

Study group on earthquake risk buildings: progress report 2001/2002



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ABSTRACT: This report summarises the recent and current activities of the Society's Earthquake Risk Buildings Study Group. Work over the past year has focused on the development of the detailed guidelines for assessment and improvement of structural performance of all existing buildings. This has included development of material covering legislative and regulatory issues, approaches for performance assessment, modeling the earthquake, displacement based procedures, reinforced concrete structures, steel structures, and unreinforced masonry buildings. Three test case studies have been done and further work on the benefit/cost. A draft document for comment by selected commentators is expected to be issued mid-2002. Progress with introduction of proposed legislation awaits a review of the Building Act by the Department of Internal Affairs, but the Guidelines are intended to be of value to engineers under the current legislation.

1 INTRODUCTION

1.1 *Background*

The proposed changes to the Building Act have not progressed since last year. Nevertheless, the Study Group has been actively developing technical documentation that will be required by consultants and territorial authority officials. Significant progress has now been made on the considerable task of producing Detailed Procedures for the assessment and improvement of structural performance of earthquake risk buildings. The Study Group has been tasked by BIA with preparing a document which essentially draws together, updates and extends the Society's publications *Guidelines for Assessing and Strengthening Earthquake Risk Buildings (the revised 'Red Book')* (NZSEE, 1995), and *The Assessment and Improvement of the Structural Performance of Earthquake Risk Buildings (the 'Green Book')* (NZSEE, 1996). Developments on the joint Australia/NZ Draft Standard for Structural Design DR902 (Standards New Zealand 2001) and the emergence of displacement based analysis and design are two particular factors that the Group has taken into account.

This report highlights the activities and achievements of the Group since the report presented to the NZSEE Conference in 2001. (Brunson and Hopkins 2001)

1.2 *Study Group Members*

The Study Group provides a broad representation from design offices, Territorial Authorities

2.4 *Merged with 2.3. Not yet renumbered.*

2.5 Modelling the Earthquake

2.6 Demand on and Capacity of Structure

2.6.1 Relationship with Current Loading Standards

2.6.2 Overall Structural Response Considerations

2.6.3 Member Capacity Considerations

2.6.4 Outline of Force-based and Displacement-based
Procedures for Assessment of Member Capacities

2.6.5 Concrete Structures

2.6.6 Steel Structures

2.6.7 Unreinforced Masonry Structures

2.7 Performance Assessment

C3 – Improvement of Structural Performance

3.1 General

3.2 Performance Criteria

3.3 Options and Strategies

3.4 Analysis and Design

3.5 Overall Performance Assessment

CA - Appendices

Currently envisaged to include detailed guidelines and commentary on pounding, torsional response, sequence of operations for hand assessment, bolted and riveted joints, simplified push over analysis, strength and deformation capacities of infilled frames.

A further section, Section D, giving Case Studies and Applications is envisaged. This will be built up over time as experience is gained in application of the Guidelines and shared amongst users.

3 OUTLINE OF KEY INPUTS AND ISSUES

General

The combination of the range and complexity of existing buildings and the methods of analysis means that considerable judgement will always be necessary in applying the procedures. It is not considered possible to produce a deterministic set of procedures for existing buildings that will generate identical outcomes when applied by different engineers to the same building. The focus of the Detailed Procedures is however on minimising the range of findings that different engineers would arrive at for any particular building.

It is intended that the process framework provided by the Detailed Procedures would allow flexibility for engineers to make appropriate assumptions, exercise judgment and be innovative, provided that a conservative and reasoned approach is adopted.

The basic concept and approach, as described in last year's report, has not been altered significantly. There is a conscious effort to use or relate to codes for new buildings and change these requirements only when absolutely necessary. The document is designed to move with future code developments, as it must. In particular, the Group is conscious of the development of the joint Australian/New Zealand loadings code and has incorporated material and approaches from it where it appears appropriate.

Section A - Legislative and Regulatory Issues

These sections aim to provide TA's with guidance on establishing formal and consistent policies for identification, assessment and setting of improvement standards. Underlying the guidelines is a strong desire to see TA's address the issue of earthquake risk buildings and to put themselves in a defensible position in the event of a major earthquake. Both active and passive policy approaches are contemplated.

The policy may, at the Territorial Authority's discretion, include the following:

- Implementation Options
- Identification of Earthquake Risk Buildings
- Required levels of structural performance improvement
- Appropriate timetables for completion of improvement work
- Special approaches for Heritage Buildings
- Prioritising actions
- Service of Notices (if applicable)

Section B - Initial Evaluation Process

No further work has been done on this section since the publication of the Draft for Comment in August 2000. Material from the August 2000 Draft, particularly the more general sections, will be moved as appropriate to fit with the overall Guidelines.

Section C2.2 – Performance Requirements

This section sets the scene by defining Performance Objectives, Performance Requirements and Performance Criteria, moving from the general objective to prevent danger to people, to achievement of performance in relation to current code, to criteria for measuring performance in relation to the normal definition of ultimate limit state.

Section C2.3 – Approaches for Performance Assessment

An overview of available approaches and analysis procedures is given. Guidance is given on how and when to apply them in any particular case. Emphasis is given to critical structural weaknesses, and the need to exercise judgement before choosing an approach. It is recognised that the sophisticated approaches will be justified for only the most important and complex of structures.

Section C2.5 - Modelling the Earthquake

The various methods of modelling earthquake effects for structural analysis are presented, including acceleration response spectra, displacement response spectra, and time history records. This section benefits from work done in preparation of the Draft Australian/New Zealand loadings code.

Section C2.6 – Demand on and Capacity of Structure

This section contains the bulk of the detailed guidelines that engineers will use in assessing existing buildings.

The Guidelines are related to current codes which means that unless specifically stated otherwise, the same criteria apply when assessing capacity of elements. Overall Structural Response Considerations provides another reminder of the severely detrimental effect that critical structural weaknesses can have on the performance of structures and their key elements.

Displacement-based approaches to analysis and design are finding increasing favour and application in the design of new buildings and the assessment of existing ones. The Group has elected to introduce material on this approach, particularly for concrete structures for which development of procedures is most advanced. This has meant introducing material that is not yet familiar through current codes for new buildings, and Section 2.6.4 outlines and compares the force- and displacement- based procedures. Case study analyses have been performed to test the results and practicality of the processes involved.

Section 2.6.5 on Concrete Structures is a revised and updated version of Chapter 6 of the Green Book. New material has been introduced on the performance of structures with masonry infill panels.

Section 2.6.6 has seen major input from a Steel sub-group during 2001. The section is based on Chapter 7 of the Green Book but provides much greater detail, outlines analysis procedures and addresses masonry infill panels. A case study analysis and evaluation on a 3-storey building was used to test the provisions.

Section 2.6.7 on Unreinforced Masonry Structures draws on the material presented in the Red Book, but has benefited from extensive development work on the analysis of masonry elements. This takes advantage of recent laboratory and theoretical research on their behaviour.

Section C3 – Improvement of Structural Performance

This section is now the main focus of the Group in terms of developing new material. The Group recognises that it is impossible to cover every possible situation. Material developed for this section will focus on the covering the main strategies and options for improving the structural performance of an existing building. In covering a range of the most common techniques the section should provide a source of ideas and inspiration for meeting the challenges of the many and various circumstances presented by existing buildings in need of structural improvement.

Appendices

These will include detailed material of relevance and value when the scale or complexity demands a more in-depth approach.

Section D – Applications

This section is seen as separate from the others. It will consist of case studies from NZ and overseas, brought together from time to time for ease of reference. Its success will rely on practitioners being prepared to describe and share their experiences.

Evaluation of Cost Benefit of Structural Performance Improvement

In reviewing the request by the Building Industry Authority to introduce legislation, the Department of Internal Affairs has requested and commissioned an extension of the cost benefit analysis carried out by members of the Group in 1997. These earlier studies examined a number of parameters and focussed on high risk buildings in Wellington. The current studies examine seismicity throughout New Zealand, take account of four different legislation regimes

(status quo, and 33%, 67% and 100% of Loadings Standard (“current code”), and four different building ‘types’ (Pre-1935, 1935-65, 1965-76 and post-1976). The mathematical model has the capability to vary almost all parameters to explore the sensitivity of the resulting benefit to cost ratios to variations in them.

It is expected that the results of the current studies will provide a more comprehensive basis for the introduction of the legislation and allow decisions to be made which take account of local seismicity and building types. They may also provide insights into the effect of variation in the required trigger level for classification as an earthquake risk building, and the level of strengthening required of such buildings. Current NZSEE recommendations are for a trigger level of 33% of new building standard and a strengthening level of *at least 67%* new building standard.

A report on the study and the results will be published in due course.

4 CURRENT STATUS AND PROGRAMME

It is expected that the first full Draft of the Guidelines will be completed by March/April 2002, and sent to selected reviewers for comment by mid-2002. A revised Draft for Comment will then be produced based on feedback and any new material developed. This will be circulated for public comment and is likely to be accompanied or followed by a series of workshops similar to those used to introduce the Initial Evaluation Procedures.

This process will be largely independent of the introduction of the proposed legislation which is now part of a wider review of the Building Act. The Group believes the Guidelines will prove valuable in dealing with those buildings which are seen to be in need of structural improvement regardless of the existence of legal requirements to take action.

5 ROLE OF GUIDELINES IN REDUCING NEW ZEALAND’S EARTHQUAKE RISK

While there will always be differing opinion on certain matters of engineering detail, it is clear from the reaction from audiences at the Seminars on the Initial Evaluation Process held in 2000, that there is general agreement on the need to extend the application of earthquake risk reduction measures beyond the present scope of unreinforced masonry buildings.

The proposed changes to the earthquake prone provisions of the Building Act represent an opportunity to make a significant step forward in reducing earthquake risk in New Zealand. The Guidelines which are being developed are intended not only to provide a means of addressing existing buildings consistently, but to promote awareness in the community that such buildings, particularly those with critical structural weaknesses, are in need of attention.

In the current climate of risk awareness and risk management it is vital that these buildings are identified and programmes put in place to reduce the risk they represent. Such programmes may require several decades of implementation, but their existence will demonstrate to the community that the risk has been identified and plans made to address it as available funds and perceptions of the relative importance of earthquake risk dictate.

Comments and opinions from members on any part of the Guidelines are most welcome at any stage. Their value can only be enhanced through constructive criticism and contributions from those with a range of experience in dealing with this issue in all parts of New Zealand.

6 ACKNOWLEDGEMENTS

The continuing support from the Building Industry Authority for the work of this group is very much appreciated. The achievements of the Study Group have been possible because of their continuing strong encouragement and financial support.

The authors would also like to acknowledge the commitment, professionalism and enthusiasm

of fellow Study Group members in this important initiative of the NZSEE.

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