, and in what ways, Nepal's school retrofit projects changed local perceptions about seismic hazard and local construction practices. It is driven by the central question – can, and should, school retrofit projects do more than physically strengthen a school building? If school retrofits can support community change, these projects may serve as disaster risk reduction entry points in communities grappling with the two commonly intertwined underlying conditions of seismic risk –active fault lines and fragile construction (Wisner et al. 2008; Wisner, Blaikie, and Cannon 2004).

The following section provides an overview of the Nepal's public schools and a condensed history of retrofit projects and pilot programs there. It is followed by a description of our site selection and field survey methodology. We then provide short vignette of five school communities and then examine differences in knowledge and stated use of earthquake-resistant construction technologies among households near the school. It concludes with a discussion of the role schools can play in disaster risk reduction in low-income, hazard-prone communities.

Nepal Education Sector Risk and Risk Reduction Efforts

Over the last two and a half decades, Nepal and development partners have funneled significant resources into achieving Millennium Development Goals and Education for All targets of 2015. The investments have had noticeable impacts. As of 2014, the rate of achieving basic education, completion of grade 8, is over 87 percent with full gender parity, and school participation by marginalized groups has increased in lower grades to be roughly equivalent to their population proportion (ADB 2011; Nepal 2015:76).

Nepal's education sector now serves over 1 million students in early childhood education and development and nearly 7.5 million students in primary, secondary, and higher secondary education spanning grades 1 through 12. Eighty-five percent of primary and secondary schools are public institutions, receiving public funds to support teacher salaries and students, as well as construction and maintenance of school facilities (Nepal 2015b:75).

Yet, even as educational opportunities expanded for Nepalese children, many were concerned about the possibility of extensive education sector losses in earthquakes. The county has been ranked as the 11th worst in relative vulnerability to earthquakes by the UNDP (UNDP 2004). Another study estimated that Kathmandu was the city with the greatest per capita earthquake legality potential in Asia; an earthquake centered under Kathmandu and with a 10 percent chance of exceedance in 50 years could kill over 4 percent of the city's inhabitants (GHI 2001).

The fragility of school buildings was a particular area of concern. While education sector investments had expanded educational opportunities for Nepalese children, many schools had been built with little input from engineers trained in earthquake-resistant design and construction. Furthermore, nearly 90 percent of the schools were unreinforced load-bearing masonry structures where the walls, made of stone, brick, or adobe, bear the weight of the roof and upper floors (Upreti 2011:4), a construction type noted worldwide for being particularly vulnerable to seismic shaking. Collapse of unreinforced masonry was a predictable and repeatedly observed phenomenon in earthquakes worldwide (Reitherman, Krimgold, and Albright 1984; Park et al. 2011). In 2010, a study of school safety estimated that 75 percent of the nation's schools would experience partial or complete collapse in violent shaking. Approximately 60 percent of the schools needed to be retrofitted and another 15 percent rebuilt entirely, at an estimated cost of US$ 1.6 billion (Upreti 2011:11; GFDRR and NSET 2012).

With these daunting figures, Nepal embarked on a 15-year plan for addressing school safety in 2011. It started with a pilot school safety action plan for the Kathmandu Valley (NSET and ADB 2011:8). In 2012, the MOE, with support from development partners, began retrofitting 260 schools, about 10 percent of the schools the Kathmandu, Bhaktapur, and Lalitpur districts that make up the Kathmandu Valley.

Historically, communities have been the primary implementer of school construction projects in Nepal. Local school committees typically serve much like construction managers by convincing landowners to donate a suitable site, enlisting volunteer laborers, hiring a limited number of skilled laborers, and tracking purchases and construction processes. More recently, community support has become part of the MOE policy, which required communities to contribute (typically) 25 percent of the construction costs through donations, volunteer labor, or construction materials.

NSET followed the traditional practice of community-based school construction in its retrofit projects, but added a new community engagement and training element. NSET's retrofit projects were generally initiated by heavily-attended parent orientations. The projects also included extensive mason training. Masons involved in the retrofit were given semi-formal lessons on earthquake resistant construction and, at the same time, given a chance to practice with hands-on exercises and on-the-job training. Additionally, NSET tried to increase broader community awareness of risk and retrofit by inviting local residents on guided tours of the retrofit project at several points during its implementation. These tours were meant to show residents exactly how each retrofit activity occurred and to answer residents' questions about the process. This process of community engagement was also applied in NSET's new school construction projects – projects that incorporated earthquake resistant features generally absent in conventional construction. Later, when NSET began building earthquake-resistant schools in districts outside of the Kathmandu Valley, they adapted these same community outreach activities.

At the time of the Gorkha Earthquake, some progress had been made. Of the 260 schools selected for the pilot project, 160 had been completed prior to the earthquake. Over 690 masons had been trained in school retrofit. Within the Department of Education and the district education offices, 180 engineers and sub-engineers had been trained in school vulnerability assessment; a smaller subset had been trained in retrofit design. Earthquake awareness safety orientations had been provided to more than 50,000 students and 3,417 teachers within the Kathmandu Valley. The ministry had also approved a 10-year and US $560 million plan for increased school disaster resilience (Nepal 2015b:77). Despite the successes of retrofit pilot projects, the majority of students in Kathmandu Valley and almost all students outside the valley attended classes in fragile school buildings that had not been built or retrofitted to be earthquake resistant.

Methods

To investigate how community engagement impacted local construction, we selected four districts from within the impacted region where retrofit and new earthquake-resistant school construction projects had taken place. Two districts, Bhaktapur and Kathmandu, were within the Kathmandu Valley, where school retrofit programs with community engagement efforts had been focused and damage had been moderate to heavy. Because most of the damage occurred in the hilly and mountainous regions, we selected two of the most heavily damaged rural districts as our remaining locations – Rasuwa and Sindhupalchowk. These were one of the few places where NSET had completed safer school construction projects within areas of very strong to severe shaking intensity (MMI VII-VIII) during the Gorkha Earthquake.

In each of the four districts, we selected three schools in close physical proximity, typically within the same Village Development Committee and all less than 5 kilometers apart. This ensured the shaking intensities in each school site were similar. The public schools discussed represented three cases.

1. Standard Construction. The first case in each district was a school that had been constructed through standard school construction processes that lacked adequate design and construction oversight to ensure seismic resistance.
2. Technical Intervention. The second case was schools that had been retrofitted or designed for earthquake resistance, but where the technical intervention had been accompanied by little or no community engagement aspects. In the Kathmandu Valley, the selected school retrofit projects had been managed directly by the District Education Offices (DEOs). Outside contractors had been hired and community involvement had been limited or unrelated to the school retrofit. In Rasuwa and Sindhupalchowk, the school construction or retrofit had been funded and partially managed by international non-governmental humanitarian organizations.
3. Technical Intervention with Community Engagement. The last case in each district was an NSET project school where technical intervention had been combined with community engagement.

Our selection of schools was based on an electronic list of school locations and retrofit status provided by NSET. Where multiple schools in same location existed, we selected the school with highest enrollment as these schools often had several school blocks, which allowed for direct comparison of multiple school blocks at a single site. All sites were selected based upon the pre-determined selection criteria, without knowing damage sustained. Table 1 provides an overview of the 12 school sites, including intervention type and school damage.

[Table 2 about here]

We visited each school site for a full day of interviews and observations. These included 2-3 hour semi-structured interviews with school principals where we asked about the community, their earthquake experience, and detailed questions about the funding, design, construction, and construction oversight of one to three representative school blocks, including any community engagement activities carried out during the project. We also conducted a focus group discussion with local parents of students attending the school. These focus groups often included residents who did not currently have children attending, but were in close geographic proximity to it. Finally, we conducted interviews with the lead mason and/or masons responsible for the school construction project. Masons were also asked about construction techniques they implemented in local housing construction and their observations about building damage in the earthquake. In two of the eight cases, no masons remained in the community and this interview could not be conducted, although in one case, a person in the parent focus group had construction experience and was able to provide a local construction perspective on some questions typically asked of the lead mason.

All interviews were recorded, with permission, and detailed notes were typed up during, or immediately following, the interviews. The research protocol was reviewed by Western Washington University's Human Subjects Review Committee and approved. Per protocol, the names of schools and subjects have been changed to protect their anonymity.

Selected Site Descriptions

We have provided five vignettes to contextualize the issues that emerged out the schools assessed. These will help give context for our later discussion of the impacts of community engagement through safer school projects.

It should be noted that while we selected all four district to have similar shaking intensity, stark difference between districts remained. Historic processes, rooted in ethnic and caste divisions and the rugged terrain in Nepal, have resulted in differential levels of wealth, education, and power between Kathmandu Valley and other districts. The Human Development Index (HDI), which measures lifespan, literacy, and gross national income per capita, highlights these differences. While the HDI for Kathmandu and Bhaktapur are 0.622, it falls to 0.458 in the Central Mountain region where Rasuwa and

Sindhupalchowk are located (UNDP 2014). Of particular note, literacy rates for those over five years of age are above 80 percent in Kathmandu and Bhaktapur; they fall to just under 60 percent in Sindhupalchowk and to just over 50 percent for the district of Rasuwa. The Kathmandu Valley is dominated by ethnically *Brahmin* and *Chhetri*, historically high caste Hindus that maintain higher levels of income and a dominant role in the government services and politics today. In contrast, the districts of Rasuwa, and to a lesser extent, Sindhupalchowk, are populated by historically marginalized ethnic groups (Central Bureau of Statistics 2011). Outside of Kathmandu Valley, lower community development creates a more challenging environment for both technical interventions and community engagement, as the case studies below illustrate.

Broadening Horizons Secondary School. *Nawa Chhiteej* Secondary School, which loosely translates to broadening horizons in English,[i] is a two-storey public school in a small peri-urban town an hour's drive north of the Kathmandu metropolitan area. Families that can afford to have increasingly sent their children, especially their boys, to private schools in the city. Thus, Broadening Horizons' 250 students are generally from lower income households.

The first storey of the school was built in 1984 out of adobe brick and mud mortar, a construction material highly vulnerable to collapse in earthquakes. Seven years later the school was expanded and a second story was added. In 2001, NSET began a retrofit project with funding from development partners, local government, and material and labor donations from local households.

As part of the community engagement component, NSET trained and certified local masons in school retrofitting. NSET engineers also came to the site regularly to supervise the process and to further train masons during the process; at crucial stages, more experienced masons were brought in to guide local masons. Being the first in the area, the school retrofit was treated as a community learning opportunity. NSET provided a community orientation, attended by 70 people, to discuss good construction practice. Local residents, especially parents, were also invited to curated tours of the retrofit project at each major step of the process. The local school management committee and representatives of the district education offices also came to learn about the process.

The principal, in particular, took it upon himself to understand the details of the process. While he was first skeptical of the process, when he saw bars threaded through the walls to form micro-concrete bands around openings and at the plinth and lintel levels, his views changed. At project completion, he used the retrofit to both advertise the safety of his school and to promote safer construction practice in the community and disaster management at the school. Local interest in the project, and in the issues it raised about safe construction, was so high that the village government funded further community demonstrations of earthquake-resistant construction, attended by several hundred people, and a five-day training for 30 local laborers.

After the earthquake, Broadening Horizons Secondary School, experienced no structural damage. Despite heavy damage in the village, including partial or complete collapse to most adobe houses, the school did not have noticeable cracks in walls or slabs. While thousands of Kathmandu residents refused to sleep indoors after the earthquake, several families that had lost their homes in the earthquake stayed at the school for more than a month. These families were unafraid to be inside the school even during frequent aftershocks.

Jungle Stream Secondary School. In the valley next to Broadening Horizons, *Bankhola* Secondary School, meaning Jungle Stream, sits on a wide field beneath slopes leading up into the hills of a national park. Almost half of the local students attend the public school. To compete, Jungle Stream Secondary School has begun offering English language classes starting in first grade, a policy that has helped the school expand its enrollment to 400 students.

In the early 2000s, the principal secured funds from a foreign donor to relocate the small, cramped school to its current site. He leveraged further funds from businesses, government agencies, and residents in order to build a large, multi-storey main block. An engineer working for a nearby utility created design drawings but hiring of a contractor was left to the principal and school management committee. Though the mason they hired had no formal training in construction or engineering, he and the principal adjusted the school design to appeal to their aesthetics and needs. They changed the plan from an L-shape to a long rectangle and, near the end of construction, raised additional funds, and added a third story on one side of the building.

With a patchwork of funding, the inspection of the school construction was uncoordinated. The engineer involved in the design of the main block inspected one side of the building; an engineer from the Kathmandu district education office inspected the other side and told the school it could not add a concrete slab roof on the existing, small columns they had. Thus, the school was built with a concrete roof and additional floor on one side, and lightweight steel trusses and sheet metal roofing on the other.

While the official inspection process was haphazard, the school management committee and school staff watched the construction process carefully and tried to provide onsite supervision. They saw that the contractor was constantly trying to reduce labor and material costs by taking short cuts. The school staff eventually organized to ensure at least one teacher was freed from teaching duties each hour to watch the laborers. The staff and students also worked as unpaid labor during the pouring of the concrete slabs.

With low quality construction, substantial changes to the engineering design during construction, and amateur onsite supervision, earthquake-induced damage was not surprising. Infill walls in the upper floors cracked and were in danger of toppling over. All told, the school had to close six classrooms, male and female lavatories, and the main office. Thirty-forty families and about 50 armed police set up temporary shelters in the school's large open yard. However, they did not take shelter inside the school.

Mountain View Secondary School. High above the *Betrawati* River in Rasuwa, *Parbat* Secondary School, translated as Mountain View Secondary School, serves a *Tamang* mountain community. At Mountain View, all but one teacher lived outside the village and was not ethnically *Tamang,* meaning they struggled to communicate with young students who had not yet learned sufficient Nepali, and had difficulty engaging with parents.

In 2008, the school began construction on its main school block with external funding from an international non-governmental organization (INGO) and technical support and community engagement from NSET. NSET began by creating a reinforced masonry design using fired bricks. The design included reinforced concrete sill and lintel bands throughout the walls to help improve their earthquake resistance, as well as a reinforcing bar at each corner and wall intersection. While a concrete frame building was another option, NSET engineers chose the reinforced masonry design because it was somewhat similar to the rubble stone masonry used in local housing construction. Since the village had no sufficiently skilled masons, one was brought in from a town an hour's drive away. This lead mason then started construction with half a dozen local masons, all of which first received NSET training on earthquake resistant construction. An NSET engineer lived on site to provide construction oversight.

While initially the earthquake-resistant construction proceeded smoothly, the community engagement process did not. When the NSET engineer offered to provide an orientation for the village, the school staff were unable to get parents interested enough to attend. Even the school management committee, made up of local residents and school staff, did not fully support the earthquake-resistant construction. A bitter argument between the head of the school construction committee and the engineer erupted right before the pouring of the roof slab. The committee chair argued that the engineer's design was too expensive, leaving insufficient funds to cover informal payment to himself and other committee members. The budget was especially tight because the committee could not raise the 25 percent community contribution required by the MoE policy. Threats ensued and the engineer left hastily, never to return. Three years later, the construction committee raised new funds to add an unauthorized second storey. The construction team, many of whom had worked on the original construction, applied the lintel and sill bands to confine the masonry, as they had learned through NSET training. However, on two of the upper story rooms, about half of the floor area, they did not use bands. No one could remember why.

During the earthquake, the reinforced masonry block designed and partially supervised by NSET engineers performed well. No cracking was visible on exterior or interior of the building. At the same school site, several other school blocks built through the standard MoE process collapsed. After the earthquake, 20 people sheltered in the schoolyard. Despite the lack of damage, community members did not trust the additional, unsanctioned storey.

Stoney Steps Primary School. A few kilometers from Mountain View, *Dhungesidhi* Primary School, or Stoney Steps Primary School had been recipient of a school retrofit through a partnership between a national community organization and an INGO with experience in emergency response.

An engineer with the INGO designed the retrofit – a stitch band approach similar to the one used at Broadening Horizons Secondary School, though the steel bars used were smaller and less densely spaced and the concrete bands were of weaker material. At project initiation, the engineer brought a trained mason from another district to the mountain village. The engineer and trained mason stayed two days and explained how to do the retrofit to three local laborers who had gained some construction skills while working abroad. The local laborers immediately had difficulty. They were unable to drill through the stone walls to insert steel bars or hook longitudinal bars used in the bands.

While the local NGO sent a project manager frequently, the manager was unable to address technical problems. The engineer returned only two times, briefly, during construction. Privately, the school staff and other community members worried that the retrofit was superficial, at best. Ultimately, the earthquake of April 25th validated their concerns. The retrofitted stone building collapsed completely in the earthquake, crushing school desks under piles of rubble stone.

Harmony Primary School. The last school vignette comes from a rural Sindhupalchowk village. In 2004, the principal of *Samabhav*, or Harmony Primary School, was determined to find a donor interested in funding the construction of a new school block. It seemed to him that nearly every other nearby school had foreign donors and fancy new buildings. He was able to secure funding from a European donor but donor expressed concern about managing a school construction process. The donor contacted NSET and asked that the organization manage the project.

While the school management committee initially advocated for reinforced concrete construction – the material they believed was most advanced and modern – NSET suggested reinforced masonry using locally manufactured stonecrete, or stone block. Reinforced masonry with stonecrete blocks was less expensive, which the donor appreciated, and the technology was closer to the stone and brick masonry construction locally used. Furthermore, no local masons had experience with reinforced concrete, a reality that concerned the NSET engineer. NSET also believed that teaching the village how to crush local stone and mix with concrete to form the stonecrete blocks could introduce safer stone construction to the region.

The villagers initially acquiesced to the stonecrete method, carrying sand and materials on their backs from distant sources. However, when they saw the local masons creating the unfamiliar sill bands and masonry stitches on the walls, they halted the construction completely. Only after the NSET engineer forcefully argued that the village could not alter the design, did they continue.

At the time of the construction, Sindhupalchowk was embroiled in a country-wide armed struggle with Maoist rebels. Both the district government and the Maoist rebels were highly suspicious of any large public gatherings, including community outreach events connected with the school construction project. In response, NSET toned down its community engagement activities, foregoing community orientations and large tours of the construction. Rather than send the NSET engineer to be site supervisor, they sent one of their more experienced masons. Even so, part of the construction funds was appropriated as "donations" by both sides of the conflict. Despite these challenges, the two-storey building was completed.

In the earthquake, it experienced only hairline cracking, so minor as to not even require patching. Afterwards, the community heavily used the school. Thirty-five families sheltered in the school building for a month, another 10 set up shelter in the playground. The school management committee eventually insisted these families leave in order for classes to resume. Yet, even at the time of our field assessment, a local tailor was using the second floor terrace for his shop.

Changing Awareness and Practice

Each school constructed, whether the project included technical, social, or no intervention for safety, was a process embedded in a community with its own history of construction practices. To understand how the school project may have influenced community practice, we asked masons, parents, and school staff about several seismic-resistant construction techniques recommended by a number of manuals and guidelines for increasing seismic resistance of non-engineered structures (Blondet 2005; Blondet, Villa Garcia, and Brzev 2003; Arya, Boen, and Ishiyama 2013; Paci-Green and Pandey 2015). Their responses are summarized in Table 2.

[Table 2 about here]

Local construction practice between schools with no intervention and those with combined social and technical intervention show noticeable differences. At the three schools built without any intervention — Fertile Fields, Jungle Stream, and Mountainside Secondary Schools — only masons at a single school reported that shear ties with 135° bends (often informally called earthquake ties) were used. However, school staff had never seen the practice in the community around the school. Other practices were not put into practice either, though some respondents noted having seen lintel bands, stitches, and earthquake shear ties elsewhere.

In contrast, multiple seismic-resistant techniques were reported as being practiced in the communities where the school construction project had also included social intervention. The reported impact was especially noticeable in the Kathmandu Valley. Around Dry Town Primary School, masonry construction often included horizontal bands; reinforced concrete construction included the use of spacers, earthquake shear ties, and sometimes ensured proper concrete curing. At Broadening Horizons Secondary School, almost all techniques were routinely practiced. Outside the Kathmandu Valley, many fewer were. Both around Mountain View Secondary School and Harmony Primary School, spacers and shear ties were routinely used. Construction around Harmony also routinely included proper curing of concrete. However, no other seismic-resistant techniques were practiced, despite their demonstration during the school construction project.

Most intriguing were the schools that had received a technical intervention with little or no community engagement component. While communities were exposed to seismic-resistant construction techniques during the school project, the exposure did not, for the most part, transfer to local construction practice. Masons, parents and staff reported that virtually no seismic-resistant techniques of any kind were used in communities around the retrofitted Kathmandu Valley schools of Rustling Winds and Pleasant View. At Rustling Winds, parents noted that families sometimes cured concrete for a couple of days, but were adamant that spacers were not used in concrete construction.

They even noted that reinforcing bars routinely were visible on the underside of concrete stairwells. Some parents remembered the use of vertical reinforcement (probably bamboo) used in the past, but said it was never used now in adobe construction. They had seen bands, but reported that the use of bands was very uncommon in their community. In the predominantly rural and *Tamang* village around Pleasant View, parents and masons reported that no techniques were used, not even infrequently. In Rasuwa, the masons noted that they personally practice three of the techniques. The masons noted they learned these techniques while working as foreign laborers on large, engineered construction sites in Saudi Arabia and Malaysia, not while working on the safer school retrofit project. In Sindhupalchowk, masons reported only limited use of four reinforced concrete techniques, while the nearby community that had experienced community engagement reported consistent use of these same techniques.

School Staff and Masons as Agents of Change

A closer look at the role of the masons and school staff at the schools with both technical interventions and community engagement begins to illustrate how, and the degree to which, seismic-resistant construction techniques were adopted in the surrounding community. These roles suggest multiple pathways from school to community, but also the complex, though not always positive, outcomes of community engagement.

At Dry Town Primary School, in Bhaktapur, the teachers, principal and lead masons became strong advocates for safer construction practice. While the activities on the school grounds raised local awareness about seismic risk, it was what the school staff did offsite that linked the school project to local construction. The principal and teachers began walking around the neighborhood to talk with the homeowners about seismic-resistant construction, advocating that owners keep buildings low and avoid large overhangs. (After the earthquake, those same owners returned to thank the principal.) The school staff found that their message was more effective among the lower-income households where homeowners had stronger deference and respect for public school teachers. Lower middle and middle-income households that did not send children to Dry Town Primary School were more resistant to the message.

The local masons were even more influential. At Dry Town, the lead mason incorporated cost-neutral and low-cost changes like earthquake shear ties, closer tie spacing, and better detailing of the steel at beam-column joints into his construction practice. However, the lead mason could not convince most homeowners to pay for more expensive or visible changes. Local homeowners were resistant to the concept of horizontal and vertical bands – a reinforced masonry approach – seeing it as ugly and a waste of expensive steel. Retrofitting was also seen as too complex and expensive for home construction. However, the mason did convince about half of the homeowners for whom he worked to pay for vertical reinforcing steel into their masonry construction. One of these homeowners was the principal himself, who also invested in horizontal lintel bands in his new, two-storey home.

At Broadening Horizons Secondary School, the influence of the mason was even more pronounced. The trained masons were able to describe the need for proper construction to homeowners and, in most cases, convince the homeowners. The most significant change was that as people realized the weaknesses of adobe construction, highlighted by the need to retrofit the school. Homeowners turned towards reinforced concrete construction as a stronger and safer alternative, especially with the earthquake-resistant techniques the trained masons promoted. Some of the trained masons admitted they occasionally had to acquiesce to homeowner demands – requests for large cantilevered balconies or misaligned reinforced concrete frames – but the lead mason felt so strongly about safe construction he began refusing to work on construction that did not incorporate the seismic-resistant construction techniques he had learned.

In Rasuwa and Sindhupalchowk schools where social interventions were applied, albeit under circumstances of ethnic division and civil conflict, the impact on local construction was markedly less. At Mountain View Secondary School, lead masons were aware of the seismic resistant construction techniques, but did not actively promote these techniques in their community. The masons believed they were less persuasive, in part, because they could not refer to what the school engineer had promoted; no parents had come to any of the announced construction tours or risk awareness seminars. The concepts were so little reinforced, that years later, when the masons added a second floor to the safer school, they abandoned the use of horizontal bands in two of the three rooms in the second storey addition, preferring to save costs instead. Parents of the Mountain View Secondary School felt that the seismic-resistant construction techniques employed at the school were an expensive endeavor, one that was not appropriate for their smaller homes and the stone construction they typically used. They continued with their traditional construction practices, despite the attempted social intervention.

At the Sindhupalchowk school of Harmony, where the NSET engineers chose an innovative stonecrete construction method with seismic-resistant features, residents also did not integrate these features into their housing construction. They believed reinforced concrete was the more advanced material and when they could afford to enhance construction, they did so by building with reinforced concrete, rather incorporating seismic-resistant construction techniques into their traditional stone or adobe construction.

The construction of a later school block at Harmony is illustrative of local perceptions. When the school principal secured funds from a foreign donor for a new building, the community argued intensely about whether to build using seismic-resistant masonry construction or build using the less familiar, but ostensibly advanced, reinforced concrete construction. The principal advocated for safety, but the community was locked into a false dichotomy – safe masonry or reinforced concrete. The community selected concrete. In reflecting back on the process, the principal realized that he and his community did not understand that reinforced concrete could also be built with seismic-resistant techniques. The new school block constructed of reinforced concrete, but without earthquake-resistant features, sustained major damage in the earthquake and the school management committee decided to demolish it.

In contrast, at the schools that had been retrofitted, without training and community engagement, parents and school staff had little knowledge of the retrofitting process and how it did, or did not, apply to their home construction. School staff and parents at Rustling Winds Secondary School noted that they were never invited to the construction site and had not had the project explained to them. Parents at Pleasant View mirrored these feelings. Parents at both sites remembered not trusting the retrofit project. Parents at Rustling Winds were particularly vocal, saying that at the time of the retrofit, they believed the project was nothing more than an expensive, international project funneling funds to a handful of individuals within the local department of education and community leadership. As such, they were neither curious about the retrofit process, nor interested in adapting its methods to their local construction.

Knowledge of the retrofitting process had post-disaster benefits. At several sites where community engagement had occurred, residents had high confidence in the school and the earthquake-resistant features it incorporated. Because they understood these features and had seen and engaged with the construction process, they felt comfortable using the schools as shelters. At the four community-intervention schools, two had been used extensively for shelter; a third was too small for shelter use. The fourth case was Mountain View Secondary School where unsanctioned modifications of the school caused residents to distrust the school, even though it was undamaged. In contrast, at the two schools in Kathmandu and Bhaktapur where technical intervention only had occurred, parents and staff stated they did not trust the school buildings. At these sites, no families used the school buildings as shelter, even though many had lost their homes and were forced to sleep outdoors. Outside

Kathmandu Valley, the other two technical intervention only sites had school buildings that had collapsed and were summarily unusable after the earthquake.

Plans for Seismic-Resistant Reconstruction

The presence and absence of community engagement continued to shape communities, especially those in the Kathmandu Valley, as they began to recover from the 2015 Gorkha earthquake and aftershocks. When parents at Dry Town Primary School and Broadening Horizons Secondary School were asked about how they would rebuild or repair damaged homes, they were already starting repairs and reconstruction plans. Having seen the success of the school retrofit in their neighborhood, they were confident safe construction was possible. More importantly, they knew who to ask. The masons at both sites stated they were swamped with questions about seismic-resistant construction techniques and, in the village around Broadening Horizons, they had projects scheduled out for the next year. A walking transect around Broadening Horizons revealed several moderately damaged homes where local masons had begun home retrofits using the techniques they had learned at the school. At Dry Town Primary School, we observed local community members listening intently to the retired lead mason as he listed out how to reconstruct safety. His main messages, stated with the authority of someone who could point to an undamaged retrofitted school, were that homeowners needed to add even more reinforcing steel to their homes, increase the density of earthquake shear ties in columns and tie their masonry walls to the columns with reinforcing steel. He also advocated for a richer concrete mixture than was traditionally used in the area.

At the most successful site of social outreach, parents and local homeowners were also specific about what *they* believed would make recovery construction stronger. At Broadening Horizons, parents listed off lintel bands, concrete curing for at least three weeks, cement mortar in the foundation, and smaller wall openings. This contrasted sharply with nearby schools that had experienced only technical interventions or no intervention at all. Parents there only had general ideas for improvement, such as building only one and two storey homes and not using adobe bricks. These ideas were offered tentatively, and only after considerable prodding. Some parents flatly believed no local construction could be seismically-resistant, other than the temporary shelters pieced together from plastic, corrugated iron and bamboo.

At the schools in Rasuwa and Sindhupalchowk without community engagement, the mood was decidedly bleaker. Parents at Mountainside Secondary School concluded that no construction was truly safe, but that stone and adobe were completely unsafe and could not be made safe, ever. Instead, they believed the safest option was to rebuild with reinforced concrete, despite their lack of experience with the material or financial resources. Parents at Kindness Secondary School had similar, but even more ill-informed conclusions. They too said they would not rebuild in stone and believed reinforced concrete construction would be safer. They confidently stated these conclusions, despite the floors and balconies that sat cracked and collapsed at the reinforced concrete school. Alarmingly, some parents suggested that the collapse of concrete elements was because they had not added sufficient water to the concrete mixture, a practice that, in reality, would weaken the concrete.

At Harmony, where a safer school project had been completed, but with community engagement somewhat hampered by civil war, parents were not able to articulate what safer construction techniques they would use during reconstruction. Many of these parents were themselves young children at the time of the safer school construction project. However, the principal and staff were able to better remember the project and suggest safer reconstruction techniques, including using larger diameter and a higher number of reinforcing bars in reinforced concrete columns, avoiding excess water when mixing mortar, and curing concrete for longer. These school staff also advocated for smaller homes, compact in shape and one to two storeys. However, like the schools without social intervention, both parents and school staff were clear that reconstruction would have to be with reinforced concrete frame, not with masonry wall. As one parent explained, “We have already faced a tough time with stone and brick, so we want to build with RC, using the right techniques.” They planned to wait to learn safe reinforced concrete construction techniques and save money to buy the more expensive material.

Conclusion and Moving Forward

Nepal’s school retrofitting program, combined with the impacts of the devastating 2015 Gorkha earthquake, provides good evidence for how school construction can support disaster reduction and resilience education in the education sector, as more broadly defined. Where community-based school retrofit or seismic-resistant new construction had occurred in the Kathmandu Valley, parents, staff and local masons interviewed were more aware of seismic-resistant construction techniques and reported more use of these techniques in local housing construction. Further, these communities showed evidence of applying school retrofit technology in the repair of damaged housing, speeding reconstruction.

Yet, retrofit and seismic-resistant school construction projects are not a panacea. Where these school projects had occurred without concurrent community engagement in the Kathmandu Valley, school and community members were not as familiar with seismic-resistant construction. More critically, while some school retrofit projects without community engagement resulted in safe learning facilities, not all did. Two schools outside of Kathmandu Valley – a school retrofit and a school ostensibly designed to be seismically-resistant – collapsed in the earthquake. Without the concerted mason training and oversight, even the limited goal of safe learning facilities was not achieved at these sites. Thus, our assessment suggest that Nepal’s school construction projects can achieve safe learning facilities *and* catalyze change in local construction techniques, but that these changes may hinge upon community engagement through mason training, oversight, and community outreach. Yet, given the muted impact community engagement had outside the Kathmandu Valley, issues of poverty, literacy and marginalization may impose daunting challenges for attempts to transfer earthquake-resistant technologies from a single school project to broader community practice.

Further, the findings point to substantial challenges at the intersections of safer learning facilities and disaster reduction education. While evidence of increased knowledge and changed construction practice existed in the immediate vicinity of the safer school projects, the impact was partial and quickly diffused with distance from the school site and time. Masons reported that they could not convince more than half of their clients to make changes to housing construction, and even then, clients were interested only in small changes that marginally impacted cost or aesthetics. Large changes, like adding horizontal bands to masonry construction were uniformly rejected. The impact was also geographically limited. While communities next to the schools showed signs of change, these changes were not evident in communities a few kilometers away where other retrofitted schools without community engagement were assessed. Even when community engagement had occurred within a community, a temporal loss occurred. After ten years, many younger households did not remember the safer school construction project and the techniques employed.

Community engagement, rather than being considered a helpful addition to safer school construction projects, should become an essential element in achieving safer learning facilities. However, to effect widespread change, our findings suggest community-engagement interventions need to occur at every school and be sustained over time. Community engagement – awareness raising, training, and oversight – should be integrated standard school construction procedures, especially in contexts where community-based school construction and natural hazards intersect. To ensure this engagement has sustained impacts years later, school staff should have the training and support to integrate the concepts of safer school construction into curriculum, regular commemorative events, and signage in and around the school. Given the prominent role school staff have played as informal construction monitors, they also need better training and support to identify and report construction issues that may impinge upon the safety of the school building. By expanding and integrating community engagement into safer school projects, the process of building safer learning facilities will support community disaster reduction and resilience education and that education, in turn, will help ensure that whole communities are built safer going forward.

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Table 1. Overview of School Construction and Intervention Projects Assessed

District.	School Name (Pseudonym)	Building type and damage	Year of original construction/ intervention	Intended technical intervention	Community engagement
Bhaktapur	Fertile Fields Secondary School	2 storey RC-frame, infill wall damage	2008	None	None
	Rustling Winds Secondary School	2 storey retrofitted masonry, no damage	2003/2008	Retrofit	None
	Dry Town Primary School	2 storey retrofitted masonry, no damage	1987/2000	Retrofit	Mason training, onsite technical oversight, community outreach

Kathmandu	Jungle Stream Secondary School[1]	3 storey RC-frame, infill wall damage	2004-2010	None	None
	Pleasant View Secondary School	2 storey retrofitted masonry, no damage	1993/1998	Retrofit	None
	Broadening Horizons Secondary School[1]	2 storey, retrofitted adobe, no damage	1984/2001	Retrofit	Mason training, onsite technical oversight, community outreach
Rasuwa	Mountainside Secondary School[1]	1 storey metal frame, infill wall collapse	2005	None	None
	Stoney Steps Primary School[1]	1 storey retrofitted stone, complete collapse	1997/2011	Retrofit	Limited mason briefing
	Mountain View Secondary School	2 storey earthquake-resistant masonry, none	2008, unauthorized addition 2011	Resistant, new	Mason training, onsite technical oversight, community outreach unsuccessful
Sindhupalchowk	Kindness Secondary School	2 storey stone, complete collapse	1992	None	None
	Hill Settlement Secondary School	2 storey earthquake-resistant RC frame, collapse complete	2013	Resistant, new	INGO funds specific design development by DUDBC[2]
	Harmony Primary School[1]	2 storey earthquake-resistant masonry, none	2004	Resistant, new	Mason training, onsite technical oversight, community outreach limited by civil war

[1] School described in vignette

[2] Department of Urban Development and Building Construction

Table 2. Reported use of earthquake-resistant construction techniques

			Stone and Adobe Construction			Reinforced Concrete Construction				
Dist.	Intervention	School Name (respondents)	Vertical wall reinforcement	Bands at lintel or sill levels	Corner Stitches	Columns larger than beams	Spacers used	Shear ties with 135° bends	Concrete cured properly	Walls tied to frame, or banded
Bhaktapur	N	Fertile Fields (mason/staff)	N	N	N	N	N	Y, limited	N	N
	T	Rustling Winds (parents/staff)	N	Rare	N	N	N	N	N	N
	T+C	Dry Town (parents)	N	Y, limited[1]	N	N	Y	Y[2]	Y, limited	N
Kathmandu	N	Jungle Stream (masons/parents/staff)	N	N	N	N	N	N	N	N
	T	Pleasant View (masons/parents/staff)	N	N	N	N	N	N	N	N
	T+C	Broadening Horizons (masons/parents)	Y[1]	Y[1]	Y[1]	Y, limited[1]	Y[1]	Y[1]	Y[1]	N
Rasuwa	N	Mountainside (masons/parents/staff)	N	N	N	N	N	N	N	N
	T	Stoney Steps (masons/parents/staff)	N	N	N	N	Y[2]	Y[2]	Y[2]	N
	T+C	Mountain View (parents/staff)	N	N	N	?	Y	Y	N	N
Sindhu.	N	Kindness (none[3])	?	?	?	?	?	?	?	?
	T	Hill Settlement (masons)	N	?	?	N	Y, limited	Y	Y, limited	N
	T+C	Harmony (parents, some with const. experience)	N	N	?	N	Y	Y	Y	N

[1] Respondents stated adoption of technique occurred after school intervention

[2] Respondents explicitly stated adoption of technique was related to other factor. At Dry Town Primary School, shear ties with 135° bends adopted when new municipal building code enacted. At Stoney Steps Primary School, local masons adopted techniques after seeing them on foreign construction sites where they worked.

[3] The village had no masons or experienced construction laborer present at time of school construction or interviews.

[i] All school and town names have been changed to protect the anonymity of the staff, parents, and masons interviewed.