PCR TOOL 10
Quality Control

Introduction

Quality of construction is a key factor in determining whether a building will withstand disasters. There is ample evidence to show that, when hazards of similar magnitude strike rich and poor countries, it is the latter which suffer more casualties. Similarly, *within* countries, the poor generally suffer more from a disaster than the rich. Poverty is an important factor in determining construction quality, however, it can be possible to considerably improve quality with relatively little extra cost.

Experience from past reconstruction tells us that housing is built to varying degrees of quality, using various approaches to reconstruction. Donor-Driven Reconstruction (DDR), typically uses professionals for design and supervision, and contractors for construction, but does not always deliver adequate quality. However simply handing over total responsibility to home owners, through Owner-Driven Reconstruction (ODR) does not solve this, particularly if training and support is neglected.

In People-Centred Reconstruction (PCR), people are in charge of the construction process, therefore quality control starts with them. They need to know why quality matters for building back safer, and have a basic knowledge of how to measure quality in the construction technologies they have chosen. This is easier if technologies are chosen that are familiar. Building artisans also play an important role in ensuring quality of reconstruction by assisting in more specialist parts of construction. Although artisans may be in a position to help build back better, people need to be able to determine whether what they deliver is good quality. As in ODR, quality improvement does not happen spontaneously, but requires pro-active involvement of the supporting agency. The agency must determine, with the community, the existing skills levels of local actors and subsequently what training is needed to generate additional skills in building materials production, construction and quality control. They need to supervise and provide additional technical support to the construction process on a regular basis in order to make up for any deficiencies. Whilst training in construction and materials production is quite commonly provided in reconstruction projects, training in quality control is often neglected. This tool aims to help fill this gap.

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Poverty led to poor construction and maintenance in the Alto Mayo of Peru; when a moderate earthquake struck in 1990, it destroyed many houses such as this.

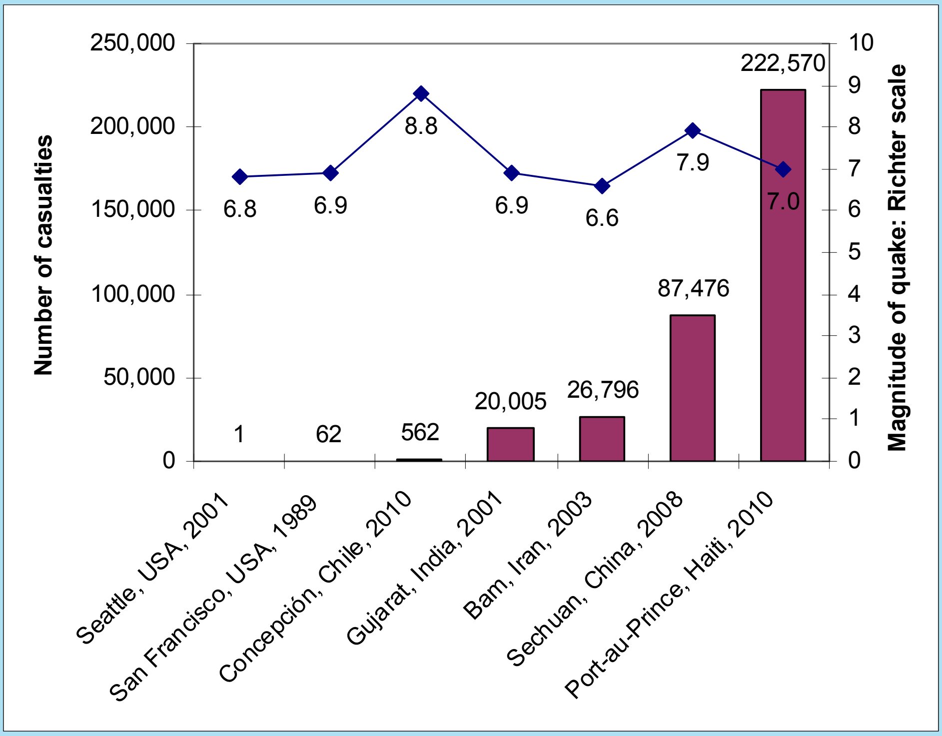
Why is quality of construction important?

The quality of buildings is important to the occupants. Collapse of buildings is the most common cause of deaths, injuries and material damage in natural disasters. Evidence shows that a lack of quality in construction is a key factor in building collapse or damage. That is not to say that other factors, such as location, design or maintenance, can be ignored, but construction quality deserves special attention; for more on the design, see PCR **Tool 8, Participatory Design**. It is also clear, from past experience, that disasters affect the poor more than the rich, and there is a correlation between the quality of construction people can afford and its subsequent behaviour during a disaster.

This apparent correlation, however, deserves further scrutiny at local levels. There is ample evidence that sometimes relatively poor people do build with technologies that resist disasters well and are not very costly; see also PCR **Tool 3, Learning from Disasters**. Certain vernacular technologies have evolved over centuries, and often taken on board disaster-resisting details in the process. For example, this is the case, in Pakistan, Peru and Turkey, where various timber frame technologies have been successfully adopted in

The poor are more vulnerable to disasters

When an earthquake measuring 6.9 on the Richter scale struck San Francisco on October 17th, 1989, it killed 62 people, affected another 3,757 and caused 5.6 billion US$ of damage. In contrast, a similar sized earthquake that hit Gujarat in India in January 2001, killed 20,005 people, left 167,000 injured and over one million homeless, at a slightly lesser loss of 5 billion US$. The next month, an earthquake measuring 6.8 just off the coast of Seattle, only killed one (from a heart attack, not building collapse), left 400 people injured and relatively few buildings damaged. But in 2003, the earthquake that affected Bam, in Iran, measuring only 6.6, killed 26,796, injured 30,000 and left 100,000 homeless. And the earthquake measuring 7.0 that struck Haiti on January 12th, 2010, killed a massive 222,570 (1 in 15 of the about 3.7 million affected) and injured around 300,000, many of those in the shanty towns of Port-au-Prince; an estimated 1.5 million became homeless. In May the year before, a much larger earthquake measuring 7.9 struck Sechuan in China, killing 87,476 (only 1 in 595 of those affected) and injuring around 360,000 people; the damage caused was a massive 85 billion US$, but only about 240,000 were left homeless. Less than two months after the Haiti quake, on February 28th, 2010, one of the strongest earthquakes ever, measuring 8.8, hit Concepción in Chile; it only killed 562. See, for example. Suresh (2005) and the OFDA/CRED International Disasters Database, EM-DAT (http://www.emdat.be/natural-disasters-trends, consulted on October 25th, 2010).



Each of these earthquakes struck relatively populated areas and the figures clearly indicate that in disasters of similar magnitude, rich countries suffer less than poor countries. Furthermore, within countries, the poorer neighbourhoods such as the shantytowns of Port-au-Prince are more affected. There appears therefore to be a correlation between poverty and disaster impact. Rich countries like the USA and Chile, are able to build to high quality standards, incorporating disaster-resistance. Besides, the majority of their population can afford to comply with these standards. Other countries, such as India, have adequate construction standards, but stark inequality within the population means many people cannot afford to build according to these standards. In most poor countries like Haiti, over half of the urban population cannot afford to build according to prevailing standards. They construct houses as best they can, but often their quality is inadequate to sufficiently withstand disasters.

post-earthquake reconstruction (see case 3 in the *Applications* section).

There is also a growing body of evidence that the cost of improving the disaster-resistance of buildings is relatively modest compared to the huge losses that can result from the impact of disasters on unprotected buildings (see: Benson and Twigg, with Rossetto, 2007). In Bangladesh, for example, it can cost only an additional five per cent to make simple modifications to improve the cyclone

photo © UN Habitat

Reconstruction using *dhajji dewari*, a traditional timber frame wall, filled in with stone and mud, in Kashmir, Pakistan

photo © Practical Action Latin America

Woman rebuilding a house in Chincha, Peru, using improved *quincha*; this is a relatively simple and familiar technology that self-builders can use with good results

resistance of traditional (*kutcha*) houses, while retrofitting hospitals against hurricanes in St Lucia and Dominica added only one or two per cent to the cost. However, the Gujarat earthquake in India caused an estimated five billion US$ in direct and indirect losses while Hurricane Mitch in Honduras in 1998 caused losses estimated at 41 per cent of GDP and Hurricane Luis in 1995 in Antigua and Barbuda led to losses equivalent to 65 per cent of GDP. Thus, there are ways of achieving quality, even when resources are scarce. This requires information about appropriate technologies, capacity building, and quality control.

Finally, construction quality also matters to the agencies supporting reconstruction. They are accountable not only to their beneficiaries, but also to the donors who are funding them. Donors need to be reassured that their money has been well spent, and they will not have to finance more reconstruction in the same location in the future as a result of poor building. Thus, agencies and donors alike have to strike a balance between the quantity of houses they can build within a given budget (which determines the number of people they are able to reach), and the quality-standards these houses must reach in order to be disaster-resistant.

What to do to achieve quality of construction?

For houses and other buildings to stand up to future hazards:

- All key partners involved in reconstruction need to be aware of the need to mitigate future disaster risks and have a basic knowledge of building structural features that can help with this;
- The design must be structurally sound to withstand anticipated risks (see: PCR **Tool 6, Participatory Design**;
- The design must be such that building artisans and families can implement them. Preferably, technologies should be selected that they are familiar with. Where essential skills are lacking, training must be provided;
- Building artisans, materials producers and families rebuilding their houses must be aware of the need for quality to ensure building safety, and have basic skills to control quality;
- Building materials and components must be produced to an adequate standard and, where necessary, protected from climate and contamination during storage;
- Agencies involved with PCR need to provide adequate technical support and supervision during construction works;
- Further extensions to houses must utilise similarly safe designs and technologies. Technologies chosen for reconstruction therefore need to be affordable in the long run, not just in immediate reconstruction when extra external resources are available;
- People must be able to maintain houses in a safe condition;
- Reconstruction grants need to cover the cost of building according to an approved design and standard, and accommodate for inflation.

What may go wrong and reduce quality?

Past reconstruction experience tells us that projects often work out differently in practice than was expected. Below are some examples of where and how this has happened, how it has negatively affected reconstruction quality and how such mistakes can be prevented:

- Housing plans, designs, specifications and guidelines drawn up by somebody with inadequate knowledge of the structural performance of buildings in disasters. To prevent this, structural engineers or suitably qualified built environment professionals need to check these documents, better yet, produce them themselves.

- Building materials and components passed as fit for purpose when they have not been checked adequately. It is important that materials and components can be traced back to source if a deficiency is discovered.
- Building materials or components not stored or handled properly resulting in deterioration or damage; it is particularly important to keep cement dry, to keep aggregates free from contamination (by wind, animals, children etc), and to protect timber from excessive sun and rain.
- Builders lack the technical skills to undertake the construction properly. It is important to assess the technical skills of builders in the area and to provide training to address deficiencies. Competent builders can be issued with certificates that show their level of proficiency.
- Site supervision may be lax. Supervisors must be aware of all the construction jobs to be undertaken. They need to be able to interpret drawings and specifications or instructions issued by professionals. They also must be able to communicate clearly with the builders.
- Supervisors given too many house construction sites to supervise. In post-tsunami reconstruction in Sri Lanka, the upper limit for a caseload was set at 100 houses, but some technical officers had to deal with 130 in two locations an hour apart; others were supposed to visit 25-30 sites per day. Under such conditions, supervision and support cannot be adequate.
- Builders take shortcuts to get a job done quicker or reduce costs; sometimes home owners do the same. This is particularly tempting when construction uses expensive materials such as cement or steel, a particular problem once concrete or mortar has set as it becomes more difficult to check its quality on site.
- Builders try to save in other ways, for example, not adequately curing concrete, mortar or stabilised soil whilst hardening, especially where water is scarce, or by mixing excessively large quantities of mortar in one go to continuously use for hours by adding small quantities of water.
- Inadequate inspection of building sites. Inspection is different from regular supervision in that it tends to be done at intervals only, often by an independent party. Its main aim is to check whether the work is up to standard and in order to approve instalments of reconstruction grants. Inspectors may face other problems which can mean that deficiencies get overlooked: too many cases to deal with; lack of transport; unwilling to risk confrontation, or may themselves be corrupt.
- Whilst there tends to be ample information on general construction, especially using modern materials, there is less on disaster-resistant building or on good vernacular construction. That which exists may be of questionable quality and not structurally verified. This lack of information affects those involved at all levels of safe building, from families to professionals.

Approaches to determining the quality of reconstruction

There are a number of approaches that authorities and agencies involved in reconstruction can take to come to a decision on the level at which quality control should be set. These range from: adopting international standards; adhering to a national regime already in place; setting regulations specific to a national reconstruction strategy; or allowing the people to decide on the desired level of quality. In People-Centred Reconstruction, it is important for those affected by disasters to have a say in the quality of construction that is adopted, as well as in the design and construction itself. If other stakeholders set quality at alternative levels that appear unachievable or unreasonable to the affected peoples, it can subsequently become difficult to obtain their interest and participation in projects. The most appropriate approach to adopt depends on the local context and therefore needs to be decided on a case-by-case basis. The issue of standards for reconstruction will be covered in more detail in a future PCR tool.

Quality Control in practice

Ensure that building materials and components used are of adequate quality

The use of materials that are poorly produced or inadequate for the intended purpose can be a significant factor in the collapse or damage of buildings in natural disasters. This can be a particular problem with materials produced by small enterprises, often in the informal sector, or those produced or gathered by residents themselves. As it is difficult to ensure the quality of materials produced in a decentralised way, some programmes consider pre-fabricating them in a few central locations where support and supervision can be provided regularly. However, even materials produced by larger formal enterprises may sometimes be sold without adequate checks, especially in the absence of national material standards.

photo © Neil Cooper

Women making concrete girders for a housing project in Madaripur, Bangladesh

It is important for the engineers and architects involved in reconstruction to **inspect the damage** done by a disaster, together with local builders and residents (see PCR Tool 3: Learning from Disasters). This may highlight why particular buildings failed. If poor materials or components are suspected as a cause, these should not be used for reconstruction until a further investigation is carried out and steps taken to improve their quality.

Where production has been to a poor standard, consider providing **additional training** to materials producers. In addition, the quality of materials produced needs to be closely monitored for at least half a year following training, and further spot checks taken after that. Any sub-standard batches must be discarded. If particular producers continue to regularly produce materials or components of poor quality, they need to be de-listed as suppliers. This approach is often the most suitable to stimulate the re-building of local livelihoods and markets.

An alternative approach to addressing poor production standards is to identify a **selection of producers** known to provide adequate quality and utilise only their products. Such producers could be selected by a project team, together with local builders and residents. Reconstruction, however, usually requires large quantities of materials, and in this case, this may mean that some producers may have to be selected that are much further away, or even abroad, with a less positive impact on the local economy.

photo © Singamuthu Jayesegaram

Testing of the quality of bricks for a reconstruction programme for IDPs in the Vavunya area of Sri Lanka

Residents and local builders will often have to purchase materials or components that are not locally produced, from shops in their area. It is therefore important that such **building merchants or hardware shops are also made aware of the importance of quality** of materials or components in a reconstruction programme. Ultimately, a project team could select or de-select such local shops in a similar way as it would with local materials producers, and only allow purchases to be made from the ones that qualify.

A project team can only do so much to guarantee the quality of materials produced or supplied locally. Although it is ultimately the decision of residents and their local builders as to how to build their houses, it is important to raise awareness of the need to use good quality materials. The damage assessment after a disaster can help raise awareness, as it can open the eyes of those participating to what is good or bad practice and quality. In addition, a project team can provide some **training on how to check the quality of local components and materials in simple ways**. For example using visual means (is sand clean and sharp? Is timber straight?), touch (does the cement have any lumps?) or sound (do two fired bricks, when knocked against each other, make a clear ringing sound?). It is beyond the scope of this Tool to list such simple tests for the many materials that could be used in reconstruction worldwide. The information required for that can usually be distilled from standards or textbooks, but it will need to be translated into a format that is appropriate to local users (see PCR Tool 9: Communicating better building).

Ensure that construction is of adequate quality

Poor quality of construction is another major factor contributing to collapse and damage of buildings in natural hazards. Similar to the materials, a damage assessment will often point out what is good and bad practice in construction. A reconstruction programme should, where possible, **accommodate good local practice**. Any technologies that performed badly in a disaster should be avoided in reconstruction, as should those building practices that contributed to collapse., However, it will be possible to improve on some through awareness raising and training, or some form of reinforcement,


photo © Practical Action / Theo Schilderman

A reconstruction project in Tacna, Peru, where adobe housing had failed in an earthquake. In reconstruction, the quality of adobe production was strictly controlled and walls were reinforced with cane

after which they could be allowed.

Community leaders as well as members are often well informed about who in the area is building where and at what stage they are in construction. They can therefore visit the sites and find out who is building their house well and who is having problems. In doing so they can **learn from the good builders** and pass on information to the weaker members. They may also be able to request the help of the successful builders on behalf of the less competent or able. This can be particularly important for households who have lost members during the disaster, who have disabled members, or who have few resources themselves to contribute to reconstruction.

Building artisans as well as residents need to understand the importance of quality in construction to avoid similar disasters in the future. They should not attempt to carry out jobs that are beyond their level of skill and knowledge and should **seek help** if they run into difficulties.

Reconstruction projects need to **provide training**, to both residents and local builders, in aspects of construction that the damage assessments highlighted as weaknesses. If additional technologies are being introduced that are new to the area, training needs to be provided in those. Training may also be needed for local authority staff responsible for ensuring construction quality. After the tsunami in Sri Lanka, GTZ and Practical Action provided a training programme on quality assessment to such technical officers. The regular training that public or private training institutions had already provided to those officers lacked the basics of disaster risk reduction and related standards. In this case, the remedy was to provide 2.5 day courses, but a better long term solution would be to incorporate disaster risk reduction in the curricula of those existing institutions.


photo © Practical Action South Asia

Training session on the construction of foundations in a reconstruction project for IDPs in Vavunya, Sri Lanka

Projects will also need to provide **adequate supervision and support on site**. There is a tendency for field visits in some projects to focus mainly on quantity with questions such as: has sufficient progress been made, and therefore can the next instalment of cash for reconstruction be allocated? Instead, such visits need to also cover quality, so may require different fieldworkers, or mixed teams. If fieldworkers who visit sites regularly cannot provide this type of support adequately, another option could be to engage master builders with proven competences in the skills required and have them reside in the area. For example, following the tsunami in Sri Lanka, Practical Action used experienced masons, in coastal locations where there was a scarcity of experienced builders, to support reconstruction there. Even after training, not every community member or builder will be equally competent to complete a particular construction component well. They may not always realise that they are doing things wrong, thus supervision, additional explanations and perhaps demonstration are needed to set them right.

Consider independent quality control

Agencies involved in reconstruction would normally aim to achieve adequate quality housing. However, they are also often under enormous pressure to build quickly, which may limit their willingness to spend time training people. Reconstruction also causes a sudden upsurge in demand in the construction sector, so good staff and builders are often hard to get, and some of the training and support may therefore be inadequate. Furthermore, donors want to keep overheads down so the less money spent on staff costs, (including for capacity building, support and supervision), the more that remains for building houses. But there comes a point when quality is compromised for cost, and too many houses end up being of inadequate quality, meaning inhabitants are still at risk of living in houses that are unsafe.

Therefore, is worthwhile to **consider independent quality control**. Many countries have a system of building inspection, with inspectors checking quality and ultimately issuing a Certificate of Completion or similar document that proves the satisfactory completion of houses and before owners are allowed to occupy them (or rent them out). This is an independent system, and if it has not suffered itself too much from the disaster, and has the capacity to deal with an upsurge in inspections, it could prove the best choice. If it cannot take on the task, then other professional institutions should be considered, e.g. housing authorities, research institutes, universities, or check consultants (see case 4 in the Applications section). Inspection would normally be required at least upon completing the foundations (at the plinth level), upon completion of the walls or structural frame, upon completion of the roof, upon completion of any services like electricity or sanitation, and upon completion of doors, windows and finishes, but it could vary somewhat according to the housing designs. Inspection should pay particular attention to structural safety. After each inspection, an inspector can sign off the respective component as satisfactory. On doing so, inhabitants are entitled to the next cash instalment to continue with the building process.

What needs particular attention in construction?

It is beyond the scope of this Tool to run through the many components of a house and the many technologies that are used to build those worldwide, to advise on their quality and particularly their resistance to a range of natural hazards. Some of the practical resources provided at the end of this tool provide more detailed guidance on that, in particular Coburn and others (1995). However, we know from damage assessments after many disasters that some mistakes or unsatisfactory types of work are repeatedly made by unqualified builders. The most important are summarised below:

- *Foundations* need to be sufficiently deep, massive and strong enough to resist damage by floods and moderate earthquakes. Building on unstable ground or steep slopes is best avoided, as it would require expensive foundations to make a building safe. Building on slopes above 10% is not recommended. Great care needs to be taken when starting to build walls above the plinth layer, as this may become a point of weakness.
- *Structural frames* should be avoided unless local builders have good knowledge of frame construction. Poorly constructed and inadequately jointed frames of reinforced concrete, steel or timber can put inhabitants at high risk. On the other hand, if frames are well built and compatible infill or cladding materials used, this can confer a high level of safety. See the description of dhajji construction in Pakistan, by M. Stephenson in the resources section, for a good example of timber-frame construction.
- *Masonry walls* need to be built with a proper bond in all directions. Walls must be level (horizontally) and plumb (vertically). Check for this using a spirit level and plumb line. If walls are built with distortion, even if it is not visible to the naked eye, this may be a source of weakness.
- *Doors and windows* need to be evenly distributed, and not placed too closely to corners or intersections of walls, as this weakens the walls' resistance to earthquakes. Lintels above those openings need to be of sufficient strength and length.
- *Roof structures* need to be anchored well to a wall plate or structural frame; they also need to

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Care needs to be taken to finish the foundations with a perfectly horizontal layer, to provide a good base for the walls

photo © Practical Action / Theo Schilderman

This roof collapsed during an earthquake in Moquegua, Peru, because of poor anchoring to the walls

be interlinked well. During earthquakes, storms and tornadoes, the building needs to maintain structural integrity, with the roof moving in unity with the walls, and keeping them together. If the roof becomes detached and starts to move independently, this can accelerate the collapse of a building. The structure needs to be completed to a high standard. Roof rafters and purlins need to be cut or cast to the correct length, with little margin for error. Joints between members need to be well made and fit snugly together. Sufficient nails and screws of the correct specification need to be used to tie joints together so that they do not become a point of weakness.

- **Roof coverings** of pitched roofs, whether sheets or tiles, need to be tied securely to the frame. Where walls are susceptible to damage by rain or humidity, they also need to provide sufficient overhang.

Applications

The following are examples of a few projects in which the need for ensuring quality has been recognised as important, and where steps have been taken to implement quality control of all houses and other buildings, as far as is practical.

Case 1: Builders Workshops after the Bandar Abbas Earthquake in Iran, 1977

An earthquake of magnitude 7.0 struck the city of Bandar Abbas and surrounding region in March 1977. After the quake, a team of the NGO Development Workshop undertook a damage assessment of villages in the area. It reported extensive damage, with many of the traditional flat-roofed buildings of mud brick or stone rubble walls collapsing or undergoing serious damage. Only timber-framed buildings covered with palm-frond matting, traditionally used as summer houses or animal shelters, remained substantially intact. Overall, the poor quality of much of the building work in the area had been a significant cause for much of the damage. Development Workshop decided to organise a course for builders to raise the standard of construction and improve the earthquake resistance of buildings that they worked on. It was organised in a location outside the earthquake-affected area, which allowed some builders from other seismically active areas in Iran to participate too. The workshop lasted two months and covered:

- Assessing the problems and potential of traditional village building and modern building techniques;
- Understanding why and how earthquakes occur and how they affect buildings;
- Techniques and designs for strengthening buildings against earthquakes covering foundations, walls, timber roofs and vault and dome roofs;
- Sharing knowledge and experimentation by the builders;
- Literacy classes, as many of the village builders were illiterate.

The focus of the workshop was on improving the skills of the builders to continue to build houses in the traditional way but with more safety.

See: Afshar F. et al (1978) in the *Practical Resources* section.

Case 2: Effective Collaboration between Communities and Professionals to Ensure Quality

The South Indian Federation of Fishing Societies (SIFFS) reconstructed some 2,300 houses in the fishing villages of Tarangambadi and Chinnangudi, devastated by the 2004 tsunami. The houses were built by a team of local labourers supervised by engineers and local people recruited and trained by SIFFS. Local people also participated in the housing design. A priority was the orientation and training of the supervisors in construction quality so that they would be able to supervise the labourers effectively to undertake reconstruction to a satisfactory standard. This involved having the supervisors participate regularly in training courses to update their knowledge. To facilitate these courses, the project's architect and technical advisor prepared a series of notes about how to implement quality in building the types of houses selected within the project. These notes covered:

- Durability of buildings and quality of work
- Quality control in the production and use of building materials – fired clay bricks, cement, sand, coarse aggregates, steel reinforcement, water, mortar, and the curing of cement mortar and concrete
- Building elements – foundations, concrete, damp-proof course, brickwork, formwork and concreting, plastering, flooring and painting
- Design details – rising damp, salt crystallisation, coping, sloping sunshades and sloping of ground away from buildings
- Health and safety on the building site.

See: Kuriakose, B. (2006) in the *Practical Resources* section

Case 3: Evolving Standards in a participatory manner

Following the massive 2005 earthquake in Northern Pakistan, the government supported by UN-Habitat decided that a very large part of housing reconstruction would be undertaken using an owner-driven approach. This raised the problem of how to ensure the quality of almost half a million houses to be constructed by households on their own or with the help of local builders. Many people were in a hurry to rebuild their house before the winter, and did so before quality standards and information resources could be developed; this resulted in many problems and mistakes. Some people, for instance, decided to rebuild with a reinforced concrete frame and concrete block infill in preference to the traditional stone and earthen buildings that had proven to be so vulnerable. However, they did not understand how a reinforced concrete frame can function to resist shaking, so the reinforcement was installed incorrectly or not tied together properly, and the quality of mixing, applying and curing of concrete was poor. This makes the houses vulnerable to eventual future earthquakes. The programme has adopted retro-fitting measures to strengthen the vulnerable concrete frame houses, but it has not been universally adopted.

In other cases rebuilding of houses in more earthquake resistant ways has been implemented more successfully. The use of *dhajji*, for example, has boomed. *Dhajii* is traditional timber-framed construction in the area with stone or earth infill. Before the quake, its use had almost died out end there were only about 5,000 *dhajii* houses left in the area. But they performed well during the quake, and since then over 100,000 new ones have been built, mostly to a satisfactory quality of construction.

The engineers, architects and planners of the Earthquake Reconstruction and Rehabilitation Authority (ERRA) have had to adapt their professional skills and incorporate more people-centred approaches. The development of housing designs and quality standards, for example, have had to be guided by people's preferences rather than produced in a design office, based on classic earthquake-resistant construction principles. They also have had to find new ways of communicating safe design to builders. Many builders do not understand lengthy descriptions, conventional blueprint drawings. Photographs showing how to build or mistakes to avoid, scale models, demonstration houses, and simple visual tests and demonstrations can get the messages across better.

See: Stephenson, M. (2008) in the *Practical Resources* section.

Case 4: Using Check Consultants to control the Quality of Reconstruction

The Joseph N. France Hospital is the main health facility of St. Kitts and Nevis in the Caribbean. When Hurricane Georges struck the islands in 1998, this was the tenth time the hospital was seriously damaged since it opened in 1966. After each hurricane the hospital was rebuilt or repaired, only to be damaged again by the next one. Following Hurricane Georges it was proposed to rebuild the paediatric ward entirely to act as a model for later redevelopment of other departments. It was recognised that the hospital had originally been built according to national building codes, but the monitoring of the quality of construction work might have been deficient. For the reconstruction, it was proposed to engage independent check consultants to maintain the quality of construction. The check consultants functions include reviewing building designs, auditing contractors and builders undertaking the work, and carrying out regular site visits to provide supervision and advice. Of note is that on the neighbouring island of Saint Martin, under joint French and Dutch administration, the area under French control usually experienced less extensive damage in hurricanes than the Dutch area. This was attributed to a greater use of check consultants to monitor construction on the French side. Check consultants were subsequently also used in the rebuilding of a home for the elders in Grenada following Hurricane Ivan in 2004.

See: UNISDR and WHO (2008) in the *Practical Resources* section.

Case 5: Guidelines and Checklists for Reconstruction

Where official standards for particular types of construction do not exist or apply, or are too complicated for artisans or self-builders to understand, organisations such as NGOs with adequate technical skills in construction can produce simplified guidelines and checklists for builders and building materials producers to improve quality. Following the 2004 tsunami in Sri Lanka, Practical Action produced a set of guidelines as well as checklists to assist masons, carpenters and users of concrete to produce adequate quality work, as well as maintenance checklists for households. The process guidelines cover testing, storage and use of building materials and a description and illustration of construction details. They are presented in an easy to follow point-by-point format that covers the essentials for the construction of a one or two-storey reinforced concrete frame masonry house with a pitched roof.

See: Practical Action South Asia (2005) and (2006) in the *Practical Resources* section

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Resources

Relevant resources on quality control in post-disaster reconstruction tend to follow two themes:

- Discussion of why quality control is important, factors that have contributed to poor quality and disaster-prone construction in the past, and what needs to be done to improve quality in post-disaster reconstruction. These are referred to as general resources.
- Specific details, instructions and guidelines on how to rebuild safely following disaster. These are called practical resources.

General Resources

1. Benson, C and J. Twigg, with T. Rossetto (2007) *Tools for Mainstreaming Disaster Risk Reduction: Guidance Notes for Development Organisations*, IFRC/ProVention Consortium, Geneva. http://www.proventionconsortium.org/?pageid=32&projectid=1
2. Parker, Jinx (1994) *Building Codes: The failure of public policyto institutionalize good practice*. OAS Caribbean Disaster Mitigation Project (CDMP), also published in Environmental and Urban Issues, Vol. XXI, No. 4, Summer 1994. http://www.oas.org/cdmp/document/papers/parker94.htm
3. Schilderman, T. (2004) *Adapting Traditional Shelter for Disaster Mitigation and Reconstruction: experiences with community-based approaches*, in Building Research & Information 32 (5), pp. 414-426. http://www.sheltercentre.org/sites/default/files/SPON_AdaptingTraditionalShelterForDisaster.pdf

4. Suresh, V. *Disaster Mitigation, Bold New Initiatives, in Kerala Calling*, February 2005, Cover Story. http://www.kerala.gov.in/kercalfeb05/p08-16.pdf
5. Thiruppugazh, V. (2007) *Urban Vulnerability Reduction: Regulations and beyond*, ASARC Working Paper 2007/8, Australian National University, Canberra.
http://rspas.anu.edu.au/papers/asarc/WP2007_08.pdf

Practical Resources

1. Afshar, F. et al. (1978) *Mobilising Indigenous Resources for Earthquake Reconstruction*, Housing Science, Vol. 2, No. 2, pp. 335-350.
2. BSHF (1998) *A Practical Guide to the Construction of Low Cost Typhoon-resistant Housing, The DWD core shelter project of The Philippines*, Building and Social Housing Foundation, Coalville, UK.
http://www.bshf.org/published-information/publication.cfm?thePubID=41
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