SEISMIC HAZARD ASSESSMENT - PRACTICAL CONSIDERATIONS

Richard D SHARPE[1] And Robert D JURY[2]

SUMMARY

Most national seismic design codes are developed over a considerable period of time by interested parties within the country. There are special challenges when this development is contracted out to a commercial enterprise for completion within tight restraints for time and budget. When the country has no existing building code and requires the seismic hazard to be assessed from first principles, the challenges are even greater. The authors have had the privilege to be associated with three such projects (Indonesia, Papua New Guinea and Nepal). In this paper, the particular circumstances encountered in developing a draft seismic code for the Himalayan kingdom of Nepal are described. These include the pragmatic considerations necessary to ensure that the wide range of needs of this developing country were considered, and that the recommended design levels were not inconsistent with those economically achievable. Special care was taken to acknowledge the influence of building practices in adjoining countries. The methodology used to cope with the fact that Nepal sits astride a very localised band of seismicity is described. It is believed that these approaches will have relevance for other countries considering introducing seismic design codes.

INTRODUCTION

There are special challenges when undertaking the development of seismic design codes for nations as a commercial project. The authors have now had the privilege to be associated with three such projects (Indonesia, Papua New Guinea and Nepal). Countries which have had national seismic design codes in place for some time have often developed them over a number of years. A typical process might involve a state regulatory authority and in-country experts from a number of both state and private organisations. Committees may be set up to examine different aspects of the seismicity predictions and work through the issues of zoning and appropriate levels of seismic load with respect to what is practically achievable and politically acceptable.

The authors were faced with leading the production of a draft seismic code for the highly seismic country of Nepal in less than a year as part of a commission to draft a national building code. Nepal had not previously had a seismic design code of its own. While there were many small centres of expertise in the government and private sectors in both the earth sciences and structural design, the bringing of all these together as is necessary for the development of a national code had not been successful. However, the initiative and drive to develop such a code came from within His Majesty's Government of Nepal's Ministry of Housing and Physical Planning. Assistance was sought from the United Nations Development Programme through the United Nations Centre for Housing Settlements. The immediate impetus for this came after an earthquake in 1988 which killed some 880 people and destroyed or severely damaged a large number of buildings. In contrast, perhaps, to the target of some code developers, the need to address the seismic resistance of domestic structures was emphasised. However, the fact that much of the principal urban centre and capital of Kathmandu was destroyed in a 1934 earthquake was also in everyone's mind. The project was internationally tendered and had strict requirements for the majority of the time input to come from Nepal-based subconsultants.

The particular challenges facing the international and national private-sector team and its government counterparts were not just the short time given to complete the task. They were a combination of the geological setting of the country and the cultural preparedness for such a product. These two aspects will be separately

[1] *Director of Earthquake Engineering, Beca International Consultants Ltd, New Zealand*
[2] *Principal, Beca International Consultants Ltd, New Zealand*

dealt with below. However, the most satisfying aspect of the project from the team's point of view was the co-operation achieved between the contributing government and private sectors within Nepal. Without the leadership and determination shown by individuals mainly from the design professions in Kathmandu (all of whom had no previous experience in codifying design practices), the development of a code tailored to the country's needs would not have been possible in such a short time.

GEOLOGICAL AND TOPOLOGY CHALLENGES

Nepal sits astride a highly seismic region. The Himalayas (Himal Kush) are the result of the Austral-Indian tectonic plate sliding beneath the Chinese plate to the north. The angle of subduction is very low (Figure 1). This means that there are difficulties in ascribing seismic events emanating from the subduction zone to a particular lineal feature. Earthquake epicentres associated with this zone therefore are scattered over a wide area when viewed from above. The assessment of the potential of identified faults is correspondingly difficult. If the seismicity model is a combination of areal source models derived from historical seismicity data and identified fault potential, the possibility of double-counting has to be guarded against.

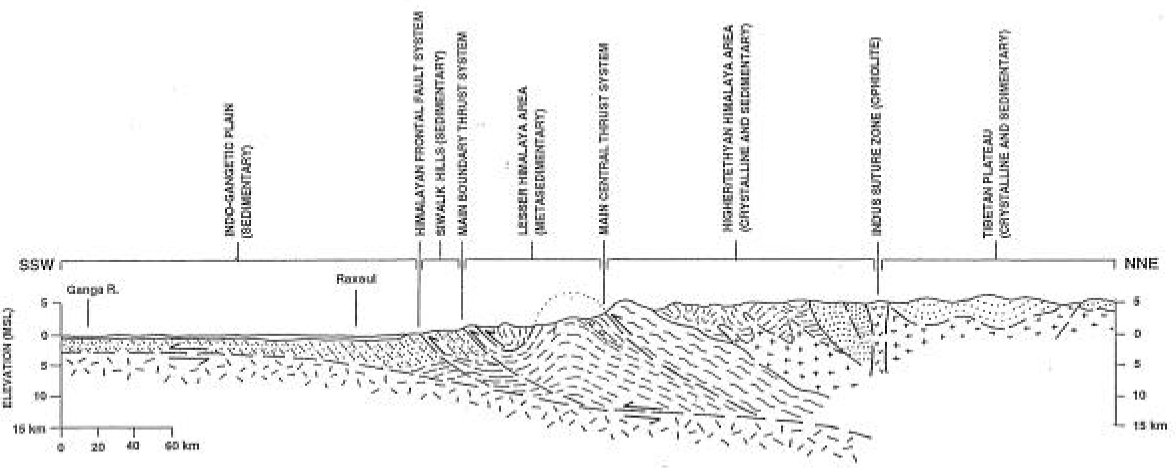

Figure 1 : Schematic Tectonic Cross-Section (S-N) Through Central Nepal

The concentrated nature of the collision zone between the tectonic plates means that the seismicity model constructed for hazard analysis has high gradients. The extent of these steep gradients coincides precisely with the width of Nepal (in a north-south direction) (Figure 2). Anyone familiar with the seismic hazard analyses will know that the calculation of hazard in the vicinity of steep gradients in source models is sensitive to the accuracy of the model.

Nepal is a land of extreme contrasts in land forms. It extends from the Gangetic plains a few metres above sea-level, through a series of foothills to a range of mountains that include the highest in the world - all within 80 km or so. This extreme range of the topology in a north-south direction means that there are a large number of building styles to be addressed as the soil conditions, building materials and environmental considerations vary enormously. Some 50 different styles were identified and documented in a survey during the drafting of the Building Code.

Standard seismic hazard analysis methodologies rely on the gridding of the seismicity model into regular and discrete area sources which are ascribed parameters assumed to be constant over the gridded element. The steepness of the seismicity gradients in Nepal meant that special care had to be taken to make sure that the size of the element chosen did not overly influence the calculation of the hazard within the national boundaries. Figure 3 shows how the grid shape and size can influence the contours of hazard. Rather than discretise the seismicity model down to a size that was incompatible with the accuracy of the base data, the hazard analysis results were adjusted to eliminate the influence of the grid size.

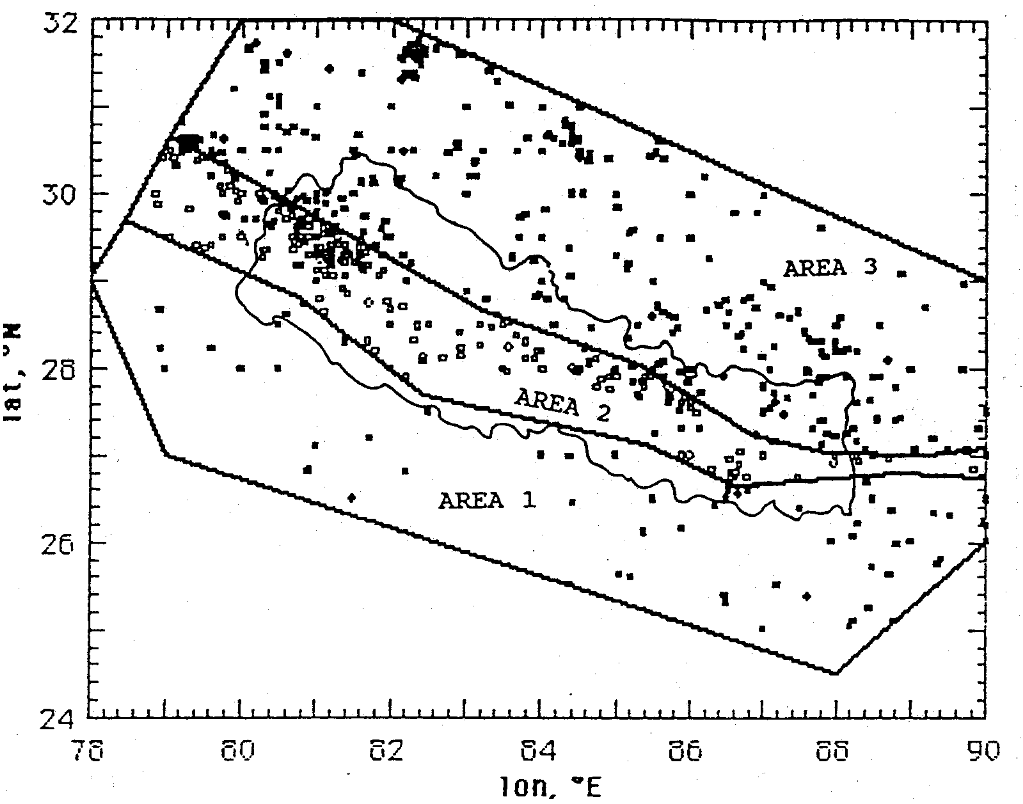

Figure 2 : Areas Defined for Seismic Assessment of Nepal

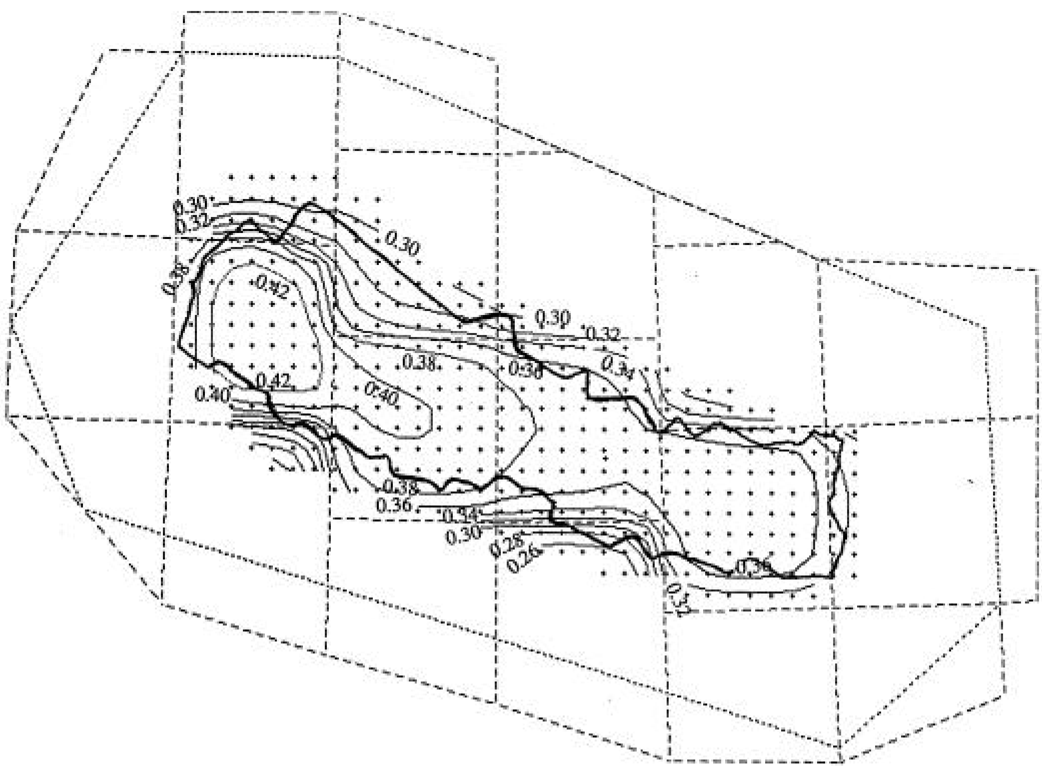

Figure 3 : Typical Influence of Seismicity Model on Hazard Contours for Nepal
(500 Year Return Period Contours of peak ground acceleration on medium soil)

CHALLENGES OF CONTRACTUAL REQUIREMENTS

Requirement for a zoning scheme

Perhaps reflecting the world-wide emphasis on seismic zonation (and, of course, micro-zonation) for regulatory purposes, there was a requirement for zonation to be one of the outcomes.

There are positive and not so positive aspects to this requirement which had to be taken into account in the final recommendations. The positive ones are :

A zoning scheme recognises that different areas have different levels of hazard, and these should be acknowledged in national planning. At the micro or village level, it teaches that certain areas are less desirable than others to develop, because of their potential for secondary effects of rock-fall, liquefaction and slumping. Importantly, it allows a logical and acceptable transition from the surrounding country’s zonation to the maximum levels appropriate for Nepal

To the team recommending the zonation scheme, it brings concerns over the underlying accuracy of the seismicity model on which it is based. These are exasperated by the highly-banded nature of the potential seismic sources and the narrowness of the country over these.

A satisfactory solution to these concerns was a simple zoning scheme which places a plateau at the maximum zone factor over the major part of the country, and a variable gradient surrounding that (defined by contours) down to comparable values in adjoining countries. Compatibility with India to the south was considered to be the most important of these. Figure 4 shows the zoning scheme chosen.

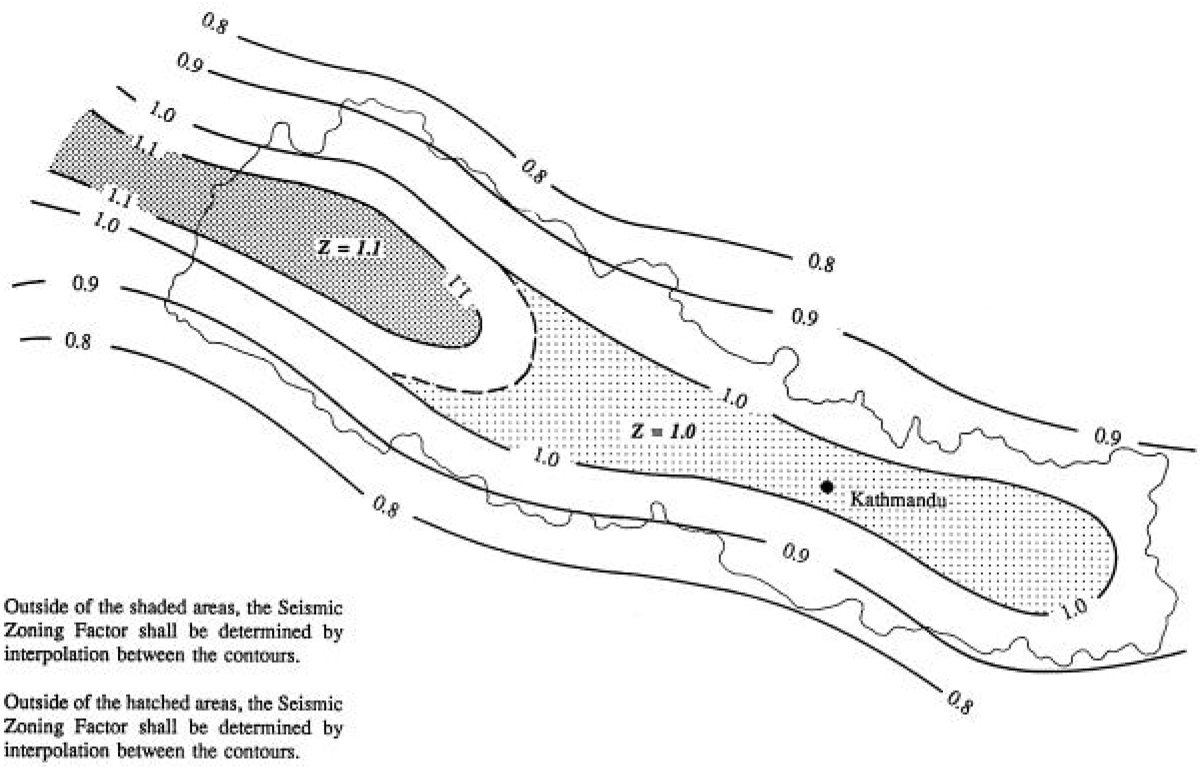

Figure 4 : Recommended Seismic Zoning for Nepal

Desk Exercise

The budget and time constraints of the project meant that the assembly of the seismicity model needed to be developed from existing information. This was quite appropriate, considering the pioneering nature of the final outcome - a draft national building code. As described below, this posed a challenge in researching the quite considerable previous studies carried out in this area.

CULTURAL CHALLENGES

Information Sources

At the time of the project, Nepal did not have any coordinated system for collecting and retaining technical information necessary for such a project. There have been many geological and seismicity studies carried out - particularly for investigations of hydro-electricity potential. Perhaps in common with other countries, there exist many personal collections of such reports. Learning of their existence and tracking them done was time-consuming. In particular the staff of the Ministry of Mines and Geology, and members of the very professional Nepal Geological Society, were invaluable in their assistance to locate this information. The project's national team were able to use their networking to good effect. Probably the most extensive bibliography to date covering this information was assembled and published as a project deliverable.

For a variety of reasons, some basic data such as a sufficiently accurate digital version of a map of the country was not available, and was created by the project. Forunately, aerial photography at a scale suitable for fault mapping was available through government agencies.

Influence of Neighbouring Country Practices

Nepal, although some 1000 km from east to west, extends approximately 80 km from north to south. The nature of construction within Nepal is therefore strongly influenced by its large neighbours – particularly India to the south. For practical purposes, seismic design levels need to recognise this influence. In particular, care was taken to see that design levels arising from the zoning scheme within Nepal were similar to those of India in the border area.

SUBSEQUENT BUILDING CODE

The seismic hazard mapping and risk assessment phase of this project was followed by the drafting of a National Building Code for Nepal.

The development of a building code for a country such as Nepal poses some special challenges. These include :

Coverage of All Levels of Construction

The need to have a code which could be used by foreign donors, government agencies, urban developers and rural communities was recognised. By underpinning the code development with seismic hazard mapping and assessment, it was possible to address all levels of sophistication of design in a consistent way.

Use of Other Country Codes

While there was some desire expressed by design professionals for Nepal to have a code written from scratch, it was recognised that the cost and time to do this would have made the project not viable. The material codes were created by writing modifying documents to be read in conjunction with the corresponding codes of India. In the short-term, this means that Nepal will be in a position to adopt revisions carried out by its neighbour if these are suitable. Scarce resources can then be better focussed on the sections addressing specific requirements of Nepal.

Material Standards

Successful seismic design requires that the quality of material and workmanship be controlled. The quality of the basic materials of cement and reinforcing steel on sale in the market place has been variable. The Nepal Bureau of Standards and Metrology has standards covering these materials. Regulations were passed during the code development project that required all cement available in the market in Nepal to meet the relevant material code. A long process lies financially attractive non-ductile, high-strength, reinforcing steel.

CONCLUSION

The special challenges of producing a seismic hazard assessment on a commercial basis for a developing country require pragmatic decisions to be taken with respect to the results from theoretical seismic hazard analyses. When the subject region has such steep gradients of seismicity as in Nepal, it is necessary to make especially sure that the underlying requirements of the country are met with respect to compatibility with surrounding jurisdictions, and a practical seismic zoning scheme. It is believed that these conditions have been met for Nepal.

ACKNOWLEDGEMENTS

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