Shaped by geography: appropriate construction materials for safer schools in Nepal

Overview

Country: Nepal

Stakeholders: Government of the Nepal, Department of Education, World Bank, the Global Facility for Disaster Reduction and Recovery (GFDRR)

Hazards: Earthquakes, flooding, landslides, avalanches, drought, storm and fires

Summary: Nepal is severely exposed to a variety of natural hazards. After the 2015 Gorhka earthquake, the World Bank carried out an extensive survey programme of 21,000 public school buildings in the 14 most affected districts to inform a safe schools investment programme. In developing the survey methodology and by analysing survey data, valuable information was gathered about local materials, school construction typologies and performance of existing schools. The challenge that remains to be addressed in Nepal is to identify locally appropriate materials and construction types for schools for a diverse range of geographical contexts as well as a range of local capacity and capability in construction techniques.

CONTEXT

Schools in Nepal are severely exposed to natural hazards

Nepal is located in the central part of the Himalayan mountain range and is bordered to the north by China and to the south, east and west by India. In 2009 the UNDP identified Nepal as the eleventh most earthquake-prone country in the world and additionally suffers from severe exposure to recurrent flooding, landslides, avalanches, drought, storms and fires. The devastating earthquake and the related aftershocks that hit Nepal on 25th April 2015 were estimated to have caused 8,800 casualties, 22,300 injuries and affected almost one-third of the population of Nepal. Educational infrastructure was severely affected with approximately 7000 public schools significantly damaged or completely destroyed.

OBJECTIVES

Evaluating materials and school designs for local context

This case study illustrates the process of identifying local availability and quality of materials across specific regions of Nepal and to understand local material standards as applied to school infrastructure. In addition, model school designs were evaluated to see if they were adequately engineered for hazards, locally appropriate, had well-communicated design documents and were adaptable for variable site conditions.

This knowledge was gathered as part of the Technical Assistance that Arup provided to the Department of Education in partnership with the World Bank as part of the GDFRR GPSS programme in 2015/16. Arup contributed to the developement of a Structural Integrity and Damage Assessment (SIDA) methodology for school infrastructure. The main aim was to prioritise a preliminary investment plan for the rehabilitation (repair, retrofit and reconstruction/ relocation) of educational facilities in damage affected districts in Nepal by the Ghorka earthquake. The assessment of the educational infrastructure baseline was undertaken in a post disaster scenario and the survey evaluated damage, exposure and vulnerability of schools. An understanding of local materials, building typologies and model school designs was an additional outcome from the SIDA process.

Damaged stone masonry school in Lalitpur, Nepal

METHODOLOGY

A comprehensive school infrastructure baseline for 14 affected districts in Nepal

In the context of the wider SIDA programme to define investment for a safer schools program in Nepal, the following aspects relate to gaining an understanding of materials and appropriateness of model school designs:

Firstly, local stakeholders (the Ministry of Education [MoE], local experts, National Society for Earthquake Technology [NSET]) shared Nepalese codes, material standards and guidance documents on assessment and retrofit. In addition, a desk study was performed and wider inputs were gathered from other Arup contacts in Nepal, including a set of MoE model school designs. The desk study documents were reviewed to inform the recommendations for the assessment methodology.

Then, a field mission was undertaken where the surveying methodology and app were developed collaboratively with stakeholders. Part of this mission involved testing the assessment methodology during site visits to schools in Kathmandu and surrounding areas. This allowed the team to gain first-hand experience of Nepalese school construction typologies, materials and condition state of the schools.

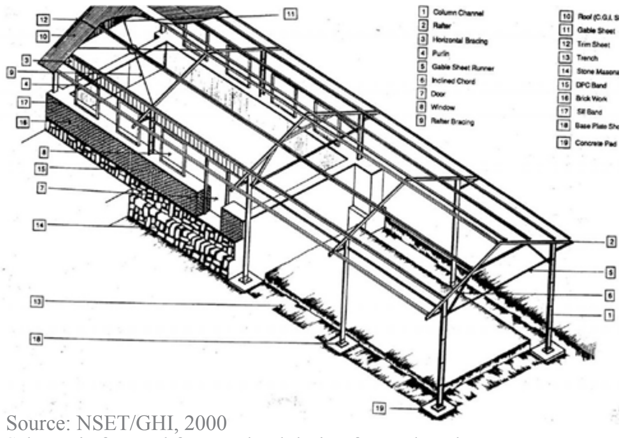
Finally, data was gathered from surveys of over 7000 schools from the completed survey programme by local engineers. This provides insight into the infrastructure baseline for schools in Nepal which included the proportion of schools in terms of material types and construction typologies. The surveys also highlighted the approriateness of the design and construction of schools in terms of both vulnerability characteristics as well as deterioration and damage from the earthquake.

CHALLENGES & OPPORTUNITIES

Challenges and Opportunities

The main challenge in understanding locally appropriate construction materials and construction methods for safe schools in Nepal is the diversity of geographical contexts (urban, semi-urban, rural and remote). In addition, there is a diversity of cultures and local construction techniques, particularly in the more remote regions.

Related to this, there is a challenge in that appropriate materials for safe school construction are not available in more rural or remote areas. Materials are hard to transport in and local materials are often limited to rubble stone and mud mortar, which, if used for construction, perform very poorly in earthquakes. This was demonstrated in the performance of a model school typology with a lightweight steel frame and community built infill walls. Where the walls were built using rubble stone or brick with mud mortar, they often suffered serious damage or collapse in the earthquake.



Source: NSET/GHI, 2000
Schematic for steel frame school design for earthquakes

Source: NSET/GHI, 2000
Steel frame school design with stone infill walls using mud mortar

That said, there is a strong local community of seismic engineers in Nepal (NSET and others in the academic community) who are promoting awareness of risks to schools and the need to implement safer construction methods and retrofits. There is also strong engagement from MoE and government stakeholders that recognize the need to build capacity of MoE engineers to review and approve proposed school designs as well as monitor the quality of construction for schools during project implementation. The SIDA data collection surveys provided an opportunity to develop local partnerships to share knowledge and train local engineers in safer school principals and carry out the building assessments.

There may also be an opportunity in partnership with the World Bank and others, to make recommendations about policies that align funding incentives with safer schools construction. For example by specific funding for school maintenance and removing incentives to build new school buildings without coordinated planning through demand analysis for school places locally.

OUTCOMES

Characterizing school construction in Nepal

The SIDA methodology provided insight into local materials, construction typologies and model school designs. This has enabled the development of a retrofitting and reconstruction program to be developed which is informed by local needs and includes opportunities to enhance local practices. There are district geographical contexts (urban, semi-urban, rural or remote) for schools which relate to which materials are available locally and local construction capability. More than half of school buildings were constructed of load bearing masonry (rubble or brick), followed by one quarter built from steel frame construction with masonry infill walls, and around 10 % of reinforced concrete frame construction with infill masonry walls. Many schools in rural and remote areas had rubble stone with mud mortar walls which were shown to be highly vulnerable to collapse and damage which endangers occupants in earthquakes. Most schools are low rise which are generally less vulnerable, but built from heavy masonry construction which can be more vulnerable. The Nepalese codes and standards are fairly robust, but it is not clear how often they are used in practice. For example, rough wall strength checks for certain model school designs determined the designs to be under capacity according to the code requirements.

More than three-quarters of schools are sited on foothills or mountainous terrain outside of Kathmandu Valley and many schools are on vulnerable sites and exposed to landslides and other foundation failure.

Many schools sites are located on steep slopes

Learning

- To capture the diversity of construction techniques and use of local materials, further engagement with rural and remote communities is recommended. As part of this, the perceived safety of different construction techniques and materials by different communities should be assessed.
- Alternate materials to rubble stone should also be explored (lightweight systems such as prefabricated systems or timber panels) that are possible to transport for remote areas.
- Existing model school designs generally assume a flat site and do not give guidance on site specific adaptation measures such as cut and fill, retaining walls, foundation designs and materials for sloping sites. New model school designs should give guidance on site works for sloping sites and should include foundation designs for a variety of site conditions.

Find out more

Read: Post Disaster Needs Assessment, Government of Nepal, 2015, https://goo.gl/q60lgs

Read: Seismic Vulnerability of Public School Buildings, NSET, 2000, www.goo.gl/R6Vn2B

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