Housing construction in earthquake-prone places: Perspectives, priorities and projections for development

James Lewis argues the requirement for improved building development in earthquake-prone countries

By James Lewis

It can no longer be assumed for all earthquake areas, as it was thirty years ago, that all architects and engineers are both accessible and competent for earthquake-resistant housing. There is a long-overdue requirement for urban multi-storey and self-build small buildings to improve the standard of their construction. After almost every urban earthquake, the call goes out for building construction to be improved. But what are the requirements for improving building construction, and how can they be achieved; and are there other housing strategies to be considered for the achievement of earthquake disaster reduction as an integral part of sustainable development ?

Continued attention to rural small buildings is not disputed, but there is now also a need for redress of an imbalance in the strategy, to reflect the need that clearly exists for more attention to all kinds of urban housing – but it is not only shortcomings in the application of building construction technology that is responsible for these circumstances; so are planning, management, administration and integrity.

All forms of building construction involve a process of legitimate physical covering over of each stage of construction. As each stage is completed, it becomes concealed by a subsequent stage – from foundations under the ground through to the last coat of paint. For there to be as much certainty as possible, from stage to stage, in the achievement of construction quality, periodic, even constant, independent inspection of buildings under construction is necessary.

Legislation does exist in the form of building regulations, codes, standards and guidelines in most countries, but legislation is insufficient without regular, strategic, informed and reliable inspection to ensure its enforcement. Earthquake-responsible development can achieve more by adopting earthquake awareness through all sectors; micro-zoning of earthquake risk can be used to modify population occupancy and to modify construction standards. Peru is an example of the practice and Turkey is an example of the need.

Introduction

It is exactly thirty years since the publication of A F Daldy's groundbreaking 'Small building's in earthquake areas' by the UK Building Research Establishment (Daldy: 1972). In the preface, Daldy wrote: "This handbook is not written for the professionally qualified architect or engineer, but for builders and others who actually construct small buildings in earthquake areas. In this context a 'small building' means a building of not more than two storeys, with a total floor area not more than about 120 sqm. This is the type of building in which the large majority of people live, and which is generally built without structural calculations by professional engineers".

Since then, for the past thirty years, to counter emphasis there had been on urban, professionally designed housing, there has been appropriate attention given to low-cost, self-build, rural, domestic building construction, in efforts to facilitate resistance to the forces of natural hazards. During the same period of time, however, processes of urbanisation have continued to create the demand from many, and opportunities for some, for rapid construction of multi-storey buildings for domestic housing. These buildings for domestic accommodation, on the one hand, and urban self-build on the other, were excluded by Daldy's definition of 'small building' and by his assumption that single dwellings with an area of 120 sqm are where 'the large majority of people live'.

Structural inadequacy is exposed by failure of so many buildings. Compare for instance the building in the rear to the building in the foreground

Furthermore, it can no longer be assumed, even if it could be in 1972, that architects and engineers are available and that if they are, they have the necessary skills, and that these services can be afforded, and that there is a perception of need of them by developers, for the design of speculative multi-storey housing. Urban self-build is, by its nature, largely outside of normal professional interest. There is a long-overdue requirement for the inclusion of multi-storey housing and urban self-build to be made a part of renewed attention to housing construction in earthquake-prone places.

> *"The type of construction used in most poor people's urban housing makes them particularly vulnerable. The reinforced, concrete-framed, multi-storey block with masonry or precast panels or cladding is potentially hazardous in disaster-prone areas. Although this type of construction can be made relatively safe in all but the most severe disasters, few architects designing such blocks in the South are familiar with the engineering principles of building safer multi-storey buildings, the construction skills of the building contractors may not be adequate, and the introduction of safety features such as shear walls and cross-bracing can add significantly to the cost"* (Ruskulis, 2002) – and even if known of, are likely to be omitted by unscrupulous developers.

Multi-storey and low-rise urban self-build housing for the poor is a constant and increasing activity, and overcrowding is a normal characteristic; it follows that greater attention to the structural security of these kinds of housing would be a major component of housing security and disaster reduction, and one which would significantly contribute towards contexts of long-term sustainable development.

Structural inadequacy is exposed by failure of so many of these kinds of building in almost every earthquake, and there is ample evidence that urban, high-rise housing construction cannot, as has been assumed, be left to itself as not in need of scrutiny and improvement. If media attention to building construction failure in earthquakes were a reliable guide, it could be inferred that urban construction in earthquake-prone areas is now more in need of improvement than that of its rural counterparts, due to high incidence of occurrence, inevitably overcrowded occupancies, and consequently high numbers of casualties that urban building collapses cause.

Urbanisation no longer means only the growth of established cities, but also the growth of previously small villages to towns, small towns to large ones, and large ones to conurbations, as a consequence of migration from impoverished rural livelihoods. Nor can the process of enlargement and construction be envisaged as regular, ordered and planned, but as taking place in contexts of 'a combination of human error, indifference, corruption and greed' (Wisner: 2001).

Consequently, after almost every urban earthquake, the call goes out for building construction to be improved. But what are the requirements for improving building construction, and how can they be achieved; and are there other strategies for housing in built environments to be considered towards the achievement of earthquake disaster reduction in the even longer-term?

Thirty years is a period of time sufficient for large numbers of buildings to have been designed, constructed, occupied, and tested by the natural hazards of their locations. That some buildings have survived such rigourous testing can be assumed, and their number would be difficult to ascertain. That there have been, in that time, so many catastrophic failures of buildings built within the same period, especially buildings for housing, is made repeatedly apparent by the many earthquakes to which they and their occupants have been collectively subjected.

Urban low-rise

Urban construction for housing is not all multi-storey, and not all developer-built. Urban low-rise housing, inclusive of self-built 'shanty-towns', 'bidonvilles', and 'squatter settlements', is a significant feature of urban development in most cities of developing countries, from Rio de Janeiro to Bombay. Special programmes are in place, and need to be replicated, so that this crucial and heavily populated aspect of urban housing does not continue to be ignored as part of the urban housing fabric – whilst it is excluded from programmes for its rural counterpart. Housing of this kind, usually the product of impressive local initiatives, needs to become recognised as a part of municipal responsibility so that it may benefit from appropriate applications of secure building construction siting, guidance, legislation and control.

> *"… formal building codes in disaster-prone areas rarely consider housing and building in informal and low-income settlements. In some Southern cities 60 to 70 percent of the population live in such settlements. Building codes will have little impact in these settlements. This situation is unlikely to change unless community-based organisations representing informal and low income settlements are fully integrated into city-wide planning processes on disaster management"* (Ruskulis, 2002).

Rural construction

Since 1972 there has been emphasis on rural domestic construction. This emphasis is evidenced not only by its quantity, but also its variety of applications to very specific and often remote locations: for example: Norton (1985) for Guinea; Afshar et al (1978) for Iran; and Boyle (1988) for the Australian bush. Similarly, emphasis on some specific building types; eg: Vickery (1982) for school buildings, reflects a recognition of the importance of school buildings in disaster-prone places (Bothara: 2002), and the degree of specialisation achieved within wide ranging rural construction, a formerly significant but neglected area.

Other examples of rural emphasis relate to specific applications such as Department of Economic and Social Affairs (1977) for repair of buildings damaged by earthquakes, and Nimpuno (1993) for NGO training in structural upgrading; others are of mixed applications, such as; Aysan et al (1995); Clayton & Davis (1994), an annotated bibliography, and Dudley & Haaland (1993) on communicating technical information to local builders and householders.

Urban low-rise housing is a significant feature of urban development in most cities of developing countries

There are many buildings older than thirty years that should not fail to the extent they do

An equally large number relate to issues of concern in the USA, and for applications as part of the US overseas aid programme; for example the Office of US Foreign Disaster Assistance (1981). The former stem from the (not so rural) technical aftermath of the 1902 San Fransisco earthquake; eg: Clay Products Institute (1929); followed by earthquake resistant design in Osman (1976) and Green (1978).

However, the majority of these many examples from building construction literature, of efforts for the achievement of earthquake-resistant building construction, are related to the construction of low-cost, self-build small and rural domestic buildings; for example, and in addition to Daldy (1972): Department of Economic and Social Affairs (1975); BRE (1988); Landewijk & Shordt (1989); and Hodgson et al (1999), and for the most part, Coburn et al (1995), inclusive also of guidance in reinforced concrete construction for low-rise multi-storey buildings; and the exemplary Basin News (2002).

Probably only one or two references have anything of structural engineering content applicable to high-rise urban construction; for example Coburn & Spence (1992) and Key (1995). That professional literature, as distinct from that for informed general readership, includes of this specialist area of structural engineering can be assumed, but that its application is not assured is evidenced by repetitions of structural failure. It can no longer be assumed that urban high-rise construction can be regarded as an area of activity exempt from concern, as being subject to professional inputs or that it is automatically subject to regulated design guidance.

Although much of the damage caused by earthquakes is to buildings older than thirty years, there are many built within that time that should not have failed to the extent they did. This applies to both less-developed and developed countries; shortcomings of construction were exposed in the earthquakes at Kobe (1995) and at Seattle (2001). Repeated examples of serious earthquake damage to comparatively recent construction, can only be an illustration of a pervasive failure to apply information that has been available for many years.

The continued need for attention to rural small buildings is not disputed, but there is now also a need for redress of an imbalance in the strategy, to reflect the need that clearly exists for more attention to urban, multi-storey and self-build housing – but it is not only shortcomings in the application of building construction technology that is responsible for these circumstances; so are planning, management, administration and integrity.

The nature of building construction

Building construction proceeds in stages; starting in the ground, for foundations and drainage; proceeding to the erection of superstructure of wall, columns, floors and staircases, etc; to roofing; to the fitting of secondary components, such as window and door frames; to water supply, plumbing, and electric wiring; and to surface finishes for walls, ceilings and floors; and to painting. Some stages may overlap, or are arranged into sub-stages, as different parts of buildings are completed to separate programmes. Each stage is achieved by different trades; the arrival or departure of each one usually signifying start or completion of each stage, or sub-stage.

All forms of building construction involve a process of legitimate physical covering over of each stage of construction, especially the early stages of foundations and superstructure. As each stage is completed, it becomes concealed by a subsequent stage – from foundations under the ground through to the last coat of paint. Mistakes, omissions, deviations, and misunderstandings of requirements, have therefore to be identified and rectified within and as part of each stage. To go back to a previous stage requires costly and time consuming investigation and rectification.

Building construction of any kind takes place under pressures of time; caused by weather or by need to complete by a given date, or both, often with a high penalty or loss of financial incentive for the builder for not doing so. Opportunities to save time, and to save on the cost of materials by reductions in quality or amount, mean that temptations of expediency, shortcuts and omissions, are boundless.

For there to be as much certainty as possible, from stage to stage, in the achievement of construction quality, periodic, even constant, independent inspection of buildings under construction would be necessary. Model regulations for application in legislation have existed for many years (eg: Building Research Station, 1966) and building regulations, codes, standards and guidelines have been published in many countries: (e.g. Organisation of Eastern Caribbean States: 1991) but legislation is insufficient without regular, strategic, informed and reliable inspection to ensure its enforcement.

Project design and management, and construction inspection

Design of structural resistance to earthquake forces, depends upon an assessed or predetermined 'design level' conditioned, in part, by cost and factors of practicality. Design levels may indeed be overcome by an earthquake (or wind or flood) of greater magnitude than that designed for. Decisions concerning the level of resistance are inherent in design standards, even though the design level need not publicly be known. Absolute 'proof' against earthquake, or any other hazard, is not usually feasible.

Other aspects of building design, such as form, juxtaposition and relationship, can influence structural resistance, and means of escape in case of earthquake can all be applied so as to additionally influence occupants' chances of survival.

Inspection of building construction in progress is achieved from either of two different sources, or from both. Arrangements for project management, before construction starts, can be made inclusive, with the request or agreement of the building owner, of measures for the achievement of a required quality of construction. It can arrange for:

- separation of design, specification and tendering/bidding from the undertaking of construction itself, so that structural design is independent of the construction process (over recent years, this traditional arrangement has been repeatedly contested for reasons of cost and alleged inefficiency, but in the context of this paper, it has obvious advantages).
- arrange the inclusion of calculations and specifications of materials, in drawings and other documentation, before tendering, so that requirements for construction quality are known and costed at the outset.

Management at this pre-construction stage, can also be made to include arrangements for inspection of construction-in-progress as part of the execution of independent design management. The project management process can continue into its own inspection by the appointment of:

- site inspectorate (engineers, architects, clerks-of-works), and arrangements for:
- testing and recording of materials in use
- regular inspection and recording of construction in progress
- periodic and final payments for work only when deemed to have been completed as specified

Inspection may also be undertaken by local government building inspectors, or similar, in addition to construction inspection provided by the building owner.

Legislation is insufficient without regular, strategic, informed and reliable inspection to ensure its enforcement

Many homes were destroyed by the earthquake that devastated Northern Algeria in May 2003

The purpose of building inspectors is to ensure compliance with the requirements and standards of building legislation that is in place. Design standards can of course exceed the standards required by legislation, or may be the same, but may not be less. In other words, building legislation is likely to be a minimal requirement that it may be possible or desirable to exceed.

Shortcomings, and temptations for corrupt practice

There are many cases where construction legislation is in place, but where there is an inadequate inspectorate, or no inspectorate at all, to ensure its appropriate application: 'For example, the Marmara earthquake in Turkey in 1999 saw widespread destruction of buildings despite measures being in place to ensure that buildings were earthquake resistant. Inadequacies in the control mechanisms of local municipalities for checking the work of local building contractors meant that many buildings were not built to standard' (Ozerdem: 1999).

The need for building inspectors is the greater in circumstances of a rapidly increasing demand for housing, and a consequent financial imperative to dispense with detailed arrangements for construction project management as an obvious saving in time and cost. In these very common circumstances and on sites where minimal construction is the norm, or there is simply a practice of doing what a builder may have done before (or says he has done before), the need for inspection is crucial.

Legislated inspection aims to ensure basic construction quality, and therefore security, on behalf of current and future occupiers, users and passers-by, in accordance with defined national and local parameters and requirements. The advantages to an unscrupulous developer to offer inducements to inspectors to turn the other way, not appear for certain operations on site, or not to inspect too closely – or at all – are as obvious as are the temptations to inspectors to accept them. The risks to occupants and community, where this is the only source of inspection, are enormous; and by the time building failure occurs, due to earthquake or not, the developer, the builder, and inspectors will all have disappeared.

The construction industries in Britain and in the USA, rich and developed countries of the global North, have long histories of construction legislation, often influenced by past catastrophe, and this process is continuous (eg: Natural Hazards Observer: 2002). In spite of this, failures and corruption continue to occur. If this is the case in developed countries, then there are questions for many other countries about how effective legislation can be, how it can be achieved, how it will be implemented, and how long it will take. Construction, and construction management, in some developing countries, is evolving so as to eventually eradicate such shortcomings. Even where this is the case, it will be a long time before indigenous construction practice can consistently and pervasively achieve a quality of building construction so that all buildings are able to resist even moderate earthquakes.

Large construction companies, medium and small construction groups and self-builders will all need to be monitored, modified and inspected on all of their construction sites for appropriate compliance and quality achievement. This supported by, but in addition to, legislation in place. For this to happen requires a volume, strength and persistence of political and personal commitment by very many trained people for lengths of time much longer than working lives. And it requires people, a system, and levels of payment, to deter and to resist the temptations of corrupt practice. Even when and where all this is achievable, there will be backlogs of buildings built to earlier less exacting standards and requirements.

The savings to some governments of earthquake-prone countries, or their sheer inability, or reluctance, to achieve a trained building construction inspectorate, is self evident; but the social and economic costs to their nations, societies and communities, of not doing so is nevertheless colossal. In the meantime, there will be more earthquakes. Yes, improved building construction is needed, but in addition, so are a broad spectrum of other measures to do with buildings, to be incorporated into the overall processes of national housing development.

Projections for built development in earthquake-prone places

It is not difficult in contexts prone to the effects of natural hazards, to identify and to project the need for measures for disaster-responsible development (Lewis: 1999; Lewis: 2001), but in this, or any other context, earthquake disaster reduction is not a monodisciplinary, nor indeed a monosectoral undertaking. The Safer Cities series of Case Studies, for example, prepared by the Asian Disaster Preparedness Center presents useful strategies for urban disaster mitigation derived from analyses of real-life experiences, successful practices, and lessons learned. Focusing less on post-disaster response and relief, and more upon comprehensive approaches taken prior to disasters so as to reduce human suffering, economic losses and institutional collapse, this approach integrates disaster risk reduction with sustainable economic, social, and environmental development (Apikul: 2002).

Algerians recover what is left of their properties inside their homes destroyed in Isser 65 kilometres east of the capital Algiers

Improved building construction for housing of all kinds should and could well be a component of such programmes; but for improved building construction to be achieved in all housing activities and sectors will also require long-term programmes for legislation, training, integrated demonstration projects, the preparation of information for non-professional use, and its dissemination. The need is so widespread and pervasive that implementation will require such recurrent series of widely repeated projects to render the programme a continuous one.

Earthquake-responsible development

Building construction legislation, however, is concerned with how buildings are constructed, not where they are placed. Geological, topographical and geographical examination to identify zones of earthquake risk, with the purpose of micro-zoning, enables land-use planning to have the opportunity to deter or prevent inappropriate construction in high risk areas, and prepares the way for modification of construction standards appropriate to zones of risk. Micro-zoning need not be a prohibitively complex and time consuming exercise; methods of earthquake zoning based upon surface observations of natural features, have been developed and successfully applied in Peru for many years (Kuroiwa: 1982, 1986 & 2002).

In Turkey in 1999, even if building construction had been adequate, there would still have been earthquake disasters – though with fewer casualties (Lewis: 2001). Some buildings inevitably would have failed and roads, bridges, power lines, telecommunications, water and fuel supplies would have been disrupted. Villages and rural communities would have been isolated, and tsunamis would have inundated coastal fishing and tourist venues. The poor would still have been living in overcrowded sub-standard dwellings, and the poor would still have been highest amongst the casualties, in urban new and older buildings, shanty settlements, and in rural areas.

Development needs to adjust to a broad spectrum for disaster reduction, inclusive of all its sectors – not only those labeled 'disaster management' – to ensure equitable inclusion of small domestic buildings as well as large and commercial ones, and with inducements for equitable dispersion of communities with commensurate accessibility to services, communications and resources for self-reliance and survival.

The population of North-western Turkey increased exponentially since 1945; the population of Istanbul having increased fifteen times in thirty years. The north-western region in which the1999 earthquakes occurred, has the highest population density of all and contains more than twenty percent of Turkey's national population. The province of Kocaeli, offshore of which was the earthquake's epicentre, had a population density of 260 people per square kilometre – amongst the highest in Turkey. A centralised government has attracted migration to the capital, and to other cities now so devastatingly destroyed. In a country severely prone to earthquakes, concentration of population anywhere is to be countered – until such time as zones of earthquake risk and vulnerability can be geologically and geographically identified.

Significantly, the 2002 earthquake in Gujarat *(see article in this journal)* similarly occurred in one of India's most industrially developed and most densely populated states. Rather than waiting for catastrophe to recur in Turkey or India, and in many other countries, as they have recurred in the past and will in the future, and rather than depend only on search and rescue, it would indeed be 'better to invest in normality than in catastrophe' by wider adjustments in development strategy:

- First; all development sectors need to take on board the earthquake potential, not just those for civil defence and rescue, nor even only for housing and building construction. Issues seemingly not relevant to earthquakes often bear the greatest consequences
- Second; high density populations need dispersal over time for more appropriate risk-related geographical balance. With reconstruction programmes now necessary in India and Turkey, there is the opportunity
- Third; not only is rehousing required, but also redistribution of clinics and hospitals, education in all grades, and social services of all kinds. These to be equitably commensurate with present and future, urban and rural, populations. Sustainable economic

A man searches for his belongings in the rubble of his house after a new second quake aftershock measuring 5.8 points on the Richter scale hit Zemmouri, 60 km east of Algiers, 28 May 2003 development requires all these and communication, transportation and marketing facilities as well. As much attention needs to be given to existing rural and agricultural areas, both currently damaged and those undamaged

- Fourth; multiple series of small and diverse projects for reconstruction and development are required, not massive ones. In the face of the image of massive catastrophe, it is myriad seemingly inconspicuous measures that are the most effective for normal self reliance and quality of life, before, between, during, and in the aftermath of disasters. Though we read of national catastrophes, they are made up of myriad community and domestic small ones.

Sustainability

Much has been written about sustainability, as a matter of energy saving, adaptability, ecological compatibility, and of environmental integration. Damage and destruction caused by natural hazards is the arch-indicator of non-sustainable development. Earthquake-resistant building construction is therefore prerequisite for sustainable housing. The original ethos of the concept of sustainability had social, as well as economic and environmental dimensions, expressed through identification of social needs (WCED, 1987), and this emphasis has been furthered by the 2002 Johannesburg Conference. For there to be sustainable development, 'needs' have to be appropriately identified and expressed in the first place. There can surely be no greater need than for secure building construction for housing, resistant against earthquakes so as to reduce recurrent deaths, injuries, damage and suffering, as well as parallel economic losses. Sustainable development initiatives, such as the Sustainable Cities Programme (UN Habitat, 2002) have the imperative to focus on this need on behalf of humanity. It is not before time:

> "*(Kluge) …suspects that we are unable to learn from the misfortunes we bring on ourselves, that we are incorrigible and will continue along the beaten tracks…. He looks at the destruction of his home town with the horrified fixity of Walter Benjamin's 'angel of history', whose 'face is turned towards the past. Where we perceive a chain of events, he sees one single catastrophe which keeps piling wreckage and hurls it in front of his feet.*
>
> *The angel would like to stay, awaken the dead, make whole what has been smashed. But a storm is blowing from Paradise; it has got caught in his wings with such violence that the angel can no longer close them. This storm irresistibly propels him into the future to which his back is turned, while the pile of debris before him grows skyward. The storm is what we call progress'* "
> (Sebald 2003).

Sustainability is the name of the angel that faces the future, for the piles of debris to be reduced.

References

Afshar, Farroukh; Cain, Allan; Daraie, Mohammad-Reza; Norton, John (1978) *Mobilising indigenous resources for earthquake construction* Housing Science 2/4 pp335–350. Pergamon

Apikul, Christine (2002) *Making Cities Safer … Before Disasters Strike* Natural Hazards Observer XVI/6 July Natural Hazards Research and Applications Center. Boulder

Aysan, Yasemin; Clayton, Andrew; Cory, Alistair; Davis, Ian; Sanderson, David (1995) *Developing Building for Safety Programmes: Guidelines for organising safe building improvement programmes in disaster–prone areas* Intermediate Technology Publications. London

Basin News (2002) *Disaster Prevention and Mitigation* (Building Advisory Service and Information Network) Special Issue No 23 June. SKAT St Gallen

Becker, J; Johnston, D (2002) *Planning for earthquake hazards in New Zealand: a study of four regions* Australian Journal of Emergency Management 17/1 pp 2–8 Autumn

Bothara, Jitendra K (2002) ISDR Earth Summit Debate http://www.earthsummit2002.org/debate

Boyle, Charles (1988) *Disaster-resistant Construction for Traditional Bush Houses: A handbook of guidelines* Australian Overseas Disaster Response Organisation. Sydney

BRE (1988) *Cyclone Resistant Housing for Developing Countries* Building Research Establishment. Watford

Building Research Station (1966) *Model Regulations for Small Buildings in Earthquake and Hurricane Areas* Tropical Building Legislation: Note 7. Watford

Coburn, A W; Spence, R J S (1992) *Earthquake Protection* John Wiley. Chichester

Coburn, Andrew; Hughes, Richard; Pomonis, Antonios; Spence, Robin (1995) *Technical Principles of Building for Safety* Intermediate Technology Publications. London

Clay Products Institute of California (1929) *Earthquakes and Building Construction: A review of authoritative Engineering Data and Records of Experience* Clay Products Institute of California. San Fransisco

Clayton, Andrew; Davis, Ian (1994) *Building for Safety Compendium: An annotated bibliography and information directory for safe building* Intermediate Technology Publications. London

Daldy, A F (1972) *Small Buildings in Earthquake Areas* Building Research Establishment. Watford

Department of Economic and Social Affairs (1975) *Low-cost Construction Resistant to Earthquakes and Hurricanes* United Nations. New York

Department of Economic and Social Affairs (1977) *Repair of Buildings Damaged by Earthquakes* United Nations. New York

Dudley, Eric; Haaland, Ane (1993) *Communicating Building for Safety: Guidelines for methods of communicating technical information to local builders and householders* Intermediate Technology Publications. London

Green, Kevin W Ed (1978) Seismic Design *Research & Design Quarterly* AIA Research Corporation

Hodgson, Robert L P; Seraj, Salek M; Choudhury, Jamilur R (1999) *Implementing Hazard-resistant Housing* Proceedings of the First International Housing and Hazards Workshop, Dhaka. Bangladesh University of Engineering and Technology / Housing and Hazards Group, University of Exeter

Key, David (Ed: 1995) *Structures to Withstand Disaster* The Institution of Civil Engineers/Thomas Telford. London

Kuroiwa, Julio (1982) *Studies on the prevention of earthquake disasters and their application in urban planning in Peru* Mimeo:

Workshop on Planning for Human Settlements in Disaster-prone Areas, UNCHS 1983 Nairobi

Kuroiwa, Julio (1986) *Planning and Management of Regional Development for Earthquake Disaster Mitigation* Mimeo UNCRD

Kuroiwa, Julio (2002) *Communication* ISDR Earth Summit Debate http://www.earthsummit2002.org/debate

Landewijk, Jan van; Shordt, Kathleen; Eds (1989) *Settlements and Disasters. Proceedings of the Workshop, Amsterdam 1988* Disaster and Emergency Reference Center, Delft University of Technology

Lewis, James (1999) *Development in Disaster-prone Places* IT Publications. London

Lewis, James (2001) *Improved building construction?* Radix website (Knowing versus doing) www.anglia.ac/geography/radix/

Meichenbaum, D. 91994) *A Clinical handbook/practical therapist manual for assessing and treating adults with post-traumatic stress disorder (PTSD)*. Waterloo, Ontario: Institute Press

Natural Hazards Observer (2002) *Florida Passes Statewide Building Code to Make Structures More Hurricane Resistant* Natural Hazards Observer XXVI/5 May p5

Nimpuno, Krisno (1993) *Participation in structural upgrading: A training course for NGOs*

Norton, John (1985) *Introduction of Earthquake Resistant Building Techniques in the Koumbia Area, NW Guinea, Africa* Final Report to USAID. Development Workshop Europe

Office of US Foreign Disaster Assistance (1981) *Transition Housing for Victims of Disasters* Disaster Assistance Manual Vol I. Agency for International Development. Wasington DC

Organisation of Eastern Caribbean States (1991) *Draft Building Guidelines for the Organisation of Eastern Caribbean States* UNCHS/UNDP

Osman, Mary (1976) *Earthquake Design: It Cannot All Be Left to the Engineers* AIA Journal December

Ozerdem, A (1999) *Tiles, taps and earthquake-proofing: lessons for disaster management in Turkey* Environment and Urbanisation 11/2 pp177–179 (quoted in Becker & Johnston, 2002)

Ruskulis, Otto (2002) *Developing processes for improving disaster mitigation of the urban poor* Basin News (Building Advisory Service and Information Network) No 23 June. SKAT St Gallen

Sebald W G (2003) *Air War and Literature: Zurich Lectures* (p68) in On the Natural History of Destruction (trans. Anthea Bell) Hamish Hamilton Penguin. London *(Kluge is writing of the destruction by bombing of the town of Halberstadt during World War II. The quotation from Walter Benjamin is from* Illuminations *(trans. Harry Zorn: London 1970)*.

UN-Habitat (2002 onwards) *Monthly Electronic Newsletter of the United Nations Human Settlements Programme* 1/1 January: http://www.unhabitat.org/hb/index.asp

Vickery, D J (1982) *School buildings and natural disasters* UNESCO. Paris

WCED (1987) *Our Common Future* The World Commission on Environment and Development. Oxford University Press

Wisner, Ben (2001) *Same old story* The Guardian: Science February 1: also on the Radix website: www.anglia.ac/geography/radix/

Author

James Lewis is a UK Chartered and Registered architect, and consultant in environmental hazards and human settlements to the Commonwealth, United Nations and European Commission. He has worked on construction inspection as resident/site-architect in the United States, Hong Kong and the United Kingdom; and on earthquake reconstruction planning in Algeria, on hurricane-resistant construction methodology in the Caribbean, on the design of new buildings and the inspection and evaluation of buildings under construction in Bangladesh, and on the impact of flooding on buildings. He is Visiting Fellow in Development Studies at the University of Bath.

James Lewis
Datum International
datum@gn.apc.org
www.livingwithflooding.co.uk