

2002 Technical Conference
“Learning from earthquakes: What are the gaps in our approach?”

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**NZSEE 2001
Conference**

SESSION 1 CHAIR: RICHARD SHARPE

1.1 Lifelines mitigation in Hawkes Bay

Evans, N.L.

. *Keywords: Lifelines Project, Hawke's Bay*

ABSTRACT: This paper summarizes the findings of the recently completed Hawke's Bay Engineering Lifelines Project. It is the first provincial lifelines project completed in New Zealand.

Earthquakes pose the highest natural hazard risk to lifelines in Hawke's Bay. Studies indicate that the region is one of the most earthquake prone regions in New Zealand with at least 22 known active faults and folds that are capable of producing strong earthquake shaking. Large subduction thrust earthquakes can produce high levels of shaking over a large part of the region.

Seismic hazard studies and the history of the 1931 Hawke's Bay earthquake enabled risk assessments to be made with examples of how lifelines may be affected.

Mitigation measures currently being undertaken and those possible in the future are discussed.

1.2 Improvements in research knowledge: a challenge for engineering

Falconer, R.K.H.

. *Keywords: research knowledge improvements, code changes, retrofit decisions, design*

ABSTRACT: Research on hazard and risk provides continual improvements in knowledge of processes and associated risks. This provides a challenge for engineering as the lifetimes of many structures will be significantly longer than the lifetime of “state of the art” research knowledge. For example we now understand a lot about near fault effects that mean some structures built near faults are not safe according to current knowledge even though they were state of the art structures at the time of construction. We must not feel uncomfortable about new knowledge but we must acknowledge it. We need to consider:

- How do we cope with the changes in research knowledge for structures that are already built?
- How do we respond to the fact that research knowledge will undoubtedly change our views in the future for structures that we are designing now?

1.3 Earthquake risk reduction actions for New Zealand

Dowrick, D.J.

. *Keywords: casualties, damage, earthquakes, retrofitting, risk reduction*

ABSTRACT: This paper discusses what we already do and what extra should be done to reduce earthquake risk in New Zealand. Some of these needed actions have been learned from the consequences, good as well as bad, of earthquakes that have occurred both in New Zealand and in other parts of the world. A list of 23 weaknesses is identified in New Zealand's systems of earthquake risk reduction. Remedial actions to overcome these weaknesses in a balanced way involve at least nine parties. Nine of the weaknesses have five or more parties who could or should take some remedial action over them. Engineers have technical actions to address 15 of the weaknesses, while earthquake-related professions have an advocacy role to play in all of them. The potential exists for reducing earthquake losses by about an order of magnitude, i.e. worth billions of dollars and thousands of casualties in future earthquakes.

1.4 The role of earthquakes in developing an indigenous New Zealand architecture

Sinclair, J.

. *Keywords: earthquakes, architecture*

ABSTRACT: As globalisation influences everything we do, national and regional characteristics become more significant. Architecture and urban design probably have the most influence of any activity on society and New Zealand, like other countries, must develop its own unique response to its needs. But how influential are earthquakes and the work of the New Zealand Society for Earthquake Engineering on how we build our cities and towns?

Is the focus of NZSEE too narrow, and should it be concerned with other than technical issues?

It is suggested in this presentation that there is an important role for NZSEE to play in the development of our nation - if it so chooses.

1.5 The magnitude 8.3 Arequipa, Peru earthquake & tsunami: closing a gap in our understanding of earthquake hazard

Stirling, M.W, Langridge, R.M., Benites, R. & Aleman, H.

. *Keywords: earthquake reconnaissance, subduction zone, Peru, New Zealand, seismic*

ABSTRACT: We present a precis of our reconnaissance trip to the area of the Magnitude 8.3 June 23 2001 Arequipa, Peru earthquake and tsunami. It is the only earthquake to occur in nearly 40 years that is a realistic analogue for the maximum-size earthquake expected on our Hikurangi subduction zone. We found that the earthquake produced only "moderately strong" levels of earthquake shaking (e.g. peak ground accelerations of 0.3g on alluvium), relatively minor ground damage (liquefaction and landsliding), and a large and devastating tsunami. If we apply our observations to New Zealand they imply that a Hikurangi subduction zone earthquake may be less damaging to built-up areas (e.g. Wellington) than earthquakes on major active faults. However, the extent of the area of strongest shaking in a subduction earthquake (300km length for the Arequipa event) and the associated tsunami generation will make the earthquake very significant in the regional context.

SESSION 2 CHAIR: ANDREW KING

2.1 Guidelines for the use and development of land close to active earthquake faults

Nathan, S., Stirling, M., Brunson, D. & Webb, P.

. *Keywords: active fault, planning policy, guidelines, fault rupture*

ABSTRACT: A report into the problems of land-use and development close to and across known fault lines by the Parliamentary Commissioner for the Environment (2001) recommended the development of guidelines for territorial authorities. It is hoped that these would assist in avoiding or mitigating seismic hazard through the District Plan process. This paper is a progress report on the project set up to produce these guidelines.

The issue is a complex mix of planning policy and processes, legal issues and technical considerations. The project involves developing policy for active fault hazard avoidance and mitigation, writing guidelines and illustrating how this can be done, and assisting councils to incorporate these guidelines into their plans. It is agreed that the guidelines should cover both undeveloped land and previously developed urban areas.

It is hoped to first develop an Interim Planning Guideline, highlighting key issues and outlining recommended planning provisions, and to disseminate this as a web-based document on the Quality Planning website (www.qualityplanning.org.nz). Before this is completed, it is intended to hold discussions with interested parties to review draft material.

2.2 Effective ways to model earthquake risk

Smith, W.D. & Cousins, W.J.

. *Keywords: Earthquake, Risk, Assessment*

ABSTRACT: Earthquake risk assessment should address the probability of occurrence of damaging earthquakes as well as their likely effects. New tools for performing this analysis in New Zealand include a seismicity model, a model for attenuation of strong ground motion, and estimates of likely damage as a function of the severity of ground motion. A Monte Carlo methodology provides a way of combining these in order to estimate various measures of risk.

Loss curves show the annual probability that particular loss values will be equalled or exceeded. The Average Annual Loss can be determined directly from the loss curve, but it is not a good measure of the risk for phenomena such as earthquake. The Systems Engineering literature provides procedures for objective use of other measures of risk, in particular the Conditional Expected Value. Effective risk management will require all these measures, in order to assess the likely benefits of mitigation.

2.3 Strong motion instrumentation of buildings in New Zealand

Deam, B.L. & Cousins, W.J.

. *Keywords: Building Instrumentation, Strong Motion, GeoNet*

ABSTRACT: The best way of confirming the adequacy of structural design codes is to record the responses of real buildings during earthquakes. Good acceleration records are available for the response of overseas buildings, but the construction details of those buildings are usually substantially different from those used in New Zealand. The New Zealand GeoNet Project includes provision to extend the existing building monitoring programme to cover a wider range of New Zealand buildings than at present. Also, modern instrumentation and acquisition equipment allow for a much greater range of measurements than just the traditional set of triaxial accelerographs located at 3 levels in the building. A strategy is being developed by the authors to select suitable buildings, types of measurement and instruments for the GeoNet Project. The strategy is based on similar work currently being developed in the United States.

2.4 Gujarat earthquake, January 2001 – lessons to be learnt

Walls, K.L. & Mujoo, I.

. *Keywords: Gujarat, Indian expertise, approval & construction procedures, preparedness*

ABSTRACT: The news media published many articles and reports on the devastation caused by the recent earthquakes in India, El Salvador, Turkey, Japan, Philippines, Greece and Taiwan.

These earthquakes caused serious damage to buildings and consequential loss of human lives. According to the initial press reports on the Gujarat Earthquake in India on 26 January 2001, which registered 7.9 on the Richter scale, the death toll was estimated to be 125,000. The Gujarat Recovery Program Assessment Report dated March 14, 2001 prepared by the World Bank & The Asian Development Bank reported that one million homes, two district hospitals, 1,200 health clinics, over 11,600 schools and other infrastructure services were damaged or destroyed.

Death and suffering caused by major earthquakes such as in Gujarat, have a direct social and psychological impact on survivors. Economic consequences follow as a result of direct losses and there are enormous costs of organising the rescue operations and additional unbudgeted expenditure for rehabilitation. These outcomes eventuate due to political and social norms overriding knowledge and technology in earthquake mitigation. Suggestions on how these impediments could be overcome are put forward in this paper.

2.5 Kiwi technology to protect Indian hospital from earthquakes

Sharpe, R.D.

. *Keywords: India, Base Isolation, Bhuj, Hospital*

ABSTRACT: The earthquake in Gujarat, India, in January 2001 destroyed the Bhuj District Hospital, killing almost all its 178 patients. The Indian Prime Minister's Office has decided to base-isolate the replacement hospital, following an offer of design expertise from the New Zealand Government. The replacement 300-bed hospital is being fast-tracked to have it open on the second anniversary of the earthquake. Details of the earthquake are well documented by others elsewhere. This paper describes the course of events that led up to base-isolation being adopted, and the role that the New Zealand Earthquake Technology Business Cluster played in assisting the Indian designers to meet their requirements. It is understood that this is the first significant building to be base-isolated for seismic reasons in India. The technology appears to be an ideal match for the current design and construction conditions in India.

SESSION 3 CHAIR: BRUCE DEAM

3.1 EQC's use of computer modelling in a catastrophe response

Middleton, D.A.

. *Keywords: EQC, models, catastrophe response, recovery*

ABSTRACT: The Earthquake Commission has a suite of models which combines seamlessly a geographical information system, hazard model and dynamic financial analysis model. For individual events they provide projections of claim numbers in categories of size, geographical spread, and total value. The system will also analyse investment and reinsurance strategies and changes in terms and conditions of the base cover.

The Commission must also plan for the logistical challenges facing an organisation of sixteen people having to cope with the possibility of over 100,000 claims. Our systems dynamics model provides constraints analyses of our claims process and is being extended to project cash flows.

EQC's strategic planning and catastrophe response are based upon its modelling tools. They have become so important to the Commission that they are one of the few things that the EQC "virtual organisation" has insisted on having the ability to operate in-house.

3.2 The Earthquake Commission's earthquake insurance loss model

Shephard, R.B., Spurr, D.D. & Walker, G.R.

. *Keywords: earthquake engineering practice, social economic*

ABSTRACT: The Earthquake Commission (EQC) has an integrated financial risk management computer system, called Minerva, which features facilities to monitor earthquake insurance exposures, to forecast claims numbers and amounts, and to investigate the financial sustainability of its operations.

This paper presents an overview of the Minerva earthquake loss risk modelling system: the system architecture, models and data used, outputs to assist portfolio management, outputs passed to the catastrophe response management systems, and outputs passed to the financial modelling system.

Minerva features an 'open model' with user options including attenuation, source and vulnerability models. Minerva can simulate the loss risk, and also simulate the financial performance of EQC in stochastic terms, over 10 years into the future.

Development of the earthquake loss component of Minerva raised a number of issues in relation to models and the data. These issues are discussed, including the sensitivity of the output of Minerva to them.

3.3 Inelastic response of buildings subject to revised code ground motion

King, A. Davidson, B. & McVerry, G.

. *Keywords: inelastic analysis, time history, code comparisons, ground motions, limited ductility, fully ductile*

ABSTRACT: This paper reviews a BRANZ building research levy funded study into the dynamic response of buildings to design earthquakes as prescribed by the draft revised loading standard [SNZ 2000]. This work was the combined effort of Compusoft Engineering (with assistance from Buller George Consulting Engineers), Geological and Nuclear Sciences and the Building Research Association of New Zealand.

The study involved the design and performance assessment of 44 buildings in various New Zealand locations. Variables considered include different ground conditions, high and low seismicity regions, various building heights (3, 10 and 20 storey), different structural materials (steel and concrete), limited and fully ductile detailing, different structural forms (moment resisting frames, shear walls and eccentrically braced frames) and different regularity (regular and torsionally susceptible). The performance of these buildings under three different limit states was assessed.

The paper discusses the procedures used during the study, practical problems encountered, code ambiguities identified and briefly the findings to date. The model buildings that resulted and the various ground motion records selected are available electronically for further study.

3.4 Seismic design issues and strategies using the proposed loadings code

Bell, D., Davidson, B.

. *Keywords:*

ABSTRACT: The proposed Loadings Standard has a number of major changes from the current 1992 version. New seismic hazard spectra and scaling factors can result in significant changes in design actions. The introduction of a "constant displacement" region in the spectra could have serious implications to design.

The authors have developed preliminary designs to the proposed code for forty structures for the Wellington and Auckland regions. This paper will overview the experience gained from this project. One of the most significant outcomes of the study is the applicability of using base shear as a means of scaling response spectrum analyses.

3.5 Study group on seismic design of storage tanks summary progress report

Whittaker, D.

. *Keywords:*

ABSTRACT: The NZSEE Study Group on Seismic Design of Storage Tanks is working towards publishing a revision to the 1986 Red Book incorporating an amended procedure for determining seismic loads on tanks. Industry Funding from interested parties has been obtained to assist the Study Group to complete its work.

SESSION 4 CHAIR: DAVID MIDDLETON

4.1 The role of engineers and scientists in reducing the impact of urban disasters

Angus, L. & Dance, J.

. *Keywords: emergency management, readiness, response, rescue*

ABSTRACT: Increasing risk associated with the impacts of natural and technological hazards has led to concerns about New Zealand's capability to manage significant emergencies, particularly in urban areas. This has resulted in the development of thinking into a new approach to emergency management. This is a comprehensive risk management approach incorporating Reduction (mitigation), Readiness, Response and Recovery activities in a coordinated manner, by all involved stakeholders. As key stakeholders, the involvement of scientists and engineers in each of the 4 R areas is of critical importance.

Engineers and scientists have a long history of involvement in understanding the impacts of hazards through planning, design standards assessment and strengthening of at risk structures and regional Lifeline Groups. They have been active in post-earthquake reconnaissance in bringing back the lessons learnt to New Zealand. There is, however, a need to become more involved in establishing relationships prior to events, so that post-earthquake response can be improved. In response, engineers are critical in a number of areas, including evaluation of buildings and infrastructure and Urban Search and Rescue in the case of structural collapse. Emergency managers will be seeking to engage with engineers more in these areas.

4.2 Working party on integrated planning for earthquake response - 2001 report

Brunsdon, D.

. *Keywords: earthquake, response, priority response agreements, register*

ABSTRACT: The focus of the Working Party is on promoting the need for key organisations to be better prepared to respond following a major earthquake, and in particular highlighting the pre- and post-event roles of Society members. This work involves liaison with the Ministry of Civil Defence and Emergency Management, the Earthquake Commission, the Building Officials' Institute of New Zealand and a range of territorial authorities. The Working Party is the vehicle by which the Society's strategic direction *Promoting the need for a higher level of preparation to respond to major New Zealand earthquakes* is addressed.

4.3 Observations on the role of engineers following the Nisqually earthquake

Duncan, D.

. *Keywords:*

ABSTRACT:

4.4 Urban search and rescue and the role of the engineer

McGuigan, D. Bull, D. & Deam, D.

. *Keywords: urban search and rescue, structural evaluation, shoring methods, collapse analysis*

ABSTRACT: Previous international incidents have highlighted the need for specialist task forces to be engaged in Urban Search and Rescue (USAR) activities for retrieving victims from collapsed buildings. These task forces comprise personnel from a range of rescue agencies. A review of New Zealand's USAR capabilities has shown that there is presently a lack of capability and organised structure to deal with USAR events and has recommended the establishment of specialist USAR task force units in New Zealand. These units include professional engineers to advise on structural aspects of rescue operations. A research project is being conducted to establish the framework for training of professional engineers in urban search and rescue situations, as no formal training methods exist in New Zealand at present. The

education includes developing a familiarity of the organisation of specially trained USAR task forces. An engineering perspective of a recent Category 2 USAR course is presented.

4.5 Project Phoenix – preparing to respond to a major earthquake in Wellington

O’Kane, K.

. *Keywords: earthquake, exercise, emergency management*

ABSTRACT: Exercises in July 2001 involve Auckland and Wellington local authorities, and the Ministry. They build upon past activities that examined the basis for mutual support in the event of the 'design event' earthquake in Wellington. The exercises will simulate the gathering, transport, and distribution of supplies and personnel in the critical period after the event. Much of the value of this activity has already been collated from a series of workgroups that have examined immediate demands and the means of meeting them. The exercise programme is also being linked to USAR and health initiatives to establish and test coordination systems. Phoenix is also providing a catalyst for revisiting the existing guidelines for exercise development.

SESSION 5 CHAIR: KEVIN O’KANE

5.1 Seismic security of state highway bridges: screening and retrofit – progress summary

Chapman, H.E. Kirkcaldie, D.E., Lauder, M.K. & Oakden, G.J.

. *Keywords: bridge, lifeline, seismic, evaluation, retrofit*

ABSTRACT: Transit New Zealand is undertaking a project to retrofit state highway bridges so as to ensure that seismic performance of the network will be to an acceptable standard. Preliminary screening of all 3800 bridges and culverts has been completed, and structures that require further analysis have been identified. The paper describes the background to the project, the methodology used and the results of the screening. It also discusses the basis of ranking the structures for further analysis, the issues involved in allocating a justifiable level of funding that will provide the required security of the network and the options for procuring the design and construction services necessary for implementing the programme.

5.2 Seismic retrofit of highway bridge foundations using micropiles

Turner, J., McManus, K. & Armour, T.

. *Keywords:*

ABSTRACT:

5.3 Earthquake response of building parts

Shelton, R., Park, S. & King, A.

. *Keywords: earthquake, parts, inelastic response, floor accelerations*

ABSTRACT: A suite of buildings was designed in accordance with the earthquake provisions of the draft joint NZ Australia Loadings Standard. Inelastic time history analyses were carried out using the Ruaumoko 3D program, and selected earthquake records. From the output of these analyses, interstorey drifts, floor accelerations and response spectra were obtained, and a force based equation developed. This equation forms the basis of the provisions of section 9 of Part 4 of the Standard .

5.4 Modelling the spread of post-earthquake fire in Wellington city

Cousins, W.J., Heron, D.W., Mazzoni, S., Thomas, G.C. & Lloyd, D.

. *Keywords: urban fire spread, fire following earthquake, fire loss modelling*

ABSTRACT: Large earthquakes are often followed by fire. Sometimes, because fire suppression can be difficult after large earthquakes, it develops into conflagration that in turn can lead to very serious loss of

life and property. A GIS (Geographic Information System) model containing property and valuation data is shown to be a versatile platform for modelling the spread of post-earthquake fire in the urban setting. We describe two approaches. One uses a buffering technique to define potential “burnout” zones that are sampled randomly to give estimates of losses. From repeated sampling we are able to assess the probability of exceedance of various levels of loss as a function of the number of ignitions and the spacing between buildings. The other uses a cellular automaton technique for determining both the rate and extent of fire-spread in response to a wide range of factors including wind, radiation, sparking, branding, and individual separations of buildings.

5.5 Seismic safety of schools in Kathmandu Valley, Nepal: Problems and opportunities

Bothara, J.K., Dixit, A.M., Nakarmi, M., Pradanang, S.B., Thapa, R.C.

. *Keywords: owner-built, craftsman, building vulnerability, seismic safety*

ABSTRACT: The National Society for Earthquake Technology-Nepal (NSET) has been in existence for approximately eight years and has received support from the New Zealand Society for Earthquake Engineering to interact with the international earthquake engineering community. It has initiated and undertaken (with national and international organizations) many mitigation measures such as building aseismic retrofitting and construction, publication of materials, extensive training and awareness raising, and a national earthquake safety day each January. This paper outlines one of NSET's projects, which is showing real potential to bring about change to existing practices.

The Kathmandu Valley Earthquake Risk Management Project (KVERMP) implemented by NSET placed a special focus on schools. It assessed the seismic vulnerability of public school buildings of Kathmandu Valley and identified intervention options. School buildings in Nepal are highly vulnerable to any future earthquake. The loss suffered by a community in the collapse of a school may psychologically be much more as it houses entire future generation. Schools are ideal for temporary shelter, medical clinics, and other emergency functions. Functioning schools provide a feeling of normalcy. They are also particularly receptive to earthquake safety programmes. Furthermore, introducing seismic safety into a school is a step forward for awareness raising, for introduction of seismic safety at the community level, and technology transfer. The strengthening of a school becomes a model for domestic construction, as schools are matter of concern for all.

5.6 Study group on earthquake risk buildings: progress report 2001/02

Hopkins, D.C., Brunson, D.

. *Keywords: earthquake risk, buildings, structural performance, design, retrofit*

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.

SESSION 6 CHAIR: KEVIN MCMANUS

6.1 Calibrated displacement prediction accuracy using the substitute structure method

Edwards, M.R., Wilson, J.L. & Lam, N.T.K.

. *Keywords: displacement, prediction, concrete, substitute, structure*

ABSTRACT: Considerable research has been undertaken in assessing the displacement response of structural systems to earthquake ground motion. As part of performance based seismic design, methods have been presented in several structural assessment documents enabling practitioners to make some prediction of peak displacement. This paper describes some of the research that has been undertaken to examine the nature of deformation and damping in reinforced concrete frame systems with a particular focus on the substitute structure method. The findings have been incorporated into a detailed time history analysis model that has, in turn, been used to calibrate a linear idealisation of response. Comparisons made with other published predictive methods have been encouraging for the limited structure range considered. The results suggest that a substitute structure methodology can be calibrated to provide an improved prediction of maximum displacement response when compared with other published methods.

6.2 Accounting for seismic risk in financial analysis of property investment

Beck, J., Porter, K. & Shaikhutdinov, R.

. *Keywords: property investment, market and seismic risk, loss analysis, decision analysis*

ABSTRACT: A methodology is presented for making property investment decisions using loss analysis and the principles of decision analysis. It proposes that the investor choose among competing investment alternatives on the basis of the certainty equivalent of their net asset value which depends on the uncertain discounted future net income, uncertain discounted future earthquake losses, initial equity and the investor's risk tolerance. The earthquake losses are modelled using a seismic vulnerability function, the site seismic hazard function, and an assumption that strong shaking at a site follows a Poisson process. A building-specific vulnerability approach, called assembly-based vulnerability, or ABV, is used. ABV involves a simulation approach that includes dynamic structural analyses and damage analyses using fragility functions and probability distributions on unit repair costs and downtimes for all vulnerable structural and nonstructural components in a building. The methodology is demonstrated using some results from a seven-storey reinforced-concrete hotel in Los Angeles.

6.3 The influence of foundation conditions on the earthquake response of two tanks

Larkin, T.

. *Keywords: earthquake tank foundation interaction design*

ABSTRACT: Surface mounted tanks are an important part of the infrastructure. This paper presents the results of analyses of the seismic response of two tanks including the compliance of the foundation soil. The soil – structure interaction is solved in the frequency domain in an approximate strain compatible manner. The method is applied to two typical situations where tanks are employed. One is low lying soft ground adjacent to harbours and rivers. The other involves elevated terrain where the foundation soil is likely to be reasonably competent ground. Significant interaction is found to occur in both cases, but particularly in the case of the soft soil. The translations and rotations of the tanks are shown to be substantial in some situations and greatly effect the forces acting on the tank. Time dependent factors of safety of bearing capacity and shear are presented to investigate the capacity of the foundation to withstand bearing and horizontal shear.

6.4 Is there a relationship between observed felt intensity and parameters from strong motion instrument recordings?

Davenport, P.N. & Dowrick, D.J.

. *Keywords: intensity, MMI, JMA, Arias, strong motion records*

ABSTRACT: Felt intensity, commonly represented as Modified Mercalli Intensity (MMI), has been used for a long time to quantify the impact of earthquakes. Values are often presented in the form of isoseismal maps for significant seismic events. More recently, with strong motion recorders being increasingly widespread, it has become possible to compare the observed felt intensity to parameters derived from the instrumentally recorded strong motion. In this study, we have selected the strong motion records obtained in New Zealand since 1965 where there is a matching isoseismal map available, and compared the MMI value at the recorder site to instrumentally derived parameters. These include the peak ground acceleration, Arias seismic intensity, JMA seismic intensity and some selected spectral values.

6.5 Influence of hysteretic form on seismic behaviour of structures

Judi, H., Fenwick, R. & Davidson, B.J.

. *Keywords: spectra, hysteretic forms, damping, strain hardening*

ABSTRACT: In the seismic design spectra in the Loadings Standard no recognition is given for the influence of differing hysteretic behaviour associated with different materials, structural types and detailing standards. In practice hysteretic behaviour varies widely, from the near bilinear typical of eccentrically braced frames to the pinched forms associated with masonry.

To investigate this a series of time history analyses were made with different ground motions and a range of hysteretic models. It is shown that the hysteretic form, provided that appreciable energy can be dissipated, has only a small influence on the maximum displacement that is sustained. Varying the viscous damping level was found to have a significant influence on elastically responding structures but a smaller effect on structures with some ductile capacity. Increasing the strain-hardening ratio was found to have a small influence on the required strength for a given ductility.

POSTER PAPERS

7.1 Effects of microzoning and structure on damage ratios for houses in the M 7.2 1968 Inangahua earthquake.

Dowrick, D.J., Rhoades, D.A. & Davenport, P.N.

. *Keywords: damage ratios, earthquakes, foundations, houses, microzoning*

ABSTRACT: In a recent study the present authors examined the damage ratios for houses and household contents in the Inangahua earthquake for intensities MM5-MM10, including the effects of chimney damage. The present study continues this work by examining the effects of ground class and construction type on damage levels. Houses from six towns are considered, i.e. Inangahua, Reefton, Westport, Greymouth, Runanga and Hokitika covering a range of intensities from MM10.5 down to MM7.0. A range of ground classes is also considered, covering the three classes described in the draft joint Australian/New Zealand loadings standard. The structural types considered comprise two foundation types (piled vs. concrete perimeter wall footings).

7.2 Seismic performance of reinforced concrete perimeter frames with slabs containing prestressed units.

Lau, D.B.N., Fenwick, R.C. & Davidson, B.J.

. *Keywords: precast prestressed flooring, seismic performance, reinforced concrete, perimeter frame, elongation*

ABSTRACT: Three tests were conducted to assess the influence that floors constructed with precast prestressed components have on the seismic performance of ductile perimeter reinforced concrete frames. All units represented a bent of a frame with two internal bays and two cantilever spans. One unit had a near identical frame but a floor slab containing precast concrete members was added to one side of the frame.

The addition of the precast floor was found to increase the lateral strength by a factor of about 2.7 for inter-storey drifts of between 1 and 3 percent. The stiffness of the slab allowed bending moments to be resisted by the cantilever spans. If allowance is made for this effect the average flexural strength increase of each plastic hinge zone due to the addition of the floor was 78 percent. Damage occurred at the interface between the beams and slab, due to both the shear transfer and relative vertical movement between the two.

7.3 New source spectral model and strong ground motion simulation of the 1994 M6.7 Northridge earthquake.

Wang, G., Tao, X. & Xie, L.

. *Keywords: source spectral model, finite fault, ground motion simulation*

ABSTRACT: This paper checked, appended and corrected the strong motion database of Western U.S. on site conditions and so on first, and then recommends a new source spectral model and model parameters depending on the statistical analysis to acceleration Fourier spectra of these strong motion recordings. The new source spectral model has some further improvement to Brune ω^2 model and Atkinson two corners one, which embodies the differences between small and strong earthquakes not only in amplitudes and corner periods, but also in the shapes that were revealed by the recordings.

Based on the new source spectral model, the different ground motion estimating methods, like Finite-fault method, Point-source method and Random Vibration Theory method, have been used in this paper to simulate ground motion of Northridge (M6.7) earthquake as an example. It is certified that the finite-fault effect should be considered in near-source ground motion estimation.