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# Hot-water cylinders can survive earthquake

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*This article discusses the protection of hot-water cylinders and is based on shaking-table tests on three hot-water cylinders with varying insulation, recently carried out by the Building Research Association of New Zealand and reported in a BRANZ research report* A hot-water cylinder to survive earthquake[1] *to be published shortly.*

## 1. INTRODUCTION

PROTECTION of domestic hot-water cylinders from fracture by earthquake movement is both desirable and feasible.

During the Inangahua earthquake of 1968 considerable damage occurred to houses and to household plumbing systems. In New Zealand an earthquake of the magnitude of the Inangahua earthquake has occurred on an average of every eight years, but others in the recent past have been in inaccessible areas with little damage to property.[2] However, most areas of New Zealand could experience without warning an earthquake of equal or greater severity.

Most New Zealand houses have a good chance of surviving a major earthquake with little serious damage, but two common failures in the plumbing and drainage system could make houses uninhabitable:

(1) The hot-water cylinder could move about sufficiently to fracture the inlet or exit pipes. The resulting damage might cost a few hundred dollars, but more important, a reservoir of water could be lost, a supply which might be essential for continued occupation of the house during the first critical days after a major earthquake when mains water supplies could be disrupted.

(2) The pipe between the water closet pan and the sewer could be sheared, thus preventing hygienic disposal of body wastes.

## 2. CHOICE OF TEST METHOD

Since every earthquake has a unique pattern of vibration there is a problem in choosing a representative simulation procedure. Testing methods range from static tests through sine-wave testing, sine-beat testing, to simulation of actual earthquakes.

The motions of particular earthquakes may be reproduced but this procedure does not deal precisely with the response to future earthquakes, nor with the modifying influence exerted by undefined buildings. A compromise in accuracy is required.

Although "sine-beat" testing would provide a more realistic representation of earthquake motion in a building, sine-wave testing was employed because available equipment was capable only of pure tone shaking. Very sophisticated tests were not justified because of the variations which exist between earthquakes, between buildings, and between positions in buildings in which cylinders are installed; and because of the negligible increase in cost incurred as a result of using conservative sine-wave testing results for strapping design.

The simultaneous application of several frequencies of horizontal acceleration, such as occurs in a real earthquake, may not significantly affect the results, but the simultaneous application of a simulated vertical acceleration, may induce damage at lower levels of horizontal vibration, particularly where the cylinder is not strapped and is able to "walk". Rotational accelerations cannot be applied directly with the equipment available and must be considered separately.

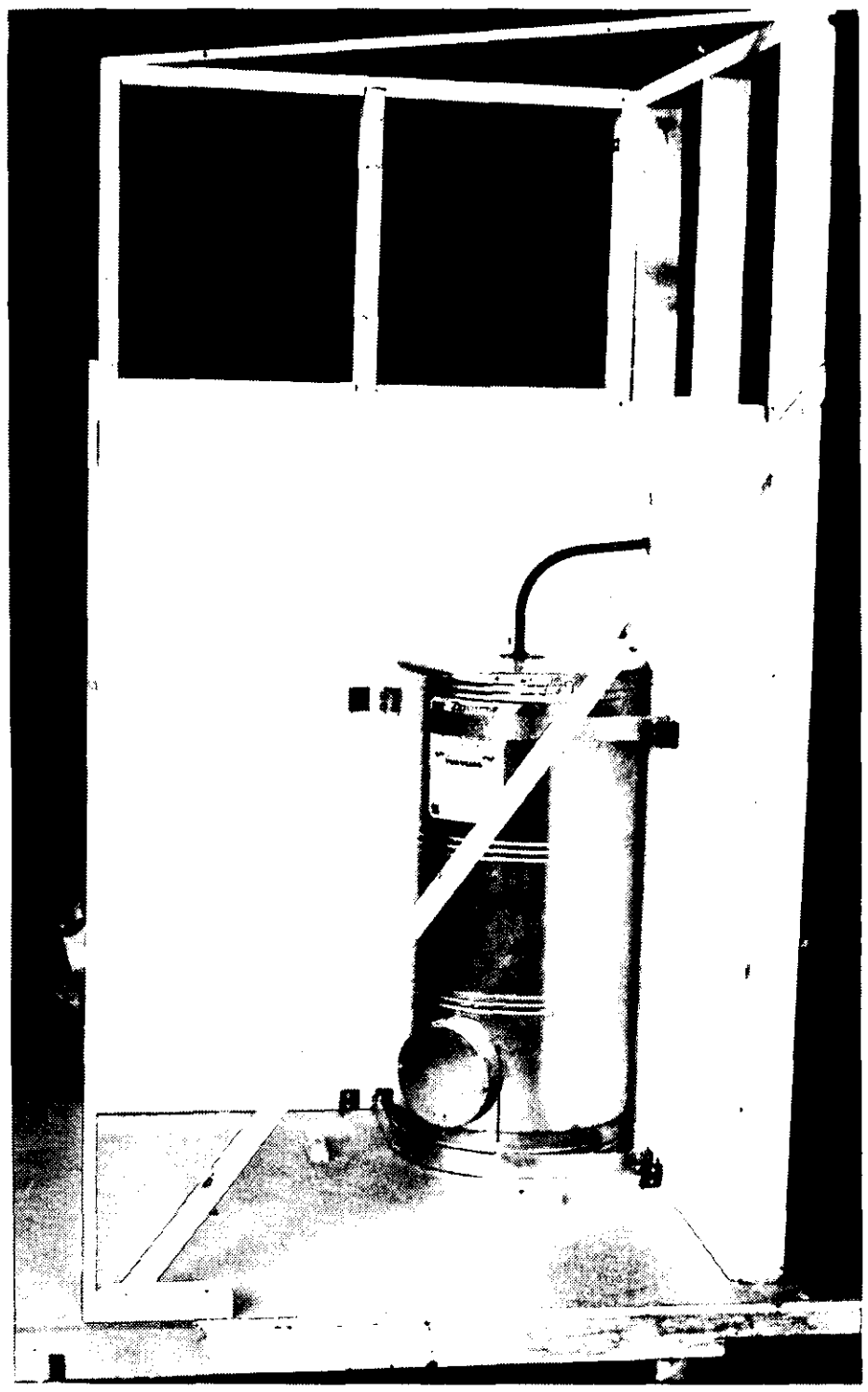

*Fig. 1: Hot-water cylinder strapped into simulated cupboard for shaking tests.*

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## 3. METHODS OF PROTECTION

Two approaches to this project are:

(1) To constrain the cylinder to move with the building,

(2) To allow the cylinder to move independently of the building by providing sufficient flexibility to connecting pipework.

The first approach was adopted as it was reported that, at Inangahua, hot-water cylinders were thrown from the cupboard,[2] indicating that the second method might not be feasible. Further, an education programme to ensure that all plumbers and plumbing inspectors adopted a recommended practice of routing pipework to avoid restraints on the pipework close to the hot-water cylinder, would be a major undertaking. The lack of restraints on pipework and the necessary re-routing of pipework tend to look untidy and "untradesman like".

To constrain the cylinder to move with a building it is necessary to locate the cylinder firmly within the casing, in a way which does not interfere with the insulation.

A rigid insulation such as foamed polyurethane is particularly suitable for this purpose. It is an excellent insulant being substantially better than the presently-used union flock (0.025 W/m°C compared with 0.045 W/m°C). Foamed polyurethane is also strong and rigid compared with other insulants. The modulus of elasticity depends substantially upon loading rate but is of the order of 500 kN/m$^2$.

## 4. THE CYLINDERS TESTED

Three cylinders were tested, one a standard cylinder with 50 mm of flock insulation, one with 50 mm of foamed in-situ polyurethane, and the third with 90 mm of foamed in-situ polyurethane, as insulation levels of this order have been shown to be desirable.[3]

These cylinders were mounted in a simulated cupboard as shown in Fig. 1. The tests showed that an adequate degree of earthquake resistance can be readily achieved by strapping. Cylinders with insulation replaced by foamed in-place polyurethane have much higher resistance, but even the standard cylinders when securely strapped have good resistance to shaking.

The strapping used in the tests consisted of a galvanised steel strap with turnbuckle bolted to angle-iron brackets which in turn were screwed to the wall. This inexpensive system was more than adequate but perhaps even cheaper systems could be devised.

## 5. RECOMMENDATIONS

The protection of a hot-water cylinder during an earthquake has not hitherto been considered practical. It has now been shown not only to be practical but also simple even for existing installations.

A major earthquake may occur in a heavily populated area of New Zealand without warning and the following action is recommended:

The house-owner should be made aware that a water supply after an earthquake could be valuable, and be encourated to fasten his existing hot water cylinder into place. NZS 4603:1976 *Installation of thermal-storage electric water-heaters* should require that:

- domestic hot-water cylinders be firmly secured into place (with straps or other fastenings together able to withstand a horizontal force equal to the weight of the cylinder and its contents)
- that a practical drain for recovery of the water be fitted and
- that attention be drawn to the means of drawing the water in emergency.

## 6. REFERENCES


[1]ELKIS, W. J. (1975): *A hot-water cylinder to survive earthquake,* Wellington, Building Research Association of New Zealand, Publication pending.

[2]SHEPHERD, R. ET AL. (1970): The 1968 Inangahua earthquake. *Canterbury Engineering Journal,* 1 June: p. 3, 23.

[3]ELKIS, W. J. (1977): *Economics of domestic hot-water-cylinder insulation.* Wellington, Building Research Association of New Zealand, (Report R26).


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