Chapter Six

Conclusions and Recommendations

6.1 Future Earthquake Losses in Eastern Anatolia

The purpose of this study has been to develop and evaluate alternative possible risk mitigation measures for Eastern Anatolia. The field, laboratory and theoretical studies presented in the previous chapters have been concerned to look in detail at possible stregthening measures for stone masonry house construction, given that it is the structural weakness of this building type which is responsible for the large levels of losses, and assuming that this will continue to be the predominant form of construction for the forseeable future.

This chapter will consider some possible scenarios for change of construction technology in the region, given present day trends, and assuming only a limited intervention capability on the part of the Turkish Government. Four principal variables affect future earthquake losses:

(1) *The population growth rate.* The current population growth rate in the region is 2.1%, but might either rise or fall depending on the rate of out-migration which will be affected by unpredictable economic factors; the possibility of a rise to 2.5% or a fall to 1.75% will be considered.

(2) *The replacement rate of existing building stock.* Field studies have suggested that the average lifespan of traditional stone masonry buildings is about 50 years; the rate of replacement depends on prosperity, but could be influenced by government incentives for reconstruction. A maximum reduction to a lifespan of 25 years is considered.

(3) *The construction types of new buildings.* The methods of construction used for new housing will be the principal factor affecting vulnerability over the next 25 years, and the one most likely to be affected by government action. At present around 25% of new construction is of upgraded traditional construction, and about 1% is reinforced concrete construction. If economic progress is slow, traditional stone masonry may continue to predominate; alternatively if there is rapid progress or an active government programme to upgrade housing, it is possible that up to 90% of new construction could be strengthened within that period.

(4) *The contribution of the Government.* Three possible levels of government action will be considered. The first is the continuation of present policy of replacement of houses destroyed by earthquakes, but no action to upgrade the remainder. The second assumes that the government will introduce a programme of public education on strengthening techniques, coupled with training programmes for village builders of the kind which has proved successful in the Yemen.[1] The third level of action would couple the education and training programmes with a system of improvement grants sufficient to meet the cost of adding a minimum level of strengthening to any new houses built.

Five alternative scenarios will be presented each incorporating possible combinations of the four variables discussed. The five scenarios are outlined below; the detailed assumptions made are set out in table 6.1, and the projected average annual rates of loss are shown in figure 6.1.

---

[1] Coburn and Leslie (1985).

Scenario A. Present Trends, No Intervention
Turkish Government continues present policy of replacing destroyed buildings but does not introduce a Loss-Reduction Programme. Best-Guess present trends continue for 25 years.
Assumptions:
- Present population growth rate (2.1% annual) continues.
- Present house replacement rate (lifespan average 50 years) continues.
- Distribution of building types in the present building stock is as surveyed; 87% traditional stone masonry, 12% modernised traditional and 1% reinforced concrete frame.
- In new construction, current trends continue (75% traditional stone masonry, 24% modernised traditional and 1% reinforced concrete frame) with gradual increase in the proportion of higher cost buildings (by 2010 the proportions are 25% traditional, 65% modernised, 10% r.c. frame).

Expected Losses 1985-2010:

Total Destroyed Houses:	**88,513**	(100%. Reference Housing Loss)
Total Expected Fatalities:	**9,885**	(100%. Reference Fatality Level)

Scenario B. No Intervention, Optimistic Assumptions
Turkish Government continues present policy of replacing destroyed buildings but does not introduce a Loss-Reduction Programme. Income levels in Eastern Anatolia rise rapidly, combined with a significant drop in population growth rate.
Assumptions:
- Population growth rate drops to 1.75% annually, from 1980 onwards.
- House replacement rate increases. Average lifespan of traditional stone masonry reduces to 25 years.
- The proportion of higher cost building types in new construction rises rapidly. By 2010, all new construction consists of 75% modernised traditional and 25% reinforced concrete frame.

Expected Losses 1985-2010:

Total Destroyed Houses:	**73,556**	(83% of Housing Loss, Scenario A)
Total Expected Fatalities:	**8,126**	(82% of Fatality Level, Scenario A)

Scenario C. No Intervention, Pessimistic Assumptions
Turkish Government continues present policy of replacing destroyed buildings but does not introduce a Loss-Reduction Programme. Population growth rate increases and income levels rise only fast enough to keep pace with population growth.
Assumptions:
- Population growth rate increases to 2.5% annually, from 1980 onwards.
- House replacement rate decreases. Average lifespan of traditional stone masonry prolonged to 75 years.
- The proportion of higher cost building types in new construction remains constant at present rate.

Expected Losses 1985-2010:

Total Destroyed Houses:	**100,956**	(114% of Housing Loss, Scenario A)
Total Expected Fatalities:	**11,310**	(114% of Fatality Level, Scenario A)

Scenario D. Mitigation Programme: Education and Training
The Turkish Government introduces a public information campaign coupled with the establishment of training centres in each affected province for village builders. House owners are encouraged to incorporate the maximum earthquake resistance that they can afford, into new construction. All other variables continue along present best-guess trends.
Assumptions:
- Present population growth rate (2.1% annual) continues.
- Present house replacement rate (lifespan average 50 years) continues.
- Around 10% of house owners incorporate triple hatıl strengthening in their new construction. 24% build in modernised traditional and 1% in reinforced concrete construction. Gradual

increase in the proportion of higher cost buildings (by 2010 the proportions are 5% unreinforced traditional stone masonry, 25% stone masonry with triple hatıl reinforcement, 60% modernised traditional and 10% reinforced concrete).

Expected Losses 1985-2010:

Total Destroyed Houses:	**72,217**	(82% of Housing Loss, Scenario A)
Total Expected Fatalities:	**7,898**	(80% of Fatality Level, Scenario A)

Scenario E. Mitigation Programme: Subsidised House Strengthening

The Turkish Government introduces a public information campaign coupled with the establishment of training centres for village builders, and an administration to distribute and monitor house strengthening subsidies. Strengthening subsidies are available to anybody building a house in a village in a designated seismic area, conditional upon them employing a trained village builder and incorporating a minimum level of seismic strengthening (e.g. triple hatıls). A maximum grant of 150,000 TL (1983) is available per house. All other variables continue along present best-guess trends.

Assumptions:

- Present population growth rate (2.1% annual) continues.
- Grant system encourages more rapid house replacement rate. Lifespan averages 25 years.
- 90% of house owners who would have built in traditional stone masonry now build with triple hatıl strengthening. The proportions of building types in new construction is 7% unstrengthened traditional stone masonry, 68% stone masonry with triple hatıl reinforcement, 24% modernised traditional and 1% reinforced concrete. by 2010, the proportions are 25% stone masonry with triple hatıl reinforcement, 65% modernised traditional and 10% reinforced concrete.

Expected Losses 1985-2010:

Total Destroyed Houses:	**56,169**	(63% of Housing Loss, Scenario A)
Total Expected Fatalities:	**5,924**	(59% of Fatality Level, Scenario A)

Table 6.1

Scenarios of future earthquake losses in Eastern Anatolia

Figure 6.1 shows the actual losses over the last 80 years, and the projections derived from the model for the 25 years 1985 to 2010 for each of the 5 scenarios. Population growth rates are also shown. It will be seen that based on present trends a rise of 50% in annual average losses by 2010 can be expected; even with optimistic assumptions (scenario B) a rise of nearly 25% is likely. The introduction of a training programme (scenario D) could be expected, with present trends, to peg the increase to only about 25%, similar to scenario B, while only the introduction of a programme of subsidised strengthening (scenario E) can be expected to result in an actual reduction in annual average losses over the period.

Some estimates of comparative costs and benefits can be made. Under present trends, the Government must be prepared to replace between 70,000 and 100,000 houses in the study area over the next 25 years, at a cost in 1983 money[2] of 250 to 350 billion TL. The cost of setting up a training programme has not been estimated, but it will be economically justified if it costs less than the cost of replacing the 15,000 to 20,000 houses which it will save in the period; though this takes no account of the lives saved and other losses avoided. The cost of the programme of housing subsidy has been calculated on the assumption that the cost of this would be 150,000 TL for each house strengthened, about 50% of the typical cost of replacing a stone masonry house. It is also assumed that the 10,000 houses currently rebuilt each year could be increased by 20 to 50%, all of them strengthened to at least the level of technology L4. The resulting reduction in housing losses in the 25 year period would be about 32,000. The estimated cost of the programme would be about 50 billion TL in grants, for a saving in reconstruction costs exceeding 100 billion TL., and the saving of over 3,000 lives.

---

[2] Costings throughout this report have been presented in terms of 1983 prices, related to the 1983 earthquake and other field work costings carried out in 1983.

The uncertainty of these projections is of course high, with an estimated probability of about 50% that the actual outcome will be within +/-50% of the expected value. There is certainly a possibility that loss levels will not be as high as the projected values; but an alternative possibility which has to be considered is the occurrence of an above average level of seismicity in the next 25 years, causing very much higher levels of losses than has been calculated here. This is considered in terms of a worst-case scenario.

6.2 Worst-Case Scenario

The loss projections, being largely based on average values for hazard return periods take very little account of the possibility of variations in earthquake activity over the next 25 years. It is easy to envisage a scenario, where, within the next 25 years, a large number of high magnitude earthquakes were to occur in quick succession. It is extremely unlikely that above-average seismicity would occur in all magnitude ranges at the same time - magnitude occurrences are generally thought to be independent of each other.

The occurrence of a single, very large magnitude earthquake, M>7.5, is the worst case scenario that can be envisaged within realistic probability limits. The recurrence of an event like the Erzincan earthquake of 1939 is a very real possibility. The probability of its occurrence is somewhere between 1 in 20 (5% estimated probability of exceeding 1 event in 25 years) and 1 in 5 (130 year return period, Gumbel analysis,÷25 year study period). The probability of occurrence of a major earthquake in the next 25 years may be increased by the fact that there has not been an earthquake on the North Anatolian Fault in Eastern Turkey for the past 47 years.

If it did occur, the expected housing losses within the 25 year timespan would be increased by almost half as much again. The major tragedy however would be the extensive loss of life that would result. Such a large magnitude event would produce a very large epicentral area and very high intensities, which it has been shown are the major causes of fatalities. This would happen over an area which is already twice as densely populated as it was during the 1939 event, and likely to be four times as densely populated by the end of 25 years. The loss of 32,000 lives in 1939 could be far exceeded by a major future event unless housing in the region undergoes a radical transformation in the near future.

The chances of such an event mean that any mitigation programme that had got well established before its occurrence would achieve savings of human lives and reconstruction costs well in excess of the average figures calculated in this study.

6.3 Wider Application

The detailed loss projections, the cost-benefit studies and the appropriateness of the mitigation measures proposed are all specific to the application of loss reduction planning to villages in Eastern Anatolia. There are however a number of aspects of this study which may have a wider application. The technical studies of the improvement of the seismic resistance of rubble masonry buildings are relevant to a much wider geographical area. Houses of weak loadbearing stone masonry of similar forms are found in the seismic areas of Iran, Iraq, and throughout the Middle East. They are found in Central Asia, in the southern seismic zones of USSR, in Afghanistan, Northern Pakistan and India. Rubble masonry buildings in some form or other are found along the entire Alpine-Himalayan seismic belt, from Italy to Indonesia. Some aspects of the study of earthquake damage and preventative strengthening may also be relevant to similar rural buildings of earthen materials which are found in many seismic areas around the world including South America and East Asia.

The method of analysing damage data from earthquakes to obtain objective vulnerability relationships in terms of Magnitude : Damage : Distance is one that could have far wider application than Eastern Turkey. The Magnitude : Damage : Distance relationships obtained here are probably broadly applicable to shallow-depth earthquakes of the Mediterranean and Middle East seismotectonic regions, but there already exists a wealth of damage data in this and other regions that could undergo further analysis to derive similar relationships for many other building types. It has been demonstrated that these types of relationships have considerably better confidence limits

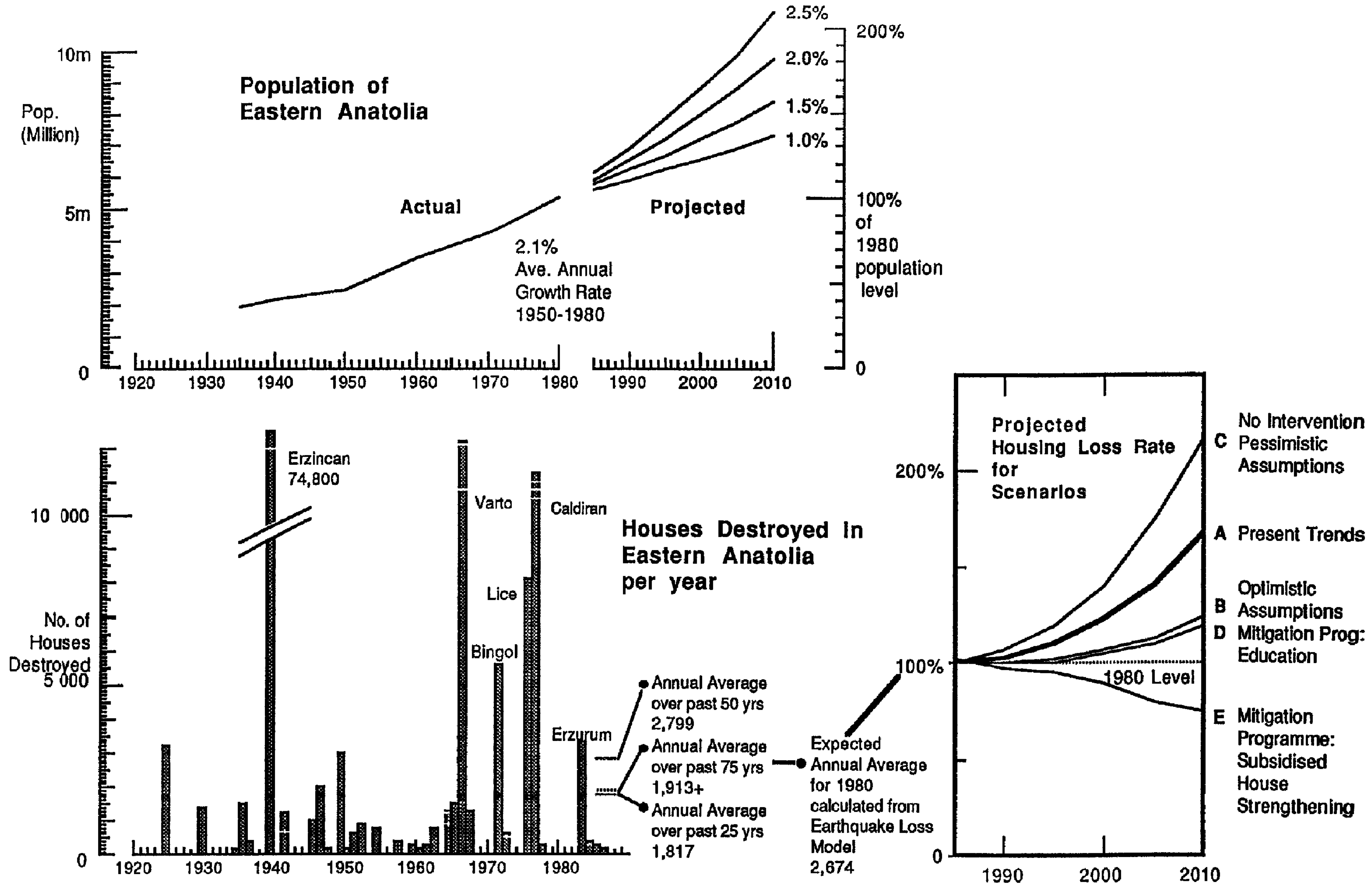

Figure 6.1 Earthquake Loss Projections for Eastern Anatolia

than studies using intensity as their parameter of ground motion.

6.4 Further Research Needed

In developing methods to evaluate alternative seismic risk mitigation strategies, this study has made a number of assumptions based on existing limited data. Considerably more data and analysis is needed in several areas in order to reduce the uncertainties involved and provide a sounder basis for planning future mitigation programmes, both in Turkey and in other high-risk regions. The following are some of the more important areas needing further study:

(1) *Earthquake Damage Data.* The damage data available from Turkey for earthquakes since 1966 is much better than for most comparable areas. However for the future it will be important to improve the quality of this data by distinguishing levels and modes of damage to the different classes of buildings more precisely defined in terms of both the location and the construction technology employed. A practical method of conducting field surveys in areas of earthen and stone masonry buildings has been developed.[3]

(2) *Measurement of earthquake ground motion.* The statistical damage attenuation model used here is not directly correlated with the actual cause of damage, which is earthquake ground motion. The lack of strong motion instruments in the high risk regions makes it impossible to use parameters of ground motion as a means of predicting earthquake damage or interpreting test results. The behaviour of stone masonry buildings in the epicentral area of earthquakes is at present very little understood, because the ground motion causing it has never been recorded. The establishment of further instrumentation in the field in the high risk areas is of considerable importance.

(3) *Testing programmes.* During the present study only three full-scale dynamic tests were carried out, but the benefits from these tests were considerable, both in terms of the actual data acquired, and in terms of the demonstration and educational effects involved. The impulse table designed and built for these tests can now be used to acquire further data on the performance of other types of construction, and different types of ground motion. Details of further testing work needed are given in the report on the impulse table tests.[4]

(4) *Cost-benefit studies.* In the present study only a very crude cost-benefit study of alternative mitigation policies has been presented, without any attempt to examine the programme costs or to apply a social discount rate to future costs, or deal with alternative scenarios arising from the sporadic nature of earthquake occurrence. A more detailed study would be needed before the benefits of alternative programmes could be properly assessed.

6.5 Recommendations

Mitigation Programmes

The most effective way to reduce the losses from future earthquakes in Eastern Anatolia will be to encourage and assist village builders to improve the earthquake resistance of future houses built in the materials that they can afford and are familiar wit. For very many villagers this will be stone masonry. Other measures considered are either too costly, ineffective, or socially unacceptable (section 1.4). Current rates of change of construction technology in the region are insufficient to reduce future earthquake losses.

Improving Earthquake Resistance of Stone Masonry

A variety of measures to improve the earthquake resistance of traditional stone masonry can be introduced at no cash cost to the houseowner(section 3.2). These should be given priority in any mitigation programmes.

At the next level of cost, priority should be given to the strengthening of wall construction using horizontal ties either of concrete or of timber at cill, eaves and lintol levels. A range of possible

[3] Coburn (1985).

[4] Spence, Bayülke, Coburn and Hibbs (1987).

improvement techniques at different levels of cost has been proposed (section 3.3). All proposed modifications should be carefully assessed to study their appropriateness for implementation by the village builders in each location.

Implementation

The Turkish Government should take action to stimulate improvements in the building technology used for rural housing in Eastern Anatolia. The objective should be to assist the local people to improve the seismic resistance of their houses by incorporating structural strengthening at the time of rebuilding, at whatever level of technology is appropriate to their economic circumstances.

There should be three separate elements to such Government action:

(1) A public education programme to explain the seismic risk, demonstrate the consequences of living in unstrengthened houses, and describe the techniques of building needed to strengthen them.

(2) A substantial builder training programme, which should teach village builders through practical demonstration how to incorporate the necessary strengthening modifications, and in other ways improve the earthquake resistance of houses of traditional construction. The aim should be to establish one or two training centres in each province, and train eventually one builder for each 100 inhabitants.

(3) A programme of housing subsidies to be used to incorporate strengthening modifications into new construction. A variety of uses for this subsidy would be permitted depending on the scale and technology to be used, and there would need to be a strict monitoring of the use of the subsidy, and supervision of the quality of the modifications used.

In order to design an effective programme, a pilot scheme should first be implemented in a particular high-risk area on a scale of a single district. In this pilot scheme, the findings of the Oxford Polytechnic study on socio-cultural aspects of improving aseismic housing should be followed. The pilot scheme should be monitored to assess the economic and cultural effects of the housing upgrading, and the findings used in the design of a larger programme.

Research

The Turkish Government should also seek international funds to continue, and expand its research into earthquake monitoring, with particular emphasis on the monitoring of strong ground motion (which will involve a much expanded network, and the design of new simpler and cheaper instruments) and on the collection of earthquake damage data. Research and testing of modified traditional construction should be continued using the Ankara impulse table and other testing facilities.

International Efforts

The governments of other countries with a similar combination of high seismic risk and vulnerable building types should undertake studies of future losses and possible mitigation programmes along similar lines to the present study; these countries include parts of India and Pakistan, Afghanistan, Iran and parts of South America.

The UK Government should continue to support the efforts of such countries to reduce earthquake risk, not only out of concern for the huge losses of life which are involved, but also as an alternative to the continuation and increase of international relief and rescue activity.

References

R.1 Publications Arising from this Project

J.Y.F. CHOU, M.J. COWDRILL, 1984, *Testing of Brittle Masonry Structures under Earthquake-Type Loading*, Dissertation for Part II, Engineering Tripos, University of Cambridge.

A.W. COBURN, 1982, 'Models of vulnerability', *9th Regional Conference on Earthquake Engineering*, Istanbul.

A.W. COBURN (ed.), 1982, *Bingöl Province Field Study, 2-24 August 1982: Preliminary Report*, Turkish National Committee for Earthquake Engineering and The Martin Centre for Architectural and Urban Studies, Cambridge University.

A.W. COBURN, 1984, 'Strengthening rural buildings to reduce future earthquake damage', *First Symposium on Major Earthquakes in North Eastern Anatolia*, Erzurum.

A.W. COBURN, 1984, 'Data on structural vulnerability derived from post-earthquake surveys', Discussion Document for European Association on Earthquake Engineering Working Group 10, *Vulnerability and Seismic Risk Analysis.*

A.W. COBURN, 1985, 'Proposal for international standardisation of recording earthquake damage to earthen buildings', *International Newsletter on Earthen Buildings in Seismic Areas*, INTERTECT, Dallas, U.S.A.

A.W. COBURN, 1986, 'Analysis of earthquake damage and proposals for strengthening stone masonry buildings in Eastern Anatolia', *Middle East and Mediterranean Regional Conference on Earthen and Low-Strength Masonry Buildings in Seismic Areas*, Ankara.

A.W. COBURN, 1986, 'Relative vulnerability assessment', *8th European Conference on Earthquake Engineering*, Lisbon.

A.W. COBURN, 1987, *Seismic Vulnerability and Risk Reduction Strategies for Housing in Eastern Turkey*, Ph.D. Thesis, Department of Architecture, University of Cambridge.

A.W. COBURN. N. AKKAŞ, 1983, 'A statistical study of earthquake damage: The Köşker earthquake of April 1983', *United Nations Seminar on Vulnerability Analysis, (Committee on Earthquake Vulnerability in the Balkan Regions)*, Bucharest.

A.W. COBURN, J. KUBIN, R.J.S. SPENCE, 1984, 'Vulnerability and seismic risk reduction for rural housing in Turkey', *8WCEE*, San Francisco, USA.

A.W. COBURN, J.D.L. LESLIE, A. TABBAN, 1984, 'Reconstruction and resettlement 11 years later: A case study of Bingöl Province, Eastern Turkey', *International Symposium on Earthquake Relief in Less-Industrialised Areas*, Zurich.

A.W. COBURN, R.E. HUGHES, 1983, *Dhamar Province Earthquake 13 December 1982, Yemen Arab Republic*, Preliminary Report to the Central Planning Office, Joint Relief Committee.

A.W. COBURN, R.E. HUGHES, 1984, *Report on Damage to Rural Building Types in the Erzurum-Kars Earthquake 30 October 1983*, Joint Project on Vulnerability of Low-Income Housing in Earthquake Areas of Turkey, Turkish National Committee for Earthquake Engineering and The Martin Centre for Architectural and Urban Studies, Cambridge University.

A.W. COBURN, R.J.S. SPENCE, 1984, 'Seismic risk reduction for Eastern Turkey: The strengthening of stone masonry buildings', *International Conference on Natural Hazards Mitigation Research and Practice*, New Delhi, India.

R.J.S. SPENCE, 1986, 'Earthquake Risk Assessment; A review of methods with particular reference to rural housing in Eastern Turkey', Keynote Paper, *Middle East and Mediterranean*

Regional Conference on Earthen and Low-Strength Masonry Buildings in Seismic Areas, Ankara.

R.J.S. SPENCE, N. BAYÜLKE, A.W. COBURN, M.O. ERDİK, 1986, 'Earthquake loss reduction in Eastern Turkey: The design of a low-cost shaking table', *Eighth European Conference on Earthquake Engineering* , Lisbon, Portugal.

R.J.S. SPENCE, N. BAYÜLKE, A.W. COBURN, A.D. HIBBS, 1987, *Impulse Table Tests on Full Scale Stone Masonry Houses* , Joint Report, Earthquake Research Department, Ministry of Housing and Public Works, Republic of Turkey and The Martin Centre for Architectural and Urban Studies, University of Cambridge.

R.J.S. SPENCE, A.W. COBURN, 1982, *Vulnerability of Low-Income Housing in Earthquake Areas: Progress Report*, ODA Project R3662: The Martin Centre for Architectural and Urban Studies, University of Cambridge.

R.2 Other References

S. AKBAR, 1987, Thesis in preparation for Ph.D. degree, Department of Architecture, University of Cambridge.

N.N. AMBRASEYS, 1971, 'Value of historical records of earthquakes', *Nature* ,**232**, 375-379.

N.N. AMBRASEYS, J.A. JACKSON, 1981, 'Earthquake hazard and vulnerability in the northeastern Mediterranean: The Corinth earthquake sequence of February-March 1981', *Disasters*, **5.4**, 355-368.

E. ARIOĞLU, K. ANADOL, 1978, 'Response of rural dwellings to recent destructive earthquakes in Turkey (1967-1977) and design criteria of earthquake-resistant rural dwellings', *Housing Science*, **2.3**, 237-258.

A.S. ARYA (chairman) at al., 1980, *Guidelines for Earthquake Resistant Non-Engineered Construction*, International Association for Earthquake Engineering.

Y.F. AYSAN, P. OLIVER, 1987, *Culture and Housing After Earthquakes*, Oxford Polytechnic.

P.W. BURTON, R. McGONIGLE, K.C. MAKROPOULOS, S.B. ÜÇER, 1984, 'Seismic risk in Turkey, the Aegean and the eastern Mediterranean: the occurrence of large magnitude earthquakes', *Geophys. J.R. astr. Soc.*, **78:2**, 475-506.

A.W. COBURN, J.D.L. LESLIE, 1985, *Dhamar Building Education Project: Project Assessment*, Report to Executive Office of the Supreme Council for Reconstruction of Earthquake Affected Areas, Yemen Arab Republic.

A.W. COBURN, R.E. HUGHES, D. ILLI, D.F.T. NASH, R.J.S. SPENCE, 1982, 'The construction and vulnerability to earthquakes of some building types in the Northern areas of Pakistan', *Proceedings of the International Karakoram Project Conference*, Vol. 2., Royal Geographical Society, London.

A.W. COBURN, R.E. HUGHES, D.F.T. NASH, R.J.S. SPENCE, 1982, 'Damage assessment and ground motion in the Italian earthquake of 23.11.1980', *7th European Conference on Earthquake Engineering*, Athens.

F.C. CUNY, 1983, *Disasters and Development*, Oxford University Press.

A.F. DALDY, 1972, *Small Buildings in Earthquake Areas*, Building Research Establishment, Department of the Environment, United Kingdom.

EARTHQUAKE RESEARCH INSTITUTE, 1973, *Public Education Project on the Subject of Earthquake and Earthquake Resistant Construction*, Ministry for Reconstruction and Resettlement, Republic of Turkey.

EARTHQUAKE RESEARCH INSTITUTE, 1975, *Specifications for Structures to be Built in Disaster Areas*, Ministry of Reconstruction and Resettlement, Republic of Turkey.

M. ERDİK, V. DOYURAN, P. GÜLKAN, N. AKKAŞ, 1983, *A Probabilistic Assessment of the Seismic Hazard in Turkey*, Report No. 83-1, Earthquake Engineering Research Center, Middle East Technical University, Ankara.

M. ERDİK, K. EREN, 1983, *Attenuation of Intensities for Earthquakes Associated with the North Anatolian Fault*, Earthquake Engineering Research Center, Middle East Technical University, Ankara.

K. ERGİN, U. GÜÇLÜ, Z. UZ, 1967, *Turkey ve Cıvarının Deprem Kataloğu (A Catalogue of Earthquakes for Turkey and Surrounding Areas, 11 A.D. to 1964 A.D.)*, Faculty of Mining Engineering, Istanbul Technical University.

O. ERGÜNAY, 1973, *An Earthquake Zoning Map for Turkey*, Earthquake Research Institute, Ministry of Reconstruction and Resettlement, Ankara.

O. ERGÜNAY, E. İNAN, N. BAYÜLKE, U. KOŞAN, 1985, *Strong Motion Accelerograph Records of Turkey*, Earthquake Research Department, Ministry of Public Works and Housing, Ankara.

O. ERGÜNAY, M. ERDİK, 1984, 'Turkish experience on the earthquake performance of rural stone masonry buildings', *International Conference on Natural Hazards Mitigation Research and Practice, Small Buildings and Community Development*, New Delhi.

P. GÜLKAN, O. ERGÜNAY, 1984, 'Mitigation of earthquake-induced losses in Turkey: The legislative aspect', *International Symposium on Earthquake Relief in Less-Industrialised Areas*, Zurich.

A. GÜRPINAR, M. ERDİK, O. ERGÜNAY, 1981, 'Siting and structural aspects of adobe buildings in seismic areas', *International Workshop on Earthen Buildings in Seismic Areas*, Albuquerque, New Mexico.

J. JACKSON, D. McKENZIE, 1984, 'Active tectonics of the Alpine-Himalayan belt between western Turkey and Pakistan', *Geophys.J.R.astr.Soc.*, 77, 185-264.

K.L. KAILA, N. MADHAVA RAO, 1975, 'Seismotectonic maps of the European area', *Bul.Seis.Soc.Am.*, **65:6**, 1721-1732.

J.D.L. LESLIE, 1984, "Think before you build': An earthquake reconstruction project in Yemen', *International Symposium on Earthquake Relief in Less-Industrialised Areas*, Zurich.

S.V. MEDVEDEV, 1968, 'The international scale of seismic intensity', *Seismic Zones of the USSR*, Nauka, Moscow.

Y. OHTA (ed.), 1980, *Engineering Seismological Studies on the 24 November 1976 Çaldiran Earthquake in Turkey*, Dept. of Architectural Engineering, Hokkaido University, Sapporo, Japan.

R. REZANI, 1978, 'Seismic protection of unreinforced masonry and adobe low-cost housing in less developed countries - policy issues and criteria', *Conference on Disasters and Small Dwellings*, Oxford.

C. SCAWTHORN, 1986, 'Strengthening of Low-Strength Masonry Buildings: Shaking Table Tests', *Middle East and Mediterranean Regional Conference on Earthen and Low-Strength Masonry Buildings in Seismic Areas*, Ankara.

STATE INSTITUTE OF STATISTICS, 1980, *Census of Population by Administrative Division*, Prime Ministry, Ankara.

M.N. TOKSÖZ, A.F. SHAKAL, A.J. MICHAEL, 1978, 'Space-time migration of earthquakes along the North Anatolian Fault Zone and seismic gaps', *Procs. Conference VI; Methodology for Identifying Seismic Gaps and Soon-to-Break Gaps*, National Hazards Reduction Program, U.S. Dept. of the Interior. UNESCO, 1976, *Country Monograph of Turkey*, Intergovernmental Conference on Assessment and Mitigation of Earthquake Risk, Paris.

UNITED NATIONS , 1975, *Low-Cost Construction Resistant to Earthquakes and Hurricanes*, Department of Economic and Social Affairs, U.N. ST/ESA/23, sales no. E.75.IV.7.