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Cover picture

Part of the Olive View Hospital building which developed a permanent horizontal displacement during the 1971 San Fernando earthquake and had to be demolished. The seismic resistance of structural concrete is discussed in the paper on p. 2.

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A response to uncertainty

IN 1979, we move further into what J. K. Galbraith calls the "Age of Uncertainty". As a profession, we now have some experience of its pressures and challenges. It requires flexibility, and seems to need broad strategies which can accommodate considerable variation, in contrast with the simple projections of trends which served us in more predictable times. The study of options helps in the shaping of strategy. It is the age of involvement, in which the community looks critically at decisions which affect it, and this includes technical decisions. Technology is no longer accepted as an unquestioned benefit. We are asked to explain its social — this includes environmental — consequences. We are required to demonstrate that this technical strategy is superior to an alternative technical strategy.

The apparent change has taken place in an astonishingly short period. No doubt, if we looked deeper, and further back in time, we would find the generating forces standing out clearly. Be that as it may, the shift is real enough. We have only to compare our attitudes and professional experiences in the field of energy, or in transport, or to consider the present climate in respect of bulk urban services, to sense the magnitude of the shift.

As a profession we have options, and these options can be the basis of strategy. We can bewail the fact that times are different, and likely to be more so. We can react, dig in, and develop concern that society is no longer according us the status that is justly ours. That will be, exactly, society's response to the choice of the negative option.

Or we can select the constructive course, and give society cause to note the actions of a profession, as distinct from an assembly of technical people. Technology needs to be explained and assessed. Very well, we will explain and assess it. This is the age of public involvement. Very well, we will take part in the common endeavours of society. If strategies and policies have to replace trend projections, we will make our contribution to the formulation of strategies and policies.

The negative option was never acceptable, and we recognised that some years ago. Already we have some of the equipment we, as a profession, require for the "Age of Uncertainty". Our continuing education programme has started well, monitored training is getting under way, and we have a "Committee for the Future". *Print Out* has the potential to become a positive improvement in our own communications. In these times, more than ever before, part of our ability to respond flexibly to uncertain times lies in an effective vehicle for intra-professional discussion of issues and courses of action.

The tools we have now to hand, or are fashioning, will enable us to contribute to policy making. We should be. Engineering is not the only way of learning to think, but it will stand comparison with a good many other ways of making progress with the art. The times need positive contributions to policy from the professions.

Again we can say that we are doing it, whether it be the transportation and traffic group's paper on the present transport proposals from government, or the Auckland Branch's meeting last year in which the Hon. G. Gair participated.

There is much more to do, and the fields to which we can make relevant contribution range from local government finance to the technical and general financial needs of a period in which there is going to be some emphasis on the maintenance of existing assets.

If we opt for a course like this one, we will be too busy to worry about status. More accurately, we will not have to worry about it. We will have it. ▽

Earthquakes and structural concrete

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A considerable amount of research and development relating to the design of earthquake-resistant reinforced and prestressed concrete frames and shear walls has been conducted in New Zealand in recent years. New codes for earthquake-resistant design have emerged. A capacity design procedure has been recommended which is aimed at ensuring ductile behaviour of the structure and minimising strength degradation during earthquakes. The paper summarises some of the background philosophy and research which has been conducted into the seismic resistance of structural concrete.

1. INTRODUCTION

NEW ZEALAND is situated in part of the seismically active circum-Pacific belt. The early settlers, coming from non-earthquake countries, introduced few measures for earthquake resistance in their buildings. Codes for earthquake-resistant design in New Zealand have gradually evolved since the Hawke's Bay earthquake of 1931. During the last decade, particularly, much attention has been given to earthquake engineering, and seismic provisions now dominate most structural design procedures in New Zealand.

New Zealand has been fortunate in that since the Hawke's Bay earthquake major earthquakes have not occurred close to large population centres, and therefore the damage has not affected a great proportion of the population. However, other countries have suffered significant damage and loss of life. For example, the massive earthquake which struck the city of Tangshan in China on the morning of 28 July 1976, which measured at least 7.6 on the Richter scale, killed an estimated 655 000 people.

This paper briefly considers the design philosophy for tall, seismic-resistant building structures which has emerged in recent years in New Zealand, along with the results of recent laboratory and analytical research conducted in New Zealand on the effects of earthquakes on structures. Mention will be made of the new draft SANZ Concrete Design Code[1] which has been available for comment during 1978. Structural concrete will be considered since this has become the predominant structural building material in New Zealand.

2. SEISMIC DESIGN PRINCIPLES

Lessons from past earthquakes, theoretical analyses of structures responding to earthquake ground motions, and laboratory testing have led to the current philosophy of earthquake design as expressed by the New Zealand standard code of practice for general structural design and design loadings for buildings[2]. This code recognises that it is uneconomical to design structures to resist the greatest likely earthquake without damage. The seismic design loads specified are, in common with overseas seismic codes, much less than the very large inertia forces which can develop within a structure during a very severe earthquake if the structure responded elastically. Hence code-designed structures will resist moderate earthquakes elastically, but in order to survive very severe earthquakes it is necessary for the structure to dissipate energy by ductile behaviour in the post-elastic range.

Figure 1 shows frames and shear walls which can be used in tall buildings to provide seismic resistance, and possible mechanisms of inelastic deformation which could form during a severe earthquake. If yielding commences in the columns of a frame before the beams, a column sidesway mechanism can form. In the worst case the plastic hinges might form in the columns of only one storey, resulting in a very large ductility demand at the plastic hinges of the critical storey for tall buildings, which could lead to complete collapse of the frame. Figure 2 shows part of a building which developed a 0.6 m permanent horizontal displacement in the first storey during the San Fernando earthquake, owing to a weak first storey; the building had to be demolished after the earthquake. On the other hand, if yielding commences in the beams before in the columns a beam sidesway mechanism, as illustrated in Fig. 1, will develop which makes more moderate demands on the ductility required at the plastic hinges in the beams and at the column bases. Therefore, a beam sidesway mechanism is the preferred mode of inelastic deformation, and a strong column-weak beam design approach is advocated for tall frames. For cantilever shear walls the mechanism involves a plastic hinge at the base. For coupled shear walls the mechanism shown in Fig. 1 can occur. The mechanisms of inelastic deformation of Fig. 1 are idealised in that they involve behaviour under code type

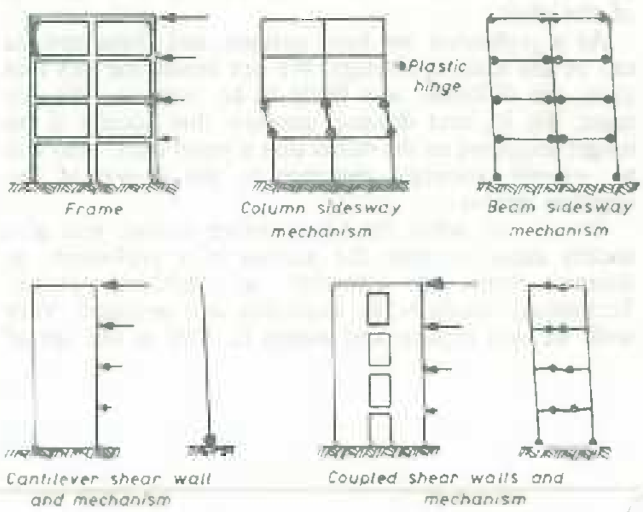

Fig. 1: Building structures under seismic loading and possible mechanisms.

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This paper is an abbreviation of the Institution of Structural Engineers' Address of this title presented by the author at the N.Z.I.E. conference in Hamilton on 15 February 1978. It was first received on 29 June 1978 and in its present form on 27 October 1978.