LEARNING BRIEF

Retrofitting and Earthquake Safe Construction for Schools

The Nepal Safer Schools Project (NSSP) piloted retrofitting techniques with 4 schools across Achham, Bardiya, and Surkhet. This work was done as part of NSSP's efforts to help schools improve their adherence to Comprehensive School Safety standards, namely under the first pillar of the Government's minimum package "Safe Learning Facilities".

The early closure of the NSSP meant that designs and plans to scale up and implement retrofitting in more schools were not realized. The scale of NSSP's pilot was small and as a sample it is not possible to draw detailed conclusions; however, the experience has provided some interesting insights and observations.

PROJECT ACHIEVEMENTS

97 Classrooms retrofitted or rebuilt to improve earthquake resilience and help save lives in the event of an earthquake*

350 Classroom designs prepared, of which 230 designs are fully approved and ready for use*

** 4 classrooms were retrofitted and 16 designs were prepared for schools outside of the project with technical support from NSSP, driven by demand from the schools*

Masons trained across four districts

26%

of trained masons engaged to use their skills on Project structures

LESSONS FROM THE PROJECT

Retrofitting costs were within one-third of the estimated price of a new build to achieve the same degree of seismic resilience

On average, the construction costs[1] per square foot for buildings retrofitted under the project was NRs. 766.59. In one school in Surkhet, the Project also demolished and rebuilt a new reinforced concrete building. The cost of the new building was NRs. 2,254 more per square foot than buildings retrofitted to the same level of seismic resilience on the same site.

RETROFITS COST within **1/3** the price of a new build

School buildings are especially well suited for retrofitting interventions

Schools in Nepal generally have simple blocks of classrooms with few finishing details and less complex plumbing or electrical wiring than a home, which makes most school buildings good candidates for retrofitting. Revealing the bare walls and then performing strategic structural strengthening work is a relatively straightforward process. This makes it an appropriate methodology for these types of structures.

Not all school buildings can be retrofitted

The NSSP conducted Rapid Visual Assessments (RVAs) of 353 buildings, with a total of 1,077 classrooms. 7% of these assessed buildings were not deemed suitable for retrofitting, and were instead recommended to be demolished and rebuilt because of poor building condition. Importantly, buildings also need to be assessed with a multi-hazard view that takes into account not only seismic resilience but also other disaster risks such as landslides and flooding, and the need for other mitigation measures such as site civil engineering works or relocation if these risks cannot be managed.

[1] *This includes labour, materials, and management. This does not include costs of surveying and design, and additional technical support from the NSSP.*

THE NSSP RETROFIT PROCESS

1. **CONSULT** school communities on willingness to use retrofit technology to make school buildings safer
2. **ASSESS** buildings to understand the existing condition with a Detailed Engineering Assessment
3. **DESIGN** a retrofit plan for each building, accompanied by material procurement and costing estimates
4. **APPROVE** these retrofit plans with the Government of Nepal's Centre for Education and Human Resource Development
5. **TRAIN** School Management Committees on handling the procurement and financial aspects of a retrofit and local masons on earthquake safe construction principles
6. **PROCURE** construction materials to prepare for retrofitting
7. **RETROFIT** buildings, with regular technical construction supervision from qualified engineers, leadership of a construction technician, and on-the-job upskilling for masons
8. **REVIEW** as needed from the preparation to the completion of the retrofit process, with robust quality control of work, checks for material quality, and updates to the design if required and a comprehensive construction audit
9. **PAY** grant instalments to schools based on progress milestones, covering costs of materials, labour, and project management

The biggest costs in retrofitting were non-local materials

On all pilot retrofitting sites, the highest proportion of costs was for materials that couldn't be sourced locally, such as cement, steel bars, GI wire, CGI sheets, and paint. On all sites these types of materials came to more than 60% of the overall construction costs.

Stronger market development and early surveys for construction materials is needed

Initially, designs and plans were made for two building blocks in the pilot to be retrofitted using welded wire mesh technology. However, the welded wire mesh needed was not available to order or purchase from vendors on the local market, and transport from Kathmandu was prohibitively expensive. Designs were then revised to use steel bars, which is the technique that was also used all other classrooms. Similarly, even "local" material availability varied greatly between districts; for instance, while chips and aggregate were easily available in Surkhet, they were much more difficult to procure in Achham. It is important to note that new builds would also face the same market and procurement challenges, and encouraging strong market linkages will be the key to ensuring all earthquake safe construction across the country. In future projects, it is recommended to include a survey of local materials at the beginning of the process, in advance of the design phase, and also try to ensure that there is not a complete reliance on a single supplier for key construction materials to avoid delays.

Retrofitting all buildings in a school requires complex planning and management, which schools need to be aware of

While extended school closures due to the Covid-19 pandemic over the course of the retrofitting pilot meant that the NSSP's experience was not of a typical school year, when classes are in session the logistics of emptying classrooms to conduct retrofitting work and ensuring that there are adequate alternative spaces for students to study in the meantime is complicated. School management needs to understand and

RETROFITTING COST FACTORS

NUMBER OF STOREYS: Buildings that are multiple storeys had a lower cost per square foot retrofitted than buildings that are multiple storeys. This is because in single-storey buildings there is a higher ratio of expensive foundation strengthening work to classroom space in a building that is a single storey. Similarly, very small buildings with just a couple of classrooms have the same mobilization costs as larger buildings, and so the unit cost can be higher for buildings with fewer classrooms.

ROOFING INTERVENTIONS: Buildings that need extensive strengthening work on the roof, or full replacement for the roofs, had higher costs.

ORIGINAL BUILDING TYPE: Different types of construction have different material cost considerations when retrofitting. For instance, buildings originally constructed with mud mortar need to be secured with a GI mesh over the walls, a step which is not necessary in structures that originally used cement.

LOCATION AND TRANSPORTATION: The distance of the school from local markets, challenges of transportation of materials during monsoon or other adverse road conditions, and additional labour needs to carry material from the delivery vehicle to particular tricky work sites all were factors that could cause costs to rise.

PROVIDING TECHNICAL SUPPORT TO ENABLE RETROFITTING

The Nepal Safer Schools Project teams were approached by four schools with requests for technical support. Two of these schools already had designs and drawings prepared by CEHRD; on one of these, NSSP technical teams made regular site visits for and provided implementation guidance for these designs to on-site workers, and advised the SMC on material procurement and the school completed retrofitting of four classrooms with this assistance.

On the second, the NSSP team helped revise an out-of-date cost estimate and provided similar advice to the SMC; at the end of the NSSP, retrofitting work was underway at this school using NSSP-trained masons with experience on a pilot site.

Another school already had a budget allocated for retrofitting, but had not been able to the process move forward and as a result the budget had been frozen. The NSSP team supported design, drawings, and cost estimates which helped move the budget release process forward, and the school was procuring materials and preparing for construction at the end of the NSSP.

The final school also requested help with design, drawing, and cost estimates, which have been provided.

be prepared for how to handle this. Schools also should know to factor in time for building assessment and retrofit design. This phase that this may be comparatively longer than design for a new build, but this is balanced by less construction time, cost, and materials required on site.

Schools are eager to make their buildings safer – but technical expertise is hard to come by

While NSSP technical teams in the field for the pilot, they also extended an offer of technical assistance to any non-NSSP schools seeking to retrofit. Four nearby schools (two in Surkhet, one in Bardiya and one in Achham) contacted the teams seeking support. This shows that schools have an interest in using retrofitting to improve building safety, but even with budgets available for this work find it challenging to access technical design, construction and project management expertise.

> **“Initially, we had doubts that mere jacketing of the building might not be effective to restore its strength. We found out that the retrofitting made the buildings quite strong. With the jacketing and nets used, everyone who came to observe were convinced that the buildings are now strong enough.**
>
> *Sarfaraj Rimal*
> *Principal, Surkhet*

A comprehensive vision for overall school development and future student population is required to ensure buildings are strengthened and built safely

Many schools in Nepal have multiple small, one-storey buildings with three or less classrooms in the block. As schools and local governments gain experience using formal planning processes such as School Improvement Plans, it is important to consider the most appropriate type of buildings including factors such as safety, best use of space, classroom size requirements, and cost. As land is scarce and foundation costs are high, it often makes sense to build two or three storey buildings - if they can be designed and constructed to high safety standards. Schools often demolish and rebuild small blocks, or want the flexibility to expand upward on another storey when funds are available or when need for classrooms increases. Retrofitting work as well as new construction work on buildings must take place in the wider context of good planning and understanding of the school's needs and goals to avoid duplication of effort and short-term construction solutions that do not adequately address larger issues.

POLICY NOTES

Facilitating early engagement

Schools and local government intending to retrofit will benefit greatly from engaging early with the central-level design approval process. If schools and communities know how to contact CEHRD to begin the process, have an understanding of what will be needed for approval, and an idea of general timeframes, this can help boost confidence, improve collaboration between implementers and approvers, and increase community willingness to try retrofitting.

Planning for larger buildings

Many schools increasingly want to build upwards to make larger, multi-storey buildings rather than many smaller, single-storey buildings. This often makes sense from a land use perspective, and can also minimize some construction costs. However, it is important that schools plan early and comprehensively for multi-storey buildings. This should be part of the School Improvement Plan process, so that this intention can be incorporated into any new construction or retrofitting plans. Modular design planning, where foundations and ground floors are engineered to have the possibility of adding additional floors in a structurally safe way later, is important if a school does not have the resources or need to construct all at once. It is also important to design for factors such as disability friendly access for future additions in advance.

Documenting as-built design

In any project, it is important to establish a design change control process and that the design be responsive to discoveries that may occur during the . If any design needs to be updated during the construction process, having a system for maintaining a set of as-built drawings that can be referred to in the future is essential.

Building retrofit design capacity and optimizing process

Increasing preference for retrofitting in schools will depend largely on ease and speed of accessing design support. Optimizing the process for identifying issues that need to be remedied, such as a "library" of commonly observed shortcomings that can be linked to potential interventions, may help make this process more effective.

Outreach on CSSMP and building safety standards to private schools

Maintaining engagement with private sector schools, especially through bodies such as PABSON, is crucial to ensure that all students in Nepal can study in safer environments. Private school environments may have additional or unique challenges that need further policy work; for instance, often private schools use buildings that are rented or leased, which makes implementing building safety standards complex.

Training local labour forces in retrofitting

Increasing national capacity in retrofitting requires structured vocational training for local masons. The Nepal Reconstruction Authority has previously made recommendations that a 25-30 day on-the-job training be used for retrofitting and that this be adopted and led by local governments to enhance local capacity; a system like this would be extremely useful in increasing retrofitting practice. Using a system of more experience on-site Construction Technicians would also help relieve the pressure of supervision on limited engineers and sub-engineers.