Research news and notes+

EARTHQUAKE ENGINEERING RESEARCH AT THE UNIVERSITY OF CANTERBURY

R. Shepherd*

In February 1960 the University of Canterbury Engineering School moved to its new buildings at Ilam, thereby gaining greatly improved facilities for research work. Subsequently the implementation of a very successful post-graduate scholarship scheme gave much needed encouragement to graduate student activity.

Specific concern with Earthquake Engineering problems was prompted by Mr R. I. Skinner of the Engineering Seismology Section of the N.Z. Physics and Engineering Laboratories at Lower Hutt. The work undertaken at the University has benefited greatly from Mr Skinner's enthusiastic initial assistance and generous continuing interest.

The research undertaken is reported under project sub-headings, listed in essentially chronological order.

Much of the completed work has been described in published papers. The figures in parentheses following the brief project summaries refer to the publications listed at the end of this report.

Several recently started research projects are not listed here. It is intended that they will be included in subsequent activity reports. A complete list of research projects currently being carried out in the University of Canterbury Civil Engineering Department was prepared in October 1968 for publication in New Zealand Engineering in 1969.

PROJECTS

(a) Dynamic Analyses as Part of the Seismic Design Process.
R. Shepherd.

Methods of dynamic analysis useful in the design of high-rise buildings have been developed (4,6,9,12,13,14,16,17,18,22).

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* R. Shepherd, Reader in Civil Engineering, University of Canterbury, Christchurch.

+ Comment upon the introduction of this section is given on the Editor's page. Further contributions from research workers or organisations will be welcome.

(b) An Investigation of the Dynamic Response of Structures using an Electrical Analogy.
R. Shepherd and R. J. O'Driscoll (M.E.1961)

An examination was made of the methods available for determining the earthquake response of multi-storey buildings, particular attention being paid to the modal analysis technique. (2 & 3)

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(c) The Response of Structures to Lateral Loading.
R. Shepherd & J. H. Wood (M.E.1963)

A digital computer was applied to the extension of O'Driscoll's work. (1, 3 & 7)

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(d) Investigation of the Dynamic Properties of Structural Frameworks using Modal Analysis Techniques.
R. Shepherd & R. A. H. Donald (M.E.1964)

Wood's modal analysis work was extended to include consideration of axial column deformation, coupled torsion and bending, soil structure interaction and floor flexing effects. (8, 10, 11)

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(e) The Response of Structures to Earthquakes.
R. Shepherd & W. R. Walpole (Ph.D.1968)

The post elastic behaviour of seismically loaded structures was investigated using a digital computer. (20, 23, 24)

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(f) Behaviour of Shear Walls.
T. Paulay

The elastic and post-elastic behaviour of multi-storey, reinforced concrete coupled shear walls is being investigated as a continuing project. (27)

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(g) Dynamic Characteristics of Civil Engineering Structures.
R. Shepherd & A. M. Reay (Ph.D.Candidate)

Small amplitude shaking tests have been completed on one six storey and three eight storey buildings. The correlation between the experimental results and the theoretically predicted properties is being examined. (15)

(h) The Dynamic Study of Prestressed Concrete.
R. Park & D. S. Hunt (M.E.1967)

The behaviour of pretensioned prestressed concrete beams subjected to alternating loads of high intensity was studied. The effect on the ductility, stiffness and mode of failure was investigated.

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(i) Dynamic Properties of Continuous Mass Systems.
R. Shepherd & G. K. Sidwell (Ph.D.Candidate)

In an attempt to improve understanding of the vehicle-bridge interaction and the response to earthquakes, twelve bridges have been tested. Correlation between experimental and analytical results is being examined.

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(j) Microzoning and Building-Ground Interaction under Earthquake Loading.
R. Shepherd & J. H. Travers (Ph.D.Candidate)

The surface layer modification of seismic waves is being studied. Attempts are being made to correlate the predicted movements at ground level and those at depth with the relationships determined experimentally. (19)

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(k) Ductility of Reinforced Concrete Components under Seismic Loading.
R. Park & D. C. Kent (Ph.D.Candidate)

The theoretical and experimental ductility of reinforced concrete members when subjected to repeated cyclic loading into the post-elastic range is being examined. The effect of lateral confinement is being considered. (21)

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(l) Ductility of Prestressed Concrete Members.
R. Park, R. Shepherd & R.W.G. Blakely (Ph.D. Candidate)

The theoretical and experimental ductility of prestressed concrete members subject to earthquake loading is being examined. In particular the behaviour of joints between precast post tensioned members is being investigated.

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(m) The Behaviour of Laterally Loaded Piles in Elastic Non-Uniform and Layered Media.

D. G. Elms & C. D. Mathewson (Ph.D.Candidate)

The stress distribution in soil due to a lateral load on a flexible pile of finite length is being investigated, both theoretically and with the use of small scale models.

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(n) Behaviour of Masonry, Brick and Concrete Block Walls under Lateral Racking Loads.

J. C. Scrivener & D. Williams (Ph.D.Candidate)

Tests are being continued on reinforced masonry walls with different quantities and distribution of reinforcement. (25, 26)

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Detailed enquiries on any of the above projects should be directed to the first named research worker in each case.

1.	Dynamic Design of Earthquake Resistant Structures.	R. Shepherd and J. H. Wood New Zealand Engineering, 1963 18(4),111-117.
2.	Dynamic Responses of Multi-storey Buildings.	R. J. O'Driscoll and R. Shepherd New Zealand Engineering, 1963, 18(9),307-12.
3.	The Determination of the Normal Mode Properties of Multi-storey Rectangular Rigid Framed Structures Using an Electrical Analogy.	R. J. O'Driscoll, R. Shepherd and J. H. Wood.Proceedings Third World Conference on Earthquake Engineering 1965,2,421-442.
4.	The Design of Earthquake Resistant Multi-storey Framed Structures.	R. Shepherd, Paper read to 38th ANZAAS Congress, Hobart, Tasmania, August 1965. Journal of the Institution of Engineers, Australia, 1965,37(12),411-415.
5.	The Dynamic Interaction of Structures and Soils.	R. Shepherd and W. R. Walpole, New Zealand Engineering,1966,21(2),56-62.
6.	The Dynamic Analysis of an Apartment Building.	R. Shepherd. Bulletin of the Seismological Society of America, 1966,56(1),13-34.
7.	Normal Mode Properties of Multi-storey Frameworks.	R. Shepherd and J. H. Wood. Journal of Sound and Vibration, 1966, 3(3), 300-314.
8.	The Influence of Floor Flexibility on the Normal Mode Properties of Buildings.	R. Shepherd and R. A. H. Donald Journal of Sound and Vibration 1967, 5(1), 29-36.
9.	Determination of Seismic Design Loads on a Framed Structure.	R. Shepherd. New Zealand Engineering 1967, 22(2), 56-61.
10.	Foundation Deformation Effects in Structural Dynamic Analysis.	R. Shepherd and R. A. H. Donald. Proceedings, Fifth Australia-New Zealand Soil Mechanics Conference, Auckland. Feb.1967. 205-212.
11.	Seismic Response of Torsionally Unbalanced Buildings.	R. Shepherd and R. A. H. Donald. Journal of Sound and Vibration,1967, 6 (1), 20-37.

12. Lateral Load Analyses of the Auckland Customs House. — R. Shepherd. New Zealand Engineering, 1967, 22(7), 273-277.

13. The Determination and Distribution of Lateral Loads in the Design of Tall Buildings. — R. Shepherd. Proceedings of the Third Australian Building Research Congress, Melbourne, August 1967. 136-139.

14. Prediction of the Response of a Torsionally Unbalanced High-Rise Building to Earthquake Loading. — R. Shepherd. Proceedings of the First Australasian Conference on the Mechanics of Structures and Materials, Sydney. August 1967. 16-31.

15. Some Apparatus for the Small Amplitude Dynamic Testing of Multi-storey Buildings. — R. Shepherd and A. M. Reay. Strain, Journal of the British Society for Strain Measurement,1967,3(4) 16-21.

16. A Comparison of Calculated and Measured Periods of a Tall Building. — R. Shepherd. New Zealand Engineering, 1967, 22(9) 381-383.

17. Seismic Lateral Load Analysis of a Steel Framed Building. — R. Shepherd. New Zealand Engineering, 1967, 22(10) 407-413.

18. Dynamic Elastic Analyses in the Earthquake Resistant Design of an Office Building. — R. Shepherd. Journal of Sound and Vibration, 1968, 7(2), 31-40.

19. Surface Layer Modification of Seismic Waves. — R. Shepherd and J. H. Travers. Paper presented to 40th ANZAAS Congress Christchurch, N.Z. January 1968. A modified version accepted for publication by New Zealand Engineering, 1969.

20. Post Elastic Seismic Response of a Reinforced Concrete Frame. — W. R. Walpole and R. Shepherd. Bulletin of the N.Z. Society for Earthquake Engineering 1968, 1(2).

21. Ductility of Reinforced Concrete Frames Under Seismic Loading. — R. Park. New Zealand Engineering 1968, 23(11), 427-435.

22. Dynamic Elastic Analyses in the Design of Typical N.Z. High-rise Buildings. — R. Shepherd. Proceedings Fourth World Earthquake Engineering Conference, 1969 (in Press).

23. The Inelastic Response of a Steel Frame. — W. R. Walpole and R. Shepherd. Proceedings, Fourth World Earthquake Engineering Conference,1969.(In Press).

24. Dynamic Elasto-Plastic Response of a Reinforced Concrete Spandrel Frame.	W. R. Walpole and R. Shepherd. Bulletin of the Seismological Society of America 1969. (In Press).
25. Concrete Masonry Wall Panel Tests. Static Racking Tests with Predominately Flexural Effect.	J. C. Scrivener, N.Z. Concrete Construction July 1968, 119-124.
26. Static Racking Tests on Concrete Masonry Walls.	J. C. Scrivener. International Conference on Masonry Structural Systems, Texas. November 1967.
27. The Coupling of Reinforced Concrete Shear Walls.	T. Paulay, Proceedings Fourth World Earthquake Engineering Conference, 1969. (In Press).