Good Engineering without Appropriate Communication doesn't lead to Seismic Risk Reduction: some thoughts about appropriate knowledge transfer tools

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ABSTRACT :

Modern seismic engineering know-how often has little impact on the construction reality because either engineers are not involved in the construction process of a majority of buildings or execution is inaccurate and supervision weak. Similarly, traditional seismic building cultures, where still existing, are ignored by modern engineers because of a lack of scientific evidence. The issue at stake here is not seismic engineering as such but the transfer on information from one actor to another. The question of proper communication of technical know-how is a fundamental one if seismic risk reduction is to be achieved. The present paper presents the training and communication efforts made during the post-earthquake reconstruction process in Pakistan, from 2006 to 2008, and sketches a series of possible means of communication to reach various groups of stakeholders. In particular it stresses the importance of future investments not to go only into engineering research but also into the research and development of communication tools.

KEYWORDS: Appropriate seismic engineering, appropriate technology, knowledge transfer, communication, training of artisans, local seismic culture

1. INTRODUCTION

Today, more than half of the world's population live in urban agglomerations. An important part of these people live in the mega-cities of developing nations, many of which are located in areas at risk of natural disasters.

Cities in developing countries very often possess a high rise city centre and a huge periphery of low rise, one to four storey residential area. Structural engineers are involved in the design of the more interesting high rise buildings, whereas 'normal' low rise buildings are left to small scale contractors without the involvement of 'costly' engineers. In addition, even if engineers get involved in the design of low-rise buildings, they usually consider their job done when construction drawings leave their offices. The supervision of a proper implementation of the drawings is left to the contractor.

Know-how on earthquake resistant building techniques however is generally limited to the engineering community. Contractors and workers are considered mere executants requested to adhere to the instructions of engineers. Now, if common buildings, where a majority of people lives, are made by contractors without involvement of engineers, how can the seismic know-how of engineers have any influence on the end product?

Similarly there are places where an age old seismic culture is still alive. Local people might use earthquake resistant building techniques which are unknown to modern engineers and for which no scientific testing has been done. With no basis for calculations however engineers cannot validate and recommend such traditional methods, even if they have proved to resist earthquakes. The question therefore is: How can traditional know-how reach the engineering community?

The present paper intends to look at these two missing communication links, the transfer of know-how from engineers to workers, and the transfer of know-how from traditional societies to engineers.

2. THE PAKISTANI RECONSTRUCTION EXPERIENCE

2.1. The original training setup

The M 7.6 earthquake of 8 October 2005 killed 88,000 people, injured 75,000 and left 4 million people homeless (USGS 2005). The heavily damaged or destroyed buildings were mostly made of unreinforced brick, block or stone masonry (modern or traditional), but included also modern RC frame structures with infills. Traditional timber-reinforced buildings on the other hand proved to be fairly earthquake resistant.

Once the first relief efforts were under control, the Pakistani Government created the Earthquake Rehabilitation and Reconstruction Authority ERRA. To ensure a quick and cost-effective reconstruction process of the housing stock, a strategy was put in place which was based on a limited number of key concepts:

1. The ‘owner driven reconstruction process’ making use of the inherent potential of the affected population to rebuild their lives,
2. The ‘Build Back Better’ concept which would make use of the momentum to promote earthquake resistant building techniques and ensure safer homes for the future,
3. The provision of government subsidies as an incentive for the people to apply the new earthquake resistant building methods,
4. A training component to ensure that seismic construction know-how was widely disseminated.
5. A control mechanism through which official inspection teams would assess the adherence to the seismic building rules and approve the consecutive instalments of the subsidies.

The strategy for the dissemination of seismic building know-how was organised in cascades: ERRA would *define the rules* (elaborated or approved by consulting engineers), 11 Housing Reconstruction Centres (‘HRCs’ managed by UN Habitat in Kashmir and by the Swiss Agency for Development and Cooperation in NWFP) would *disseminate the rules* by training Non-Governmental Aid Organisation (NGOs) and their engineers. NGOs would then *train* the local workers and population, and finally the army would *control the observance of the rules* and release the various payments to the house owners.

The officially approved reconstruction techniques for which training could be imparted were *RC Frames* with brick infills and *Reinforced Masonry* ‘Indian style’ (Arya and Panda 200?). The training material had been developed by NSET (Nepalese Society for Earthquake Technology) and was in English. *Confined Masonry*, introduced by SDC, was later added to the list of accepted modern reconstruction techniques.

A few months after the start of this training setup a first serious problem emerged: there were only few NGOs interested in imparting construction training (humanitarian aid organisations are specialised in other sectors) and there were even fewer engineers interested in living for an extended period of time in remote areas and under difficult conditions (i.e. tents etc.). A change of strategy was needed.

2.2. First adaptation of strategy: Direct training of artisans

The original training content, directed towards engineers, had to be reviewed:

- The pre-eminent position of the *RC frame technique* was drastically reduced. RC frames are sophisticated structures where too many steps have to be executed correctly to ensure that they work properly (Charleson 2003 and 2008). Given the limited amount of time available for the various training sessions, RC frame technology simply could not be taught properly to a public with a very low level of technical knowhow. Trainees were invited to abstain from using RC frames and opt for more tolerant construction methods.

- The *reinforced masonry* technique developed by professor Arya and his colleagues after the Gujarat earthquake and which has been brought to Pakistan by NSET became the centre piece of the training provided to artisans.
- *Confined masonry* imported from Latin America (AIS 2004, Blondet 2005) and adapted to the local context by SDC (Schacher 2007b) became the second pillar of the training programme.

The form of the original training also had to be adapted to the new requirements:

- *PowerPoint lessons* in English, prepared for engineers, had to be simplified, both in their technical jargon and in the illustrations.
- It was also important to create a paper support in the form of highly *illustrated manuals* that people could bring home after the training sessions and use as aide-memoires in the future (fig.1).
- *Full scale models* which had already been part of the original training concept, had to be made more realistic (i.e. less conceptual) to allow trainees to refer them to their real construction experience (fig.2).
- *Small scale models* (scale 1:10) have also been developed to serve as illustrations during the training session, in the training centres as well as on itinerant trainings in the surrounding villages (fig.3).
- *On-site training* on real construction sites proved to be the best way to training people who are used to learn with their hands rather than by sitting in a tent looking at a PowerPoint presentation on a screen (fig.4).
- Finally, and most importantly, trainers had to be trained to use a *simple everyday language* instead of the technical jargon of engineers. This proved to be a tricky task: on one hand our trainers mostly were engineers used to express themselves in their professional language, and on the other, being an engineer and having to talk 'like an ignorant' was difficult to accept in a society were social standing is very important.

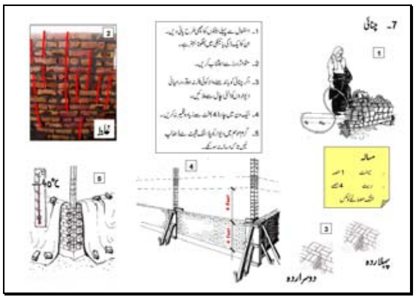


Fig.1: Illustrated manuals; Fig.2: Full scale models; Fig.3: Small scale models; Fig. 4: On-site training

2.3. Second adaptation of strategy: Appropriate solutions for remote areas

Yet, the modern construction methods taught in the training programme were only appropriate for accessible areas. In remote mountain regions without road access, transport costs for modern building materials such as steel, cement, gravel and bricks exceeded the government subsidies intended for the reconstruction. It was imperative that solutions were found where local people could use locally available materials and still get earthquake resistant houses. Field research brought up two traditional seismic construction methods:

People in the Kashmir region had been using a technique locally known as *Dhajji* where house structures are made in highly subdivided timber frames which then are filled in with stones and mud mortar (fig. 5,6,7) (Langenbach 2007b). Such buildings had resisted the earthquake very well even if built right near to the fault line. A detailed analysis of the constructions however showed some weak points for which better solutions were developed and taught in the training sessions (Schacher 2006). Given the very obvious qualities of this technique there were no major difficulties to get an official approval for their use within the reconstruction programme. ERRA suggested that this traditional building method be employed in all remote areas of the earthquake zone. But when the people of the northern part of the affected area were invited to rebuild their houses in *Dhajji*, they energetically rejected the idea: “Such buildings with their thin 10cm walls are not bullet-proof!” Their local risk analysis told them that shootings were a much greater risk to their lives than earthquakes. They wanted to have their solid stone buildings with 60cm thick walls.



Fig.5: House in Bagh-Topi, Kashmir; Fig.6: Stone and mud infill; Fig. 7: Demo house after training in Jared, Kagan valley

Further research, particularly in the remote valleys of the northern part of the earthquake affected area, lead to the discovery of a timber reinforced heavy stone masonry technique known as *Bhatar.* This building method is related to the *Taq* technique of northern India (Langenbach 2007a) and the well documented *Cator and Cribbage* technique of the Northern Areas province of Pakistan (Hughes 2000), but uses less timber which was an important issue in an environment depleted of its original forests. The old fort of Besham is one of the more interesting examples of this technique, though unfortunately it is falling to pieces due to a lack of interest and maintenance (Fig.8). However, new houses in the Battagram area, built according to the *Bhatar* method, showed deficiencies due to a loss of know-how or simply due to the fact that these were private houses with a limited budget, as compared to the old military fort in Besham where money most probably was not an issue (Fig.9). Again, construction details were analysed to understand their function and probable seismic behaviour, and guidelines were drafted showing the proper execution of every important construction detail (Schacher 2007a). This time however it was much more difficult to get an official approval. The shear mass of walls and the absence of any scientific documentation scared the engineers in charge of giving a green light. It was manly due to the pressure of the army, which has assessed the earthquake damage in these mountain regions for more than a year and which understood that people had no other choice than to rebuild with their local resources, that the *Bhatar* technique in the end was also accepted as one of the official reconstruction techniques (Fig.10).



Fig.8: Besham fort; Fig.9: New house in Tarand, Battagram; Fig.10: Demo house after training in Shamlai, Battagram

2.4. Dealing with various stakeholders

As we have seen in the previous paragraphs, modern seismic construction techniques had to be explained to the artisans and self-builders, and traditional techniques had to be made plain to the engineering community. Both of these target groups needed explanations in their own specific language. But these two groups were not the only stakeholders. The inspection teams of the army had to be trained to be able to assess the compliance of reconstructed houses with the established rules, authorities had to be convinced that rules had to fit local potentials to be followed, the public at large had to be made aware that solutions to earthquake resistant buildings did exist, and finally, international donors had to be reassured that their financial support was used to ensure safe and sustainable construction methods. Each of these stakeholders had to be addressed in its own language, using arguments pertinent to each one of them. And this had to be done for each construction technique separately. The following simplified table summarizes the type of communication material needed:

Table 1: Training material and communication strategies used in Pakistan

	Modern building materials		Traditional building materials	
Target public (stakeholders)	Reinforced masonry	Confined masonry	Dhajji	Bhattar
General public	Gen. info material	Gen. info material	Gen. info material	Gen. info material
Craftsmen, mobile teams	Training, practical examples, simple documentation	Training, practical examples, simple documentation	Training, practical examples, simple documentation	Training, practical examples, simple documentation
Army inspection teams	Training, simple doc for controlling	Training, simple doc for controlling	Training, simple doc for controlling	Training, simple doc for controlling
BSc engineers, architects	Technical docs	Technical docs	Technical docs	Technical docs
Trainers, MSc engineers	Technical docs, Training material	Technical docs, Training material	Technical docs, Training material	Technical docs, Training material
Consulting engineers to ERRA	Technical documentation	Technical docs, scientific evidence	Scientific papers, discussions	Technical discussions
Government officials	Okay from consultants	Okay from consultants	Lobbying, photo material	Lobbying photo material
International donors	Okay from consultants, technical documentation	Okay from consultants, technical documentation	Lobbying, photo material, scientific docs on related techniques	Lobbying, photo material, scientific docs on related techniques

Obviously all this material and argumentations had to be prepared while running regular training sessions. SDC alone had a team of 40 people in the field offering training at various levels, from those in the training centres to public sessions in remote villages. UN Habitat operations were even bigger.

2.5. Lessons learned from the Pakistani Experience

Despite the tremendous time pressure and the lack of resources, the overall results of the Pakistani reconstruction strategy are convincing. Thousands of workers and self-builders have been trained and hitherto unknown construction methods have been introduced or officially acknowledged. This is not only due to the great efforts put up by the training teams, but also, and most importantly, to the open-mindedness of the Pakistani authorities and their engineering consultants. They have dared to take decisions even in the absence of proper scientific evidence. And they have always kept in mind that the strategy was called ‘build back better’, not ‘build back perfectly’! People now have safer houses. Perhaps these new houses are not as safe as theoretically possible, but certainly as safe as practically feasible.

Lessons (to be) learned can be summarized as follows:

- Technical solutions must not be introduced and/or promoted blindly without analyzing the local context. This local context includes not only the types of building material but also the technical know-how available in a given area. Cultural dimensions like preferences for construction materials, building typologies or concerns for a social image must be taken into account at all levels (i.e. from the local people to national authorities).

- High level technical expertise is as necessary in the field as it is in the cities. Local know-how cannot be analysed properly and discussed at higher levels without a profound technical and cultural understanding. However, who can ensure this type of expertise? Engineers are trained in engineering but have little acquaintance with cultural issues. Architects on the other hand might be more concerned with culture but often have a limited understanding of engineering. An engineer-architect team might be the best solution to ensure a full understanding of the local potentials.
- Adult training skills are a further expertise necessary to ensure effective training. Neither an engineer nor an architect is automatically qualified to transmit his or her knowledge to craftsmen or self-builders. The training as provided in the Pakistani experience went through many trial and error phases. For example, hour-long PowerPoint presentations in a hot tent proved to be a difficult tool to keep up the interest of the audience.
- Advocacy and lobbying are important elements of a knowledge transfer programme. If the proposed solutions should stand any chance to be sustainable in the long run, solutions have to be sought and promoted which are in tune with the interests of the end-users. These interests might be in contrast with those of the authorities, the expert community or even aid organisations (which generally prefer 'efficiency' to effectiveness). It is important that the 'technical' assistance and training teams are ready to defend the interests of the end-users against other priorities. This again takes time and skills which are not easily found.
- Given the tremendous time constraints in a post-disaster environment, the right technical know-how should be developed well before a catastrophe does occur. For certain not well-known seismic construction techniques this might mean that research is done 'in times of peace'. The introduction of Dhajji and Bhatar would have been much faster if research papers and scientific evidence had been available right from the start. The engineering advisors to the government as well as international donors would have been able to study these references and take informed decisions earlier, avoiding the loss of a whole construction season.
- Last but not least, much more efforts have to go into the development of communication methods and strategies directed at various stakeholders. Again, a big part of that effort can be done well in advance of a catastrophe. Manuals, posters, lessons, films, etc. can be developed with a high degree of quality. This material can then be adapted from case to case, from country to country. Adaptation takes a lot less time than the development of such material during an emergency phase when all efforts go into managing the day to day operations, and when access to resource persons and reference libraries is difficult if not impossible.

3. DEVELOPMENT OF NECESSARY COMMUNICATION TOOLS: AN OVERVIEW

Communication has to be target specific. To be understood, or simply to be taken seriously, a speaker has to use the language (the jargon) of the addressee. It is often quite difficult to realise at which point one's own language is specific to a one's own profession. When structural engineers try to explain things through graphics and formulas, even architects are quickly lost. And architects are probably the professionals nearest to civil engineers. It's easy to see how difficult communication can become between professions further apart, like between engineers and simple workers on the building site.

The following table sets an array of stakeholders against a series of means of communication susceptible to be understood by them. Most of these tools can and should be prepared in advance of catastrophes and in such a way that they can be adapted easily to a particular situation or country. This list is neither exhaustive nor proven. It wants to be understood as a sketch of possible approaches, a collection of ideas worth further attention (and investments). It wants to make the reader aware of an important aspect of engineering which up to now has been utterly underrated, that is the appropriate communication of technical knowledge.

Table 2: A tentative listing of tools for target specific communication

X = main target group
x = additional target groups

what / **for whom**	General public	Artisans, self-builders	Contractors	Architects, BSc engineers, technicians, aid organisations	Trainers, Teachers	MSc engineers	Authorities, decision makers	International donors and experts
Info leaflets: on possible assistance and simple technical issues	**X**							
Posters: very simple step by step construction guides	**X**	x						
Radio: broadcasts on what to do and where to find assistance	**X**	x	x					
TV: infotainment, soap operas, short documentaries	**X**	x	x					
Manuals: simple and highly illustrated step by step construction manuals		**X**	x	x	x			
Videos: short training videos		**X**	x	x	x			
Models: drawings for the construction of full scale public view models		**X**	x	x	x			
PowerPoint lessons		**X**	x	x	x			
Trainer manuals					**X**			
Guidebook for practical exercises					**X**			
Tests					**X**			
Toolkits for practical classroom exercises					**X**			
Cost-benefit analysis of earthquake resistant constructions			**X**	x				
Examples of safe and unsafe solutions		x	**X**	x				
List of arguments for discussions with clients		x	**X**	x				
Photographic documentation of constructions and technical details				**X**		x	x	
Technical documentation on concepts, techniques, details without calculations				**X**		x		
Training material for university level (PowerPoint lessons, etc.)				**X**		**X**		
Training material on socio-economic and cultural assessments				**X**		**X**		
Web platform with relevant technical and scientific documentation				**X**		**X**		x
Technical documentation, bases for calculations, scientific evidence						**X**		
Research on traditional seismic construction methods, to provide evidence						**X**		x
Coffee table books, calendars, etc. on national seismic culture(s)							**X**	**X**
Cost-benefit analysis for politicians, and collection of arguments							**X**	**X**

4. CONCLUSION

Seismic engineering know-how has made great steps ahead over the last decades. Engineers are better trained to design earthquake resistant buildings than ever before. Yet, because of the tremendous rate of urbanisation and the consequent number of buildings made by small scale contractors without or with insufficient involvement of structural engineers, global vulnerability has increased instead of decreased.

In order to increase the number of safer buildings in poor countries, future investments should not be limited to further research on seismic engineering but must also, and perhaps more importantly, go into the development of communication techniques. Serious efforts have to be made to bring seismic engineering know-how out of the ivory tower and down to the building sites. The number of well-trained engineers simply is too small to cope with today's construction boom. Without an active participation of the workers and the public at large, the goal of increased seismic safety is not achievable. But, to be able to play their part meaningfully, artisans have to be trained properly, populations have to be made aware and politicians have to be convinced that the promotion of earthquake resistant building techniques are investments in the future of their country.

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