# IMPLEMENTING SCHOOL RETROFITTING PROGRAM IN NEPAL: EXPERIENCES AND LESSONS LEARNT

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**SUMMARY:**
There are about 82,000 buildings belonging to more than 33,000 schools in Nepal, out of which about 60,000 buildings require seismic improvement. Retrofitting of school buildings was first introduced by National Society for Earthquake Technology- Nepal (NSET) in 1997. There has been a greater realization by National and international community in the need for improving seismic safety of schools. The Department of Education (DOE) along the line of Flagship program of NRRC has developed a 5 year comprehensive plan for retrofitting of 900 school buildings of the Kathmandu Valley in 5 years and 60,000 buildings of the whole country in next 15 years. DOE has implemented retrofitting of 15 school buildings in 2010/2011 and another 50 buildings are being retrofitted through the support from NSET and ADB. This paper highlights the experiences, challenges faced and lessons learnt with replicable models in implementing school retrofitting program in Nepal.

*Keywords: Retrofitting, experiences, challenges, replicable models, comprehensive plan*

## 1. INTRODUCTION

Government of Nepal recognized the need of school vulnerability reduction and institutionalized School Earthquake Safety Program (SESP) in 2010. The SESP which was initiated by NSET in 1997 has demonstrated successful and feasible replicable models towards complete cycle of earthquake risk management in education sector starting from seismic vulnerability assessment to the retrofitting/reconstruction, preparing the schools for emergencies and enhancing the capacity of engineers, technicians and masons on earthquake safe construction. The program is now being implemented in the Kathmandu valley under the flagship 1 of the Nepal Risk Reduction Consortium (NRRC) led by the Department of Education (DOE) through the coordination support from the Asian Development Bank (ADB).

The Government of Nepal incorporated SESP: in the regular annual program of the DOE and implemented a pilot program in 15 schools in 2010 with the technical support from ADB through NSET. The program is now being scaled up in the valley and being implemented in 50 more schools in 2011/2012. Accordingly, program for implementing SESP in more schools has also been developed and the funding sources are also identified.

ADB and NSET developed concept paper for the vulnerability reduction of the schools of the Kathmandu Valley in 2010. Based on the concept paper, ADB and NSET again carried out snapshot study of the schools of the valley and recommend detail plans of action to reduce seismic vulnerability of all the schools of the Valley. Incorporating the lessons and experiences of piloting the program in 65 schools of the Valley, the DOE has developed a 5-6 years plan to strengthen existing 900 school buildings of the valley and calculated approximate cost of US$ 30 million. The DOE through the support from the ADB is retrofitting 260 school buildings by 2014, for which the funding resources have already been identified.

As the DOE accepted the concept paper, NSET provided assistance to develop the annual plan which was incorporated in the national program since 2010. [Ref. ADB/NSET report 2010 1]

## 2. BACKGROUND

An International Consortium of ADB, IFRC, UNDP, UNOCHA, UNISDR, and World Bank was formed in May 2009 to support the Government of Nepal in developing a long term disaster risk reduction action plan for implementing some important strategic actions suggested in the National Strategy for Disaster Risk Management (NSDRM). In addition, the Consortium initiated a multi-stakeholder participatory process with the Government of Nepal and civil society organizations to identify short to medium term disaster risk reduction priorities that are both urgent and viable within the current institutional and policy arrangements in the country.

Based on Government priorities and discussions with multi stakeholder groups, the Consortium members and government developed a draft program proposal which identified five flagship areas of immediate intervention for disaster risk management in Nepal. Improving seismic safety of schools and hospitals through structural and non-structural mitigation measures is one of five priority areas identified in the flagship programs.

## 3. THE CONCEPT PAPER

Among the consortium members, ADB is coordinating for school safety component of the Flagship Area 1. Before starting the actual program implementation, possible details of the proposed program were worked out and understanding was developed among the stakeholders so as to facilitate smooth implementation of program. Hence, a national workshop among education related key institutions was conducted on 16 July 2010 to discuss various aspects and possibilities of such school intervention program. The Concept Paper on Implementing Earthquake Vulnerability Reduction Program in Kathmandu Valley, Nepal was prepared by ADB and National Society for Earthquake Technology – Nepal (NSET) to help initiate the discussion during the workshop.

The approach of school vulnerability reduction program that was proposed by the concept paper was to evaluate all the existing school buildings of the Kathmandu Valley in respect of earthquake safety and implement retrofitting works in phases. In the first phase, the schools situated in the core city area with limited space, highly vulnerable, potential of replication. Entire work was proposed to be lead by the Department of Education and implemented through the community driven approach so as to have sustainable results. The DOE shall seek technical support from the specialized agencies for design and assessment where as supervision and quality control shall be the responsibility of the district level education authorities. The concept paper proposed an amount of US$ 30 million over a period of 5 to 6 years to cover all the schools of the valley.

Retrofitting is new technique for Nepal. Although it was initiated in 1997-98 by NSET, it couldn't take momentum for about 14 years. Globally accepted techniques as well as service of experts from Indian universities and other countries were employed by adjusting them in to the Nepalese context. Experiences from retrofitting of schools in the Northern areas of Pakistan were also considered for different types of the buildings.

### 3.1 Possible Details of Proposed Program

The concept paper was developed analyzing thoroughly the past study results on school vulnerability conducted by NSET in 2000, study conduct in Lamjung and Nawalparasi by NSET/GFDRR in 2010 and the information and experiences of implementing SESP in different districts during past 14 years.

The concept recommended possible details of the school vulnerability reduction program in Kathmandu Valley.

*3.1.1 Main concept: program results*

1. Structural and non-structural vulnerability assessment:

   Expected outcome:
   - An updated seismic assessment of schools in Kathmandu Valley (this information will provide input data for component 2 and component 4.

   Approach
   - Use of national specialists, will legitimate in-country expertise, facilitate knowledge transfer and knowledge sharing between Nepalese technical groups, sharpen local skills and capacities, and advance practical risk assessment knowledge

   Measurable output
   - Documentation and measurement of assessed schools against design codes, and recommended remedial adjustments

2. Physical retrofitting and seismic strengthening:

   Expected outcome:
   - Enhanced school building resilience from adverse hazard consequences, greater occupant survivability and safety, more reliable service continuity during /after hazard impact, leading to an overall improvement in community security and well-being.

   Approach
   - Retrofitting and strengthening operations to be undertaken with local services and trades-people thereby enabling acquired skills and experiences to be retained within the community and which can be used to enhance the safety of communities.

   Measurable output
   - Structural compliance to national building codes

3. Awareness building

   Expected outcome
   - Improvement in knowledge about constructing resilient structures
   - More resilient communities throughout Kathmandu Valley
   - Safeguarding measures for sustainability in future
   - Measureable outputs
   - Production and delivery of community-level 'self help' material and courses that would improve social mobilization
   - Delivery and testing of protocols for inter-institutional coordination and processes for regulatory enforcement

## 3.2 Program design and implementation plan

- There are total 2,121 schools in Kathmandu Valley; out of which tentatively 575 are public (community) and rest are private (institutional).
- Generally, primary schools have only one school building unit, lower secondary schools have two and secondary and higher secondary have three. Applying this tentative number of units in each school, the total number of school building units in Kathmandu Valley belonging to public (community) schools is 1,200.

There are in general 3 categories of school buildings (3 levels of vulnerabilities)

a) Existing buildings with quality of construction so poor they cannot be retrofitted (approximately 25% of total buildings)
   - Need pull-down and reconstruction

b) New construction and/or under construction, physical condition good but non-compliant

- Can leave as it is for now, since convincing communities and authorities for retrofitting these may be difficult (approximately 25% of total buildings)

c) Existing structures of sufficient quality but non-seismic resistant
- possible for retrofitting, feasible, requiring immediate intervention (approximately 50% of total buildings)

Almost 50% of the total building blocks fall under Category c), they can be retrofitted and feasible to do it as soon as possible. Approximately 25% of the total fall under category a), they need to be pulled-down and reconstructed.

Hence, approximately 900 (75% of the total) building blocks will require retrofitting or reconstruction in this phase [Ref. ADB/NSET 2010 2]

## 4. RETROFITTING PROGRAM

School retrofitting program not only covers the hardware part but also enables different stakeholders to build their capacity in different aspects of earthquake risk management. Only making buildings safer cannot solve the problem of entire earthquake vulnerability. Hence the components of this program are strengthening physical structures, knowledge management, capacity building, and technology dissemination and preparing for effective emergency response in schools.

### 4.1 Components

Recognizing the outcome of the SESP implemented in the past, the DOE has come up with a same concept of SESP. The components of the program included are based on the approach and vision of making all community of Nepal safer against earthquake which include

- Selection of 15 school buildings from the three districts of the Valley (3 from each)
- Detail seismic vulnerable assessment of selected buildings and designing for possible vulnerable reduction methods
- Implementation of retrofitting works
- Training to the DOE engineers on detail assessment, retrofit design and retrofitting techniques of different types of buildings
- Training to local masons on seismic retrofitting and earthquake safe construction techniques
- Training to teachers and orientation to students on earthquake preparedness and response in schools
- Preparation of earthquake preparedness and response plans and conduct drills
- Awareness program to the parents and the school management committee
- Development of training curricula and guidelines to different target groups.

### 4.2 Approach and Methodology

Since it was the first program of its type by the Government of Nepal and the proposed options were totally new to most of the engineers and technicians, it was decided to get service from the expert agencies like NSET to ensure the successful implementation and optimum capacity enhancement of the engineers. Following are the main approach of the program while implementing pilot program in 15 schools-

- Involve NSET and the school teachers, management committee and district level authorities of DOE to select appropriate schools.
- Give entire responsibility of technical works to NSET and make involve the DOE engineers, sub-engineers in entire process of the implementation so as to build the capacity and help them to internalize the different aspects of SESP. NSET conducted detail assessment and prepared designs for retrofitting of each individual building and supervise the work.

- DOE provide 85% of the estimated cost for retrofitting to the schools through the District Education Office (DEO) and remaining to be managed by the community.
- Implement the program through the community driven approach employing local masons which will help in creating ownership of the program, help the local people to aware on earthquake safety. *(This was also recommended by the national workshop on school safety which was conducted on 16 July 2010 and the details have been discussed in paper by Mr. A. M. Dixit on Institutionalization of School Earthquake Safety Program in Nepal).*
- Train local masons, engineers and technicians on entire spectrum of SESP.
- Conduct awareness program to the teachers, students and parents, prepare earthquake response plan and conduct drills.
- Involve all stakeholders including national, international and community based organizations as possible.

## 4.3 Technical Details

Following is the details of the selected school buildings for retrofitting**.**

### *4.3.1 Building types*

All the buildings selected were of load-bearing masonry types with some of them of RCC slab and some of flexible roofs. Some of them have RCC floor and flexible roof too. The numbers of storey of the buildings were up to 3 storeys. Almost all the buildings were typically single bay with passage on cantilever projection. Most of the buildings were elongated in shape and do not comply codes. The age of the buildings varies from 10 to 30 years. These buildings were constructed by the local people with the support from DOE, some international organizations, community contribution and through charities.

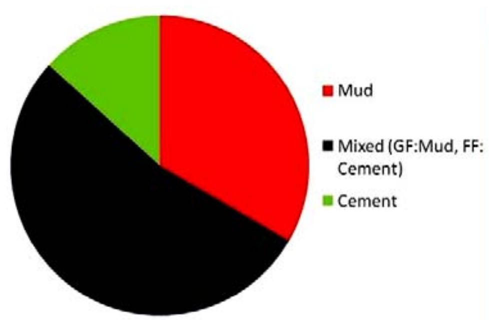


**Figure 1.** Typology of selected buildings

The above chart shows the types of buildings that were selected for retrofitting. Majority of the school buildings were of mixed type i.e. one floor with brick in mud and another brick in cement, one floor RCC and the other floor or roof of flexible material. Minimum buildings were selected with the cement mortar.

### 4.*3.2 Vulnerability Assessment* and *design for retrofitting*

Seismic vulnerability assessment and design of the buildings was carried out through the following process

*<u>Qualitative assessment</u>*

Following process were involved in qualitative assessment

- Visual inspection, data collection, verification of designs and drawings
- Determine region of seismicity
- Determine level of performance
- Determine fragility
- Identify vulnerability factors

- Determine probable performance at different intensity

*Quantitative assessment*

Following process were involved in quantative assessment.

- Field observation by visual observation
- Field verification with non-destructive and intrusive test to identify shear strength of walls
- Determination of mechanical properties of the building
- Analysis and interpretation of results

*Retrofit design*

- Setting performance objectives
- Selection of appropriate retrofitting options
- Design of retrofitting elements such as jacket, splints, bands.

Vulnerability assessment and retrofitting design was conducted by a specialized team from NSET. This opportunity was also utilized by the DOE engineers in learning the process through the practical works as well as formal trainings.

RCC jacketing and splints and bands were proposed as options of retrofitting which is shown in the figure below.

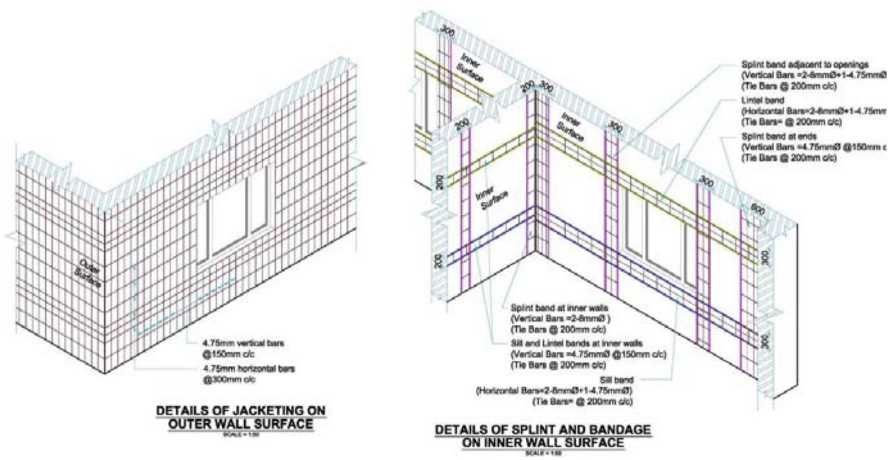


**Figure 2**. Typical design of proposed retrofitting ( source NSET)

The left portion of figure 2 shows details of reinforcing bars proposed for jacketing of exterior surface of the wall where as the right figure shows details of splints and bands of interior walls. Reinforcing bars starting from the foundation were proposed for both the sides. The number and size of the bars were designed based on the existing capacity of the wall with respect to the required strength to withstand expected level of shaking. Most of the buildings were retrofitted with this technique however some buildings were provided jacketing on the entire surface.

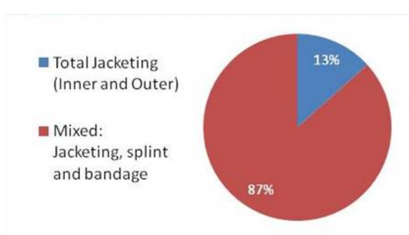


**Figure 3:** Techniques applied in different buildings ( source NSET)


**Figure 4.** Expected performance of the buildings after retrofitting (source NSET)

Figure 3 gives the different techniques of retrofitting employed in the school buildings. Out of 15 school buildings, the entire surface (interior and exterior) was retrofitted with complete RCC jacketing where as in remaining 13 schools, jacketing in outer walls and splints and bands in inner walls was provided. This was decided after analyzing different parameters of the existing building such as capacity of wall to withstand all incoming forces, bonding, quality of bricks and the masonry etc.

Figure 4 shows expected performance of the retrofitted building at different intensity of earthquake. At intensity VII, the building should be fully operational, at VIII intensity functional and at IX intensity there should be life safety of the occupants. At intensity X, the building should not collapse suddenly, the collapse should be delayed and life safety should be guaranteed.

### 4.4 Implementation of Seismic Retrofitting

The retrofitting work was implemented through the community under the supervision of DEO engineers with the technical guidance from NSET. Entire construction management including materials, human resources and site facilities was managed by the school, school management committee and the local people. NSET and DEO jointly supported the schools in all technical and management aspects for ensuring quality of the work. Special attention was given on the selection of quality materials and adequately skilled workers. Before starting actual works, orientation to the engineers, technicians and the masons was conducted this helped to replicate the designs in actual implementation.

Different training and awareness programs were inbuilt in the program. Teachers of all the schools were trained and students were oriented. Earthquake drill was conducted in all the schools. The teachers and students cooperated well in making their school safer from earthquake.

**Figure 5.** RCC Jacketing of exterior walls

**Figure 6:** RCC splints and bands on interior walls

The figure 5 above show reinforcement placed for jacketing of outer surface of the building and the figure 6 shows the reinforcement details of the vertical splints and horizontal bands in the inner walls of the buildings. These reinforcing bars are anchored properly with the wall through drilling holes and inserting galvanized steel bars throughout the wall cross-section. The size and spacing of the reinforcing bars differs in each buildings based on the design. These elements are supposed to hold the masonry unit as well as entire component of the building together to have box effect during an earthquake and minimize the extent of damage

**Figure 7.** Opportunity for students to learn **Figure 8.** Opportunity for all to learn

In the figure 7 above, the students of the school were taken to the retrofitting site after orientation on earthquake safety to observe what is being done to strengthen their school and asking the masons will their building be really safer. Similarly in the figure 8, the local people are observing the placing of reinforcing bars and discussing with the working masons and asking them either they can retrofit their buildings if required. Retrofitting of school was also utilized as an awareness building tool in the locality.


**Figure 9.** Micro-concreting grouting **Figure 10.** Surface finish

The figure 9 above shows the masons grouting the reinforced wall with 50 mm thick micro-concrete of grade M20. Before applying micro-concrete, one coat of neat cement slurry was sprayed to ensure proper bonding of the concrete with the brick wall. The figure 10 above shows the final surface finish after 2 layers of micro-concrete of 25 mm thick each was applied before plastering the surface. The final surface is ready for painting.

## 5. EXPERIENCES

SESP was the first approach of DOE that was inbuilt in the national program. Since seismic retrofitting was practiced only fewer institutions in Nepal and is not common, there were different questions which were expected to be answered during implementation of the first program. The DOE and many other institutions did not have technical capacity in assessment, design and retrofitting. The common questions to the DOE and NSET from different organizations and individuals were

- Is it technically possible to strengthen the vulnerable buildings with the available materials?
- Can the DOE handle this task successfully?
- Can it demonstrate affordability?
- Can it be socially and culturally acceptable, and will people trust?
- Can the government make required resources available and continue the mission?
- Can the local community manage the works local masons do the job?

The above questions were valid in the context of Nepal where most of the people even the decision makers are not aware enough and have understanding on possible risk reduction measures for earthquake. After completion of pilot program in 15 schools and acceptance by a wide range of people, institutions and authorities, all the questions were answered in a positive way.

- The program was successfully completed in collaboration with NSET and ADB
- It was proved that seismic retrofitting was technically possible,
- Since the cost of retrofitting was within the limit of economical feasible i.e. less than 30% of the new construction, it was proved after the implementation
- There were no major architectural alterations which did not affect the social and cultural values
- Entire work was managed by the community and local masons were employed for retrofitting. They learned from the engineers during on the job training and did actually what was needed.
- After this pilot program, Government has continued scaling-up of the program in more schools and allocated budget through the own resources. Many development partners are willing to join hands with the Government and committing the required resources. ADB, Aus Aid, World Bank, the Japan Government have already allocated funds to support the Government. Till now retrofitting the Government has already provided funds for retrofitting of 65 schools and the ADB and Aus Aid have allocated budget for retrofitting of 260 school buildings.
- The local community contributed 15% of the cost of retrofitting.

This program has tremendous impact on rising awareness from national to local level. The local people and the school management committee and the students are sanitized on the earthquake risk and the need for safety measures. They are confident that their school has become safer. They fully believed on what was being done in the school in terms of retrofitting, training and orientation and drills were required for their safety. Now the DOE and NSET is receiving number of requests for the support to retrofit the remaining schools. Private schools are also requesting to provide technical support.

The schools are now conducting earthquake safety orientation to students and drills in regular basis. The students have learnt life saving techniques during emergency. This message has been transmitted to their family and the awareness of the community has risen.

## 6. CHALLENGES FACED

Following are the major challenges faced by the DOE to undertake the job.

- There was no technical capacity within the DOE so the project was delayed until NSET was approached by the DOE and ADB.
- During first preliminary selection process, majority of the schools wanted to build new building instead of retrofitting, because they were not fully aware on possibility and effectiveness of retrofitting. It was very hard to find the schools who are interested in retrofitting and contributing 15% from their side.
- Since most of the buildings were elongated in shape, the length had to be reduced by providing seismic gaps. In most of the schools, there was no exact proper location to introduce gap. Many schools opposed introducing gaps in the existing buildings. Later after demonstrating benefit of the gap and showing examples of other schools, they agreed to follow the instructions.
- In majority of the schools, the doors are opened inside which obstructs safe evacuation. Alteration of the opening position of the doors was proposed in the design. The schools were of single bay and the very narrow passage was provided on the cantilevers and front part of the buildings. If the doors are made to be opened outside, the passage will be narrower further. By identifying special type of hinges, the problem was solved.
- The masons cooperated fully but it was very hard for them to understand the new techniques. Ensuring quality of concrete including the cement used, mix proportion, water, etc was a challenge. For this purpose, NSET and DEOs provided frequent supervision. Trained masons from NSET were also mobilized to different sites to guide the school on ensuring the quality.
- Since majority of the construction workers are flying to other countries for job, it was hard to find masons to work in schools.

- Since SESP was added in the regular program and the engineers had to carry the regular school physical development works, they couldn’t spear adequate time for SESP. The number of existing engineering staffs with the DOE was limited to look after the new construction only and no additional engineers were employed for this program.

## 7. LESSONS LEARNED

Following were the lessons from the implementation of SESP and retrofitting of 15 school buildings in the Kathmandu Valley.

- Retrofitting is only the option to reduce structural vulnerability of the buildings.
- Seismic retrofitting of school buildings is technically, socially, economically and culturally feasible and need to give more and more priority to protect the children.
- The DOE need to increase the number of qualified engineers and build capacity on vulnerability assessment and design for retrofitting.
- The Government alone cannot handle the problem of the safety of entire schools. Need to collaborate with the all the development partners, civil society, academia, expert community and the business sector.
- Participatory and community driven approach is the best way to enhance safety of public schools.
- Awareness is the key for the success and internalization of any risk reduction measures.
- Only the hardware part doesn’t provide sustainability. Hence software part such as orientation, trainings and general awareness components are to be integral part of the program.
- Need to develop more number of trained masons for the scaling up of SESP.
- There should be certain attractions to the masons to retain them in the country.
- National level steering committee and a high level technical committee need to be established.
- This is one of the best awareness rising tool.
- Since more than 75% of the existing school buildings of Nepal are vulnerable to earthquake. The Government need to take immediate steps to address this issue.
- Till now the program has been implemented in the Kathmandu Valley, this need to be replicated to other parts of the country through appropriate mechanism.
- Massive need based trainings and capacity building of different stake holders of education sector is required for the scaling up of the program.
- Strong monitoring mechanism should be developed and Peer review shall be conducted each year.
- National strategy for school safety need to be implemented

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