Earthquake Protectic Of Chattels and Ligl Office Equipment

Report to The New Zealand National Society for Earthquake Engineering

Prepared by A.W.Charleson
School of Architecture
Victoria University of Wellington

A Technical Group of the Institution of Professional Engineers New Zealand (Incorporated) ... Publishers of 'Bulletin of the New Zealand National Society for Earthquake Engineering'

The New Zealand National Society for Earthquake Engineering

Administrative Secretary R.J.S. Burns, National Bank Building, 170 Featherston Street, Wellington. Telephone 727-787, Telegram 'COLYBRAND'

P O Box 243.
Wellington, New Zealand.

30 June 1989

Mr Milton Allwood
General Manager
Earthquake and War Damage Commission
PO Box 31-342
LOWER HUTT

Dear Milton

RESEARCH PROJECT
EARTHQUAKE PROTECTION OF CHATTELS AND LIGHT OFFICE EQUIPMENT
AW CHARLESON SCHOOL OF ARCHITECTURE VUW

Please find enclosed two copies of the report submitted by Mr Charleson in fulfilment of his research project.

The Society recommends the report to you, and further recommends that you view with favour Mr Charleson's proposal for the production of booklets for public awareness.

Mr Charleson has prepared a video presentation which graphically shows the effectiveness of his recommendations for securing of chattels and equipment. You might like to invite him to make a short presentation so as to take full advantage of his work.

The full amount of financial support has now been paid out to Mr Charleson.

The Society will be pleased to assist further in implementing the recommendations of Mr Charleson's report.

Thank you for making this contribution to research towards investigating the effect of earthquake in the nation's social and economic interest.

Yours sincerely

Bruce Shephard

Bruce Shephard
President

Encl

27/7/90
Mr. Charleson called to discuss use of material in this booklet. He give verbal permission to EQC to use the information freely & in any way EQC thought appropriate.

A Technical Group of the Institution of Professional Engineers New Zealand (Incorporated) and Publishers of 'Bulletin of the New Zealand National Society for Earthquake Engineering.

The New Zealand National Society for Earthquake Engineering

Administrative Secretary R.J.S. Burns, National Bank Building, 170 Featherston Street, Wellington. Telephone 727-787, Telegram 'COLYBRAND'

PO Box 243.
Wellington, New Zealand.

30 June 1989

Mr Milton Allwood
General Manager
Earthquake and War Damage Commission
PO Box 31-342
LOWER HUTT

Dear Milton

RESEARCH PROJECT
EARTHQUAKE PROTECTION OF CHATTELS AND LIGHT OFFICE EQUIPMENT
AW CHARLESON SCHOOL OF ARCHITECTURE VUW

Please find enclosed two copies of the report submitted by Mr Charleson in fulfilment of his research project.

The Society recommends the report to you, and further recommends that you view with favour Mr Charleson's proposal for the production of booklets for public awareness.

Mr Charleson has prepared a video presentation which graphically shows the effectiveness of his recommendations for securing of chattels and equipment. You might like to invite him to make a short presentation so as to take full advantage of his work.

The full amount of financial support has now been paid out to Mr Charleson.

The Society will be pleased to assist further in implementing the recommendations of Mr Charleson's report.

Thank you for making this contribution to research towards investigating the effect of earthquake in the nation's social and economic interest.

Yours sincerely

Bruce Shephard

Bruce Shephard
President

Encl

EARTHQUAKE PROTECTION OF CHATTELS AND LIGHT OFFICE EQUIPMENT: REPORT TO THE NEW ZEALAND NATIONAL SOCIETY FOR EARTHQUAKE ENGINEERING

1.0 INTRODUCTION

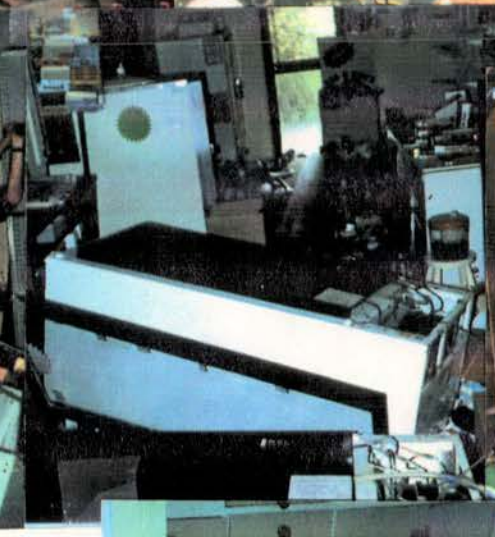
This study was initiated immediately after the author's visit to the 1987 Bay of Plenty earthquake damaged region. Several days after the earthquake some of the badly damaged areas in and around Edgecumbe were visited. The aspect that stood out was that, although in general there was not any major structural damage, there was enormous damage to chattels, plant and other equipment. Further, it was noted that in many cases this extensive damage could have been easily prevented with the use of simple, common-sense fixing devices. For the people living in the area the opportunity to protect chattels and light office equipment had passed. Objects of considerable sentimental and commercial value were destroyed. Large personal and office losses had been sustained.

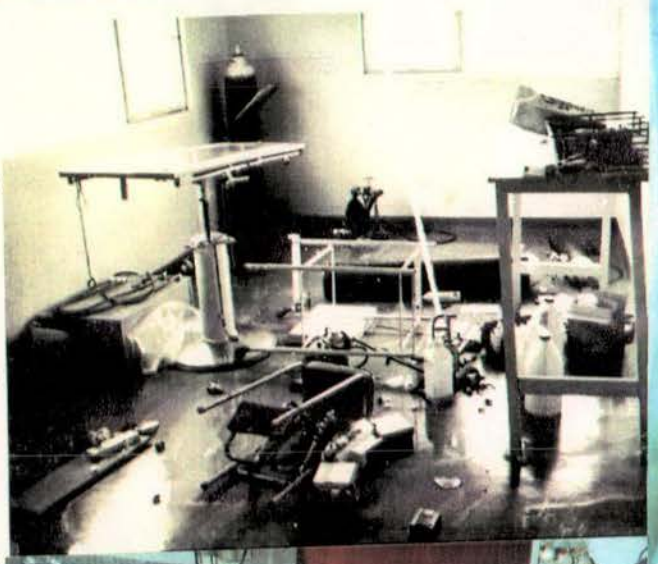
As the occurrence of this type of earthquake damage was reflected on, it seemed that there had been little research in this area and little guidance given to enable people to protect their chattels or light office equipment from damage. A lot of research and dissemination of information as to how buildings themselves behave in earthquakes has been done. Some work has been done on the seismic protection of plant items in buildings but apart from brief statements in publications like civil defence brochures, home and office contents have been all but completely neglected.

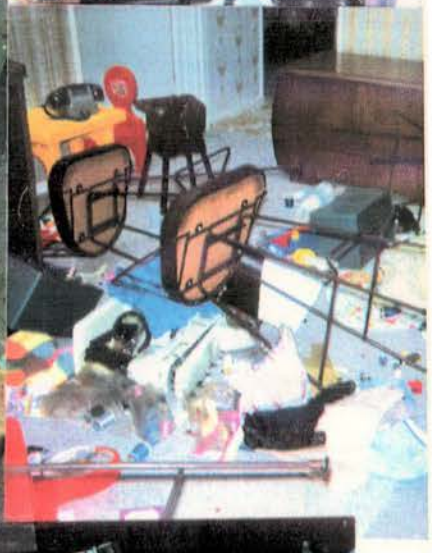
The scope of this study then is the mitigation of earthquake damage to the contents (chattels) of home and offices. A wide range of research approaches have been used. They include literature surveys, experimental work, design, field work and subsequent analysis. Each facit of the study will be reported on.

The aim of the study has been to develop practical and inexpensive techniques that can be widely used in the community to reduce losses in future earthquakes.







ACKNOWLEDGEMENTS

Financial assistance from the Internal Research Committee of Victoria University of Wellington and from the New Zealand Earthquake and War Damage Commission in conjunction with The New Zealand National Society for Earthquake Engineering is gratefully acknowledged. The contribution of several senior students, secretarial and technical staff from the School of Architecture, Victoria University, and the assistance and information received from many people in the Bay of Plenty region is also acknowledged.

A.W. Charleson,
Senior Lecturer, Building Structures,
School of Architecture,
Victoria University of Wellington,
P.O. Box 600,
Wellington.

February 1989

TABLE OF CONTENTS

1.0 INTRODUCTION

This study was initiated immediately after the author's visit to the 1987 Bay of Plenty earthquake damaged region. Several days after the earthquake some of the badly damaged areas in and around Edgecumbe were visited. The aspect that stood out was that, although in general there was not any major structural damage, there was enormous damage to chattels, plant and other equipment. Further, it was noted that in many cases this extensive damage could have been easily prevented with the use of simple, common-sense fixing devices. For the people living in the area the opportunity to protect chattels and light office equipment had passed. Objects of considerable sentimental and commercial value were destroyed. Large personal and office losses had been sustained.

As the occurrence of this type of earthquake damage was reflected on, it seemed that there had been little research in this area and little guidance given to enable people to protect their chattels or light office equipment from damage. A lot of research and dissemination of information as to how buildings themselves behave in earthquakes has been done. Some work has been done on the seismic protection of plant items in buildings but apart from brief statements in publications like civil defence brochures, home and office contents have been all but completely neglected.

The scope of this study then is the mitigation of earthquake damage to the contents (chattels) of home and offices. A wide range of research approaches have been used. They include literature surveys, experimental work, design, field work and subsequent analysis. Each facit of the study will be reported on.

The aim of the study has been to develop practical and inexpensive techniques that can be widely used in the community to reduce losses in future earthquakes.

2.0 LITERATURE SURVEY

2.1 Reduction of earthquake damage in the domestic environment.

A very limited amount of literature is available on this topic and what there is, is of a very general nature. Yanev (1974) briefly describes the damage that chattels are likely to experience and suggests in general terms some preventative measures a householder can take. An even briefer treatment is provided by Cooney (1982). In both of these references the emphasis is on the damage to the houses themselves.

In spite of an international data base search no information was obtained on work done in North America. However, Selvaduray (1986) reports on Japanese efforts in reducing earthquake hazards in domestic and office situations. He emphasises that the development and marketing of fixing devices to restrain chattels and office items has been undertaken by private companies in response to consumer demand. Further information on these Japanese developments has been sought, but to date no information has been received. It is still being followed up as it is obvious that the Japanese are more conscious of the need for this type of protection than are other nationalities.

The other brief and general references to the need to protect chattels comes from information typically produced by civil defence and earthquake preparedness organisations. Examples are given by Leslie (1988) from Southern Californian literature but only several sentences relate to chattels, and their emphasis is on the potential hazard to injury that they represent, rather than on the securing of chattels for their own sake. The same can be said of the publication by Wellington Civil Defence (1987). The importance of securing hot water cylinders is covered, and specific details are given, but apart from a consideration of the potential hazards from falling and overturning chattels, the damage and destruction of the chattels themselves seems to be merely fatalistically accepted.

2.2 Reduction of earthquake damage to light office equipment.

There was more useful literature in this area. Tailby (1988) summarises what was available with the two main sources being McGavin (1981) and Merz (1975). Of these McGavin gives details of seismic restraint to some equipment. Generally the concentration of seismic awareness is on plant whose seismic protection is already covered by New Zealand Codes; namely NZS 4203 (1984) and NZS 4219 (1983). There certainly is mention in earthquake damage reports literature of damage to plant, but again there is little mention of light equipment or the contents of offices and laboratories.

One area of exception is that dealing with seismic protection of main frame computers. There is some information available on this subject which has been summarised by Tailby.

3.0 EXPERIMENTAL WORK

In this section the experimental work performed as part of this study will be described.

3.1 Fixings into gib-lined walls.

At an early stage in the study it was recognised that the success of developing fixings to secure chattels would depend on reliable fixings to timber stud, gib-lined walls, which would be the most common wall construction. It was felt impractical to specify fixings that relied upon screwing into studs, as not only could their locations be unsuitable for the fixing that is required, but they are difficult to locate and to screw into in such a way that the strength is reliable. For example, sometimes the screw could be unknowingly located so close to the side of a stud that the pull out or shear strength of the screw could be greatly diminished.

When the range of commercially available cavity wall fasteners was examined, although safe working loads were usually given by the manufacturers, these loads were obviously based on tests using overseas materials. Also the direction of loadings relative to the walls was not given. It was therefore considered prudent to undertake a range of tests to determine the strength and stiffness characteristics of the fasteners as related to local useage. It was also important to develop an understanding of their performance, and especially their failure mode - brittle or ductile? Only after this information had been obtained could fixing schemes be designed with confidence.

A simple testing frame was set up (Figure 1) and the fixings loaded incrementally, and in a static loading situation, by increasing the load until failure occurred. Usually the deflections as well as the load were monitored. For most fixings the loads were applied in three directions:- direct pull-out; direct shear (vertical); and at 45 degrees to the wall (combination of direct pull-out and shear). A summary of the results is presented in Table 1. The results given are the average results for three tests. 9.5mm gib-board was used in all tests.

A range of fasteners to be tested was chosen according to several criteria. First, the fasteners had to be able to be removed when furniture or ornaments were relocated. Secondly, they had to be readily available in hardware shops. Diagrams of the various types are shown in Figure 2.

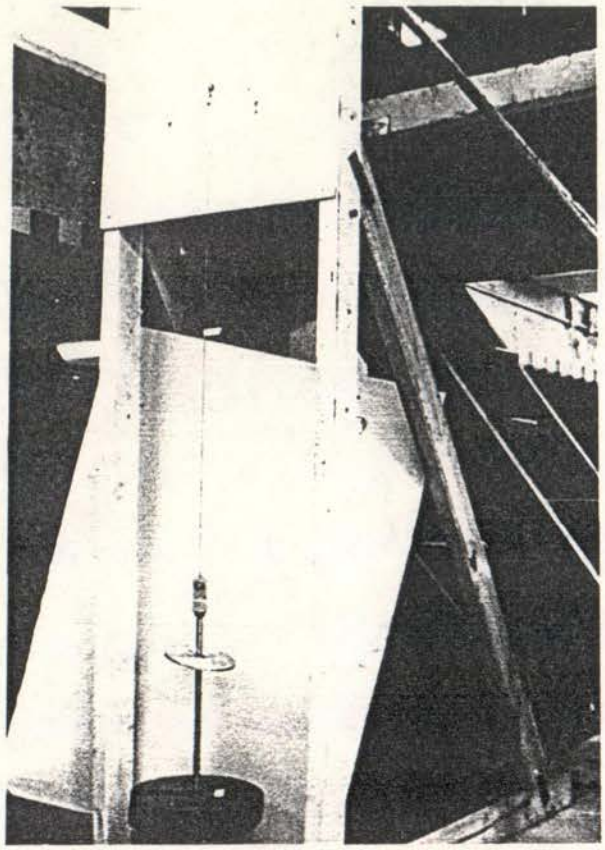


Figure 1: Gib Fixing Test Frame

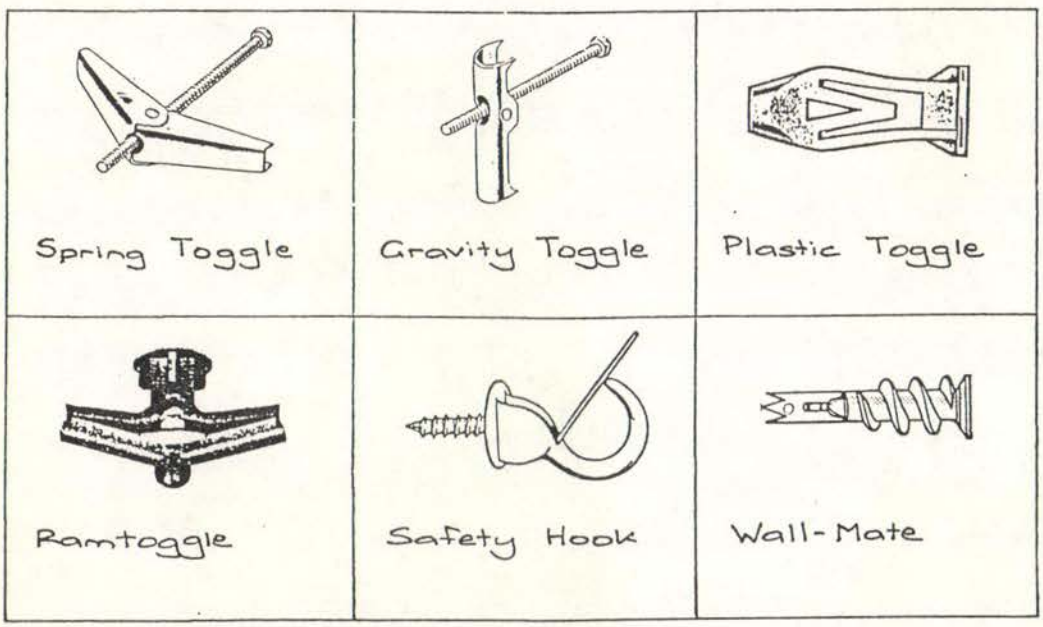


Figure 2: Types of Fasteners Used

Fastener Type	Direction of load	Failure load (Kg)	Stated Working load (Kg)	Comments
Ramset spring toggle 716217	Shear pullout 45° pullout	77.5 35.6 45.6	20	toggles pulled through gib-board in all cases
Ramset spring toggle 719119	Shear pullout 45° pullout	89.9 34.6 52.0	20 (for 12mm plaster board)	toggles pulled through gib-board in all cases
Ramset gravity toggle 716033	Shear pullout 45° pullout	54.7 25.0 32.3	15 (in 12mm plaster board)	toggles pulled through
Ramset ram-toggle 740021	Shear pullout 45° pullout	55.7 29.3 37.0	16	toggles pulled through
Ramset plastic toggle 740007	Shear pullout 45° pullout	55.0 23.3 41.0	10	toggles pulled through
Buildex Wall-Mates plasterboard anchor	Shear pullout	55.7 20.3	20	Fixing pulled through
Ramset safety hook 731289	Shear pullout 45° pullout	15.0 23.0 16.0	5	Only one test in each direction. In every case the metal hook fractured. The hook was screwed directly into wood.

Table 1: Results of Tests on Cavity Wall Fasteners

Some observations can be made from Table 1. First, apart from the safety hook which is not fastened into gib-board, the fasteners were considerably stronger for shear loads as compared to direct pullout. The average ratio of shear to pullout strength was 2.32. For most applications involving seismic restraint of items attached to walls the pullout strength is of the most relevance. Another interesting aspect is the comparison between the failure loads and the manufacturers' stated working load. The average factor of safety of 4.0 is what the industry often works to. From a strength aspect alone such a high value seems excessive but when the fasteners' deformations under load are considered the safe working loads become more reasonable. For example, at the specified working load the average deformation of the gravity toggle No. 716033 was 1mm. At twice that load the deformation was 5mm - quite unacceptable for a working load situation.

In all cases the mode of failure was by the fixing pulling through the gib-board. This is obviously not ductile behaviour and so for seismic loads there must be a factor of safety used.

There were difficulties installing the Ramset ram toggle and its use is not recommended.

3.1.1 Design Loads of Fixings

The Parts and Portions section of New Zealand Loadings Code (NZ 4203) was used to obtain design values. For single storey buildings "maximum roof accelerations will not exceed 1.8 x g/3 = 0.6g". So for fixed chattels 0.6g is taken as an upper bound of the horizontal acceleration that will occur. Thus if a fixing is sized for an acceleration of 1g there will be a factor of safety = 1.67. This seems reasonable and is suggested as a design approach. Thus a Ramset gravity toggle is suitable to secure up to a 25 Kg object in a single storey building. For multi-storey construction it is suggested that the allowable weights previously suggested should be divided by 2.0.

3.2 Nylon Monofilament.

One of the primary requirements of seismic restraining systems for chattels is that they are not visually obtrusive. In this aspect nylon is a very suitable material as under some conditions it is almost invisible.

As for the cavity wall fasteners, it was deemed necessary, before specifying its use, to carry out a testing programme in order to develop an understanding of its behaviour under load.

A very simple test set-up was used where loads were manually applied until the nylon failed in tension. Three sizes of filament were tested with each being a different brand. In every case the failure load was less than the specified strength, measured ranging between 7% and 29% of those indicated on the packaging. Obviously an allowance for this reduction in strength must be included in the design approach. The elongation of the nylon was measured over a 200mm gauge length. The breaking strain varied from 0.15 to 0.22. In all tests the nylon broke away from the knots and fixings.

A major concern with nylon is the reduction of strength due to both aging and the effect of ultraviolet light. In spite of literature searches and correspondence to nylon manufacturers no quantitative information on this problem has been obtained, so it is proposed that a factor of safety of approximately 3.0 be used for nylon. In addition, users should be made aware of the problem. Hence, in a single storey building the stated nylon strength should be equal to twice the weight of the restrained item. (In most cases however it will be more convenient to use stronger nylon than that required for strength alone due to greater ease of tying knots and handling.)

3.2.1 Fixings Associated with the use of Nylon.

As fixing systems using nylon were developed it was found convenient to use swivels and snaplink clips to make connections between the various parts of the restraint system (Figure 3). Snap links have been found to be useful in enabling the restrained object to be removed from its location for cleaning or some other purpose.

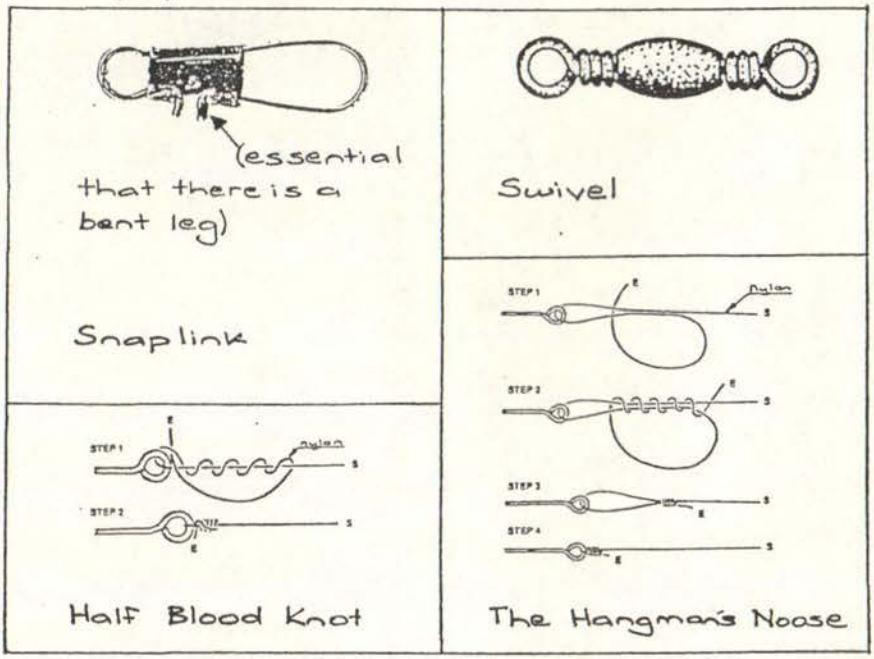


Figure 3: Snaplink, Swivel and Knots

A series of tensile tests were done on swivels and snap links. When used together it was the snaplinks that always failed although in some cases substantial yielding had already occurred in the swivel. The snaplinks failed by large deformations in the larger loop causing the free end to break free. (One unidentified brand of snaplinks (see Figure 3) had an inadequate bent leg length and suffered premature failure. The use of this type should be avoided.)

If the same design criteria for swivels and snaplinks are used as for fasteners (i.e. a factor of safety of 1.67) the allowable weights to be restrained by given sizes can be determined.

Dimensions (mm)		Weight (Kg)
Swivel	Snaplink	
19	22	12.5
32	32	20
42	38	40

Table 2. Maximum weights to be restrained by swivels and snaplinks for single storey buildings (For multi-storey buildings divide weight by 2.0)

Recognised knots were used in all tests. Both the Half Blood Knot and the Hangman's Noose Knot performed very satisfactorily. These knots are described in detail by Hungerford (1979) and others in books about fishing.

3.3 Tests on Blu-Tack.

During discussions with several people affected by the Bay of Plenty earthquake (refer to next section) the usefulness of Blu-Tack in restraining light chattels became clear. In several instances valuable pieces of crystal and china had been fixed to shelves with Blu-Tack and had suffered no damage during the earthquake. Other pieces not fixed had fallen off and were broken.

It was decided, therefore, to perform a series of tests on Blu-Tack to try to learn more about its engineering (i.e. strength) properties. Tensile tests and direct shear tests were performed. The testing done was no more than that for an initial testing programme. An indication was required of factors such as:- the influence of different surfaces and textures on adhesion; whether or not the material exhibited an "angle of internal friction" and what its tensile and shear properties were. Other, probably significant factors such as the influence of aging, the rate of loading and the method of application were not addressed. These areas should be addressed in future research.

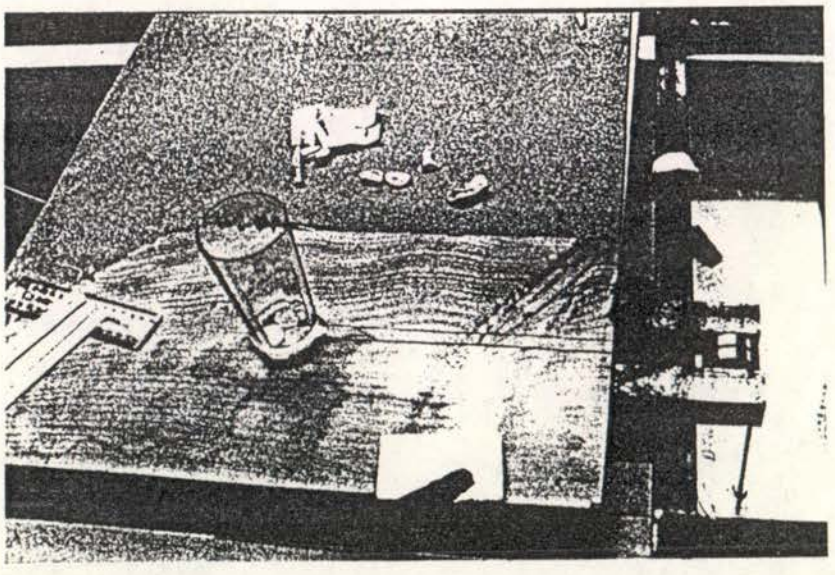


Figure 4: Blu-Tack Test Rig

Once again simple rigs were set up for the shear tests (Figure 4) and tensile tests. A summary of the findings is as follows:-

(a) The shear strength of Blu-Tack between glass and three surfaces - smooth painted particle board, polyurethaned timber, and glass, was not significantly affected by the type of surface.

(b) There was an indication of an "internal friction effect", but unlike an ideal soil the influence of normal pressure on the strength was generally not linear.

(c) The average shear strength of Blu-Tack over the range of surface materials and with normal or vertical pressure ranging from 1.84 kPa to 15.8 kPa (a total of 36 tests) was
35 kPa with a standard deviation of 7.2 kPa.

(d) The tensile test, again with the three materials, indicated an average failure stress of 55 kPa with a standard deviation of 13.2 MPa. 18 tests were performed.

Due to lack of resources it was decided not to enlarge the scope of this static testing of Blu-Tack but to test it on the shaking table. It was also felt that for the purposes of this report, which is seeking to provide information useful to householders and office managers, there was little to be gained from a more in-depth study at this stage as it would be unrealistic to expect Blu-Tack in most situations would be used in a precise, scientific manner.

3.4 Shaking Table Tests.

The purpose of these tests was to test some restraint designs in order to ensure that they were truly effective. The shaking table used was merely a set of two shelves suspended by wire from a support high above (Figure 5). When displaced horizontally there was no appreciable vertical component of movement. An accelerometer was attached to the table and accelerations were recorded on a chart recorder. The duration of each test was recorded by a clock. All tests were recorded by video film equipment so as the test could be studied at a later date. The shaking was produced by a person holding onto the table and it was done in either one of the orthogonal directions at a time. As mentioned, various restraint systems were tested and each will be reported on separately. Usually identical items were placed on both shelves so as the performance of the restrained items on the top shelf could be compared to the unrestrained items.

Figure 5: Shaking Table

3.4.1 Use of Curtain-wire.

Curtain-wire, the plastic sheathed steel spring wire, has long been used as a restraint for cupboard shelf items. Its appeal lies in the fact that it is flexible enough for easy installation and removal, and it can be displaced easily to remove an object from the shelf. As well, the light coloured plastic sheathing is not unpleasant.

Thirteen tests were made to investigate and improve upon the use of curtain-wire as a restraint for items represented by bottles.

It was found that, in general, one curtain-wire was only partially effective in restraining shelf items from falling off. In the tests, wine bottles were the items shaken and it was found that if the wire was too low (say 70mm above the shelf) with respect to the height of the bottles then the bottles toppled over the wire. If the wire was higher then there were two potential problems. First, bottles that had fallen over onto the shelf would roll under the wire and fall off; otherwise full bottles might fall against the wire and press it down, resulting in other bottles toppling over it.

Certainly for bottles (including full bottles) the only satisfactory solution was to use two wires, the lower wire to be approximately 75% of the diameter of the bottles, to stop rolling off; and the higher wire to be at approximately 75% the height of the bottle to prevent toppling of the bottle over the wire.

So for items like preserving jars and bottles the use of two wires is recommended. For squatter objects like boxes or cartons then one wire just above their half height would be sufficient.

In these and other tests extremely vigorous shaking was used. Frequently accelerations of over 1g were recorded and so these restraints would be effective for intense earthquake shaking. (Typical output from the accelerometer is shown in Figure 6).

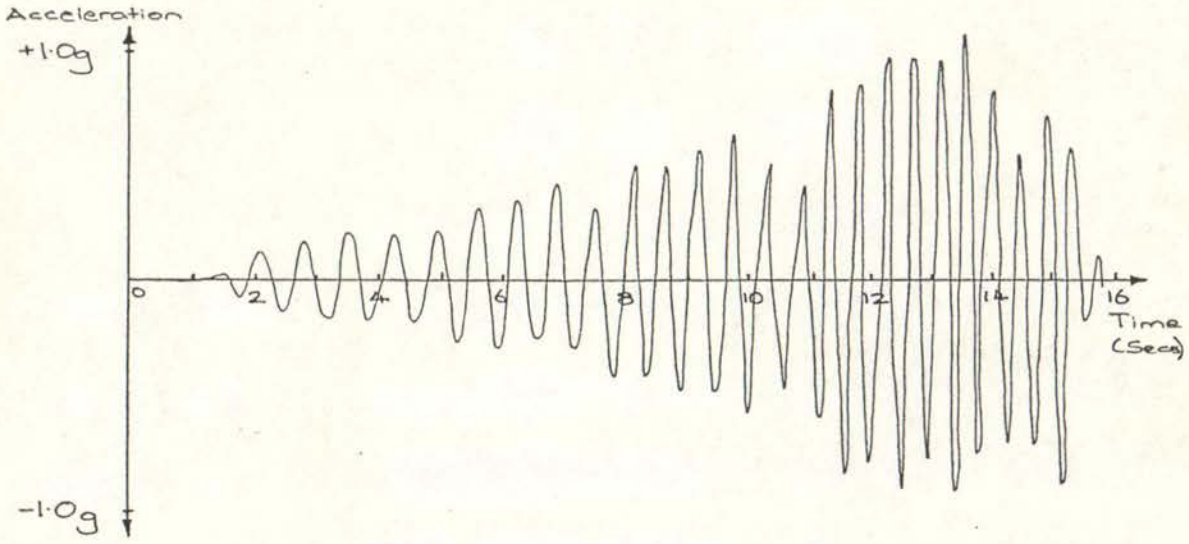


Figure 6: Typical record from a shaking table test

One curtain-wire was tested for its effectiveness in restraining a low pile of plates. It was found to be reasonably effective but not fail-safe. However, it would still be worth using in this situation.

3.4.2 Lip on the Edge of the Shelf.

A 20mm x 20mm wooden lip was attached to the outer edge of the shelf. This method has been advocated in some quarters as being a suitable restraint system. Empty jam jars less than 100mm high were placed on the shelf which was then shaken. For shaking with a period of vibration of 0.5 secs. and for a maximum acceleration of 0.8g the lip was effective. When an impulse shock was given, by suddenly pulling the shelf away from the jars, seeking to have them topple off, the lip was also effective up to an acceleration of over 1.2g. For items such as cups (upside down), coffee mugs and drinking glasses where their height is less than 5 times the height of the lip, then a lip would be considered to be quite effective, although not fail-safe.

Low piles of plates were also tested using the lip. Once again the lip was certainly advantageous as it prevented them falling until an impulsive acceleration of over 1.2g was used. At lower accelerations the bottom plates were restrained and the top plates rather wildly slid to-and-fro. The lip certainly is useful for this type of stored contents.

3.4.3 Items Restrained using Blu-Tack.

In these tests drinking glasses and bottles were fixed to the shelf using three equally spaced pieces of Blu-Tack. The diameters of the squashed Blu-Tack pieces were approximately 11mm.

Blu-Tack was completely effective for the glasses. Shaking with a period of vibration of 0.3 seconds and accelerations greater than 1g failed to cause toppling. The duration of intense shaking was about 12 seconds. The non Blu-Tacked glasses toppled and fell at a very early stage.

As expected the Blu-Tack was not quite so effective for bottles. However, acelerations of up to 1g were sustained before restrained empty bottles fell, and up to 0.65g for full bottles.

Certainly for lighter and squatter objects Blu-Tack is very effective as a seismic restraint. As mentioned in the previous section, the main unknown of concern to householders using it in this way is its aging characteristics. It is proposed to get more information on this area from the manufacturers.

3.4.4 Nylon restrained items.

In these tests various items were restrained using nylon tied to them and the cavity wall anchors. As previously discussed, nylon is well suited to this use due to its lack of visibility and also its strength. For most of the tests flagons were used as examples of the items to be restrained, and nylon was tied to the neck at one end, and to the wall fixing at the other.

It was found that under intense shaking the flagons were adequately prevented from falling off but were being strongly flung around. An attempt to reduce this "flinging" was made by threading the nylon through clear plastic tube of the same length. The situation was improved, suggesting that this enhancement might be recommended for more fragile objects. On several occasions during these tests the nylon around the neck of the flagon was so strained that it slipped off, allowing the flagon to fall. All such fixings must be tight to prevent this occurrence.

Initially each flagon had its own fixing back to the wall, but because this is relatively inefficient a scheme was tried whereby several flagons were attached to a length of nylon which ran along the shelf and was fixed to to the wall at each end. The nylon was divided into several lengths connected by swivels, and to each swivel a flagon was attached. The use of intermediate swivels meant that the flagons were prevented from sliding along the shelf and colliding with each other. Excellent performance was obtained from this system irrespective of the direction of shaking and whether or not the flagons were full.

The same system was tried for a radio-cassette player. Again it was totally successful in preventing it falling from the shelf. The other unrestrained radio fell off.

The principle of using a horizontal nylon restraint was then modified by not using the intermediate swivels. Each bottle was then able to slide in towards the centre during the shaking. Once again this system was perfectly adequate in preventing any bottles from falling and so can be recommended.

4.0 FIELD WORK

4.1 Visits to 1987 Bay of Plenty Earthquake Damaged Areas.

The first visit was made five days after the earthquake. Due to other commitments only one day could be spent in the region, but as mentioned previously, those observations inspired the initiation of this study. At that time it was not possible, for many reasons, to visit private homes or offices to survey the damage. People were still shocked and upset, and in the process of getting their situations back together again. It was necessary to wait for a time, and then return.

It was almost one year later, in February 1988, that a more extensive visit was made with a senior student from the School of Architecture. Preparation for this visit had begun in August 1987 when letters were written to the Editors of the Whakatane Beacon newspaper and the Kawerau News Gazette. They were informed of the study and it was suggested that a press release about it could be made in which a request was made for people to contact the author with information about their chattel losses. As a result of this publicity, letters from eleven people were received. These people were contacted and photographs were requested. Enough initial contacts had been made to form the basis of a visit to the Bay of Plenty.

One of the respondents to the news release was the curator of the Whakatane Museum. He was the first visited and made available for our perusal and copying the large amount of photographic material that had been collected. In the process of working through these photographs other contacts were made and subsequently visited.

The next stage of the field study was to visit the contacts who had the most information to contribute. About fifteen people were visited in their homes. More photographs were obtained, and people described exactly what had happened in their homes during the earthquake. It was most encouraging to be greeted and briefed so enthusiastically. All those contacted were so pleased to help because they could see the potential usefulness of the outcomes of a study like this. The local press was keen to follow up progress on the project and a report of an interview is in Appendix A.

4.1.1 Information gathered on damage to domestic chattels.

Having obtained a lot of information on the damage to household chattels through photographs and personal interviews the material was then collated, analysed and is summarized below. (The photographs which have been referenced are not included in the report).

ROOM	CATEGORY	PHOTO NO.	DAMAGE	COMMENTS
Kitchen/ Dining	Refrigerator	1	Movement, 150mm from wall	
		1,19,83	Doors opened, contents spilled and broken.	
	Stove	6	Movement, 150mm	
		17	Drawer came out.	
	Dishwasher	19	Door opened	
	Cupboards	2	Doors opened, pots and pans, cooking utensils fallen out (Below bench).	Accept damage
		3,4,5,7	Doors opened.	Egress from
		12,19,82	Crockery bowls, china	kitchen
		83	fallen out.	impossible for a handicapped person.
		12	Preserving jars fell and smashed	A hazard to life.
	Furniture	18,21	Stools overturned	
	Desk	18	Sewing machine and sewing items fell	
	Wall	2	Pictures swung on picture hooks	
	Shelving	19	Items fell off	
		20	Shelves broke loose	
	Bench	5,17,21	Microwave, bench oven fell off. TV set fallen off.	Egress from kitchen impossible for a handicapped person.
		9,21	Electric beater, toaster, jars and loose items fallen.	
		14	Blender fallen off.	
		16	Mixing bowl broken due to falling plate.	
		19	Toaster, milkshake machine fell.	
	Pantry	8,10,13	Goods spilled onto floor	Could be hazardous
Dining/ Lounge	Bookcase	22	Tipped over spilling contents.	
		23	TV set fell off, ornaments fell.	
	Bookcase (contd.)	29	Stereo set moved on top of case.	
		47	Tilted over, all books spilled.	

ROOM	CATEGORY	PHOTO NO.	DAMAGE	COMMENTS
Dining/ Lounge (contd.)	Wall cabinet and Mantelpiece	22,44	Cupboard door broke off.	Hazardous
		25,93	Vases, glasses fell off.	Hazardous
		26	Speakers fell off.	
		32	Fragile objects broke inside. (Glass door prevented spillage).	
		37	Fan fell	
		41	Glass shelves and objects fell to floor off a corner cabinet.	
		44	All contents spilled.	
		49	Low cabinet overturned, TV set fell and drawers came out. Ornamental plates fell. Grandfather clock toppled.	
	Table/ Desk	28	Pot plants overturned.	
		33	Small table with TV set both overturned.	
		40	Low table had TV and video fall off.	
		45	Sewing machine fell off.	
		44,49	Drawers came out of desk.	
		52	Trolley overturned.	
	Floor	43	Pot plants overturned.	
		29	TV set overturned.	
		32	Speakers overturned, objects on top fell.	
		33,46	Lamp overturned.	
		34,40,45	Chairs overturned.	
		57	Heater overturned.	Hazardous
		48	Free standing clock overturned.	
	Fireplace	43,57	Free standing fire-place shifted. Objects on top fell.	
	Miscellaneous	38	Large amounts of china and crystal broken	
		48	Hanging light fixture fell. Pictures fell from walls. Piano overturned.	Hazardous

Bedroom	Chest of drawers	59,65,71	Drawers fell out.	
		59,61	Items on top spilled.	
		60	Radio clock fell.	
		65,72,74	Toppled.	
		75	Mirror on top fell.	
	Bed	58	Water bed moved.	
		72	Head board toppled onto bed.	
	Appliance	62	Stereo toppled	Screwed-on wall cabinet OK
	Shelves	64,71	Ornaments fell onto bed.	Hazardous if heavy
		67,71	Glass shelf fell.	Hazardous
		67	Radio/stereo fell.	
	Miscellaneous	76	Pot plants toppled.	
Laundry/ Bathroom	Bench	77	Items on top fell.	
		80	Tray fell breaking toilet bowl.	
	Cupboards	80	Cupboard contents spilled.	
		79	Medicine cabinet contents spilled.	Vital medicine could be destroyed
	Appliances		Wall mounted washing machines and driers fell.	
Garage/ Storeroom	Miscellaneous	84,98,100	Cabinet and items	
		84	toppled onto floor.	
		87,92	Lights toppled.	
		88	Shelving toppled.	
		89	Sewing machine fell from desk.	
		96	Unattached shelves fell.	
			Hot water cylinders damaged and fell.	Water damage
Hallway	Cupboards	91	Doors opened spilling contents.	
	Shelving	97	Contents spilled.	
	Miscellaneous	91	Pot plants toppled.	

The next step was to try to devise/design and detail restraint systems to cater for the majority of the damage described above. These systems, some of which have been tested on the shaking table, are described in detail later in this report.

4.1.2 Information gathered on damage to light office equipment.

Visits were made to a number of offices, industries and the Whakatane Hospital. Where possible, eye witnesses of the damage were interviewed in order to get as complete a picture as possible of the damage caused to light office equipment. The following is a summary of the damage that occurred (from Tailby).

SPACE	DAMAGE
Office	Filing cabinets overturned with some drawers flying out. Cupboards toppled over or contents were spilled when weakly secured doors opened. Free standing shelves fell over, often preventing egress from rooms. Photocopier slid off desk. Typewriter fell off desk. Office equipment damaged by falling ceiling tiles and water when fire sprinklers were damaged by falling ceiling tiles. Computers affected by dust and water from damaged ceilings.
Laboratory	Equipment and supplies fell of shelves. Test equipment fell off benches. Glassware fell from cupboards.
Storage area	Goods spilled all over floor.

It was surprising that computer equipment did not sustain more direct damage due to falling off desks etc. It is thought that the intensity of shaking was just insufficient to overcome the high friction pads under some of these machines. Certainly it would be recommended that such high value and important equipment be positively secured against earthquake damage.

In the following section of the report specific restraint systems and recommendations for preventing damage to light office equipment is made.

4.2 Evaluation of Bay of Plenty earthquake damage claims.

With the permission of the Earthquake and War Damage Commission the files of a Wellington Loss Adjusting firm were made available for the purpose of extracting information. The first 58 files, which represented approximately 25% of this firm's involvement, were studied. The purpose of this exercise was first to check that claims had not been made for chattels which had not been previously identified as being "at risk", and secondly, to get an appreciation of the cost of damage. As mentioned, only a very limited amount of information was obtained, and it was not randomly selected. The files were only from the less affected suburban Whakatane and Ohope Beach area where the modified Mercalli Intensities were between VII and VIII, whereas the towns of Edgecumbe and Kawerau experienced MMIX shaking (Smith and Berryman, 1983).

A typical selection of the information obtained is shown in Appendix B. In the first column is the file number identifying the claim, usually a house; then the damaged contents are listed under convenient headings followed by the sum paid. The sum paid reprsents the cost of repair or the assessed indemnity value which ever is the lesser. The chattels were then sorted into groups (Appendix C) so that the damage cost of each type of chattel could be calculated and then the average settlement sum per house obtained. This information is presented in Table 3.

Chattel Description	No. of Houses	% Houses	Average Payment ($)	Total Cost ($)
Antiques	5	9	702	3513
Crockery	32	55	411	13163
Crystalware	24	41	276	6630
Furniture	18	31	246	4430
Glassware	20	34	623	12465
Hot Water Cabinet	6	10	155	935
Ornaments	25	43	561	14050
Stereos/TV	9	15	601	5416
				56057

(Total payments for all 58 claims was $64,000)

Table 3: Groups of Chattels and Payments made

The average payment per household, the standard $50 excess having been deducted, was $1,102. When the incidence of damage is considered, crockery damage was most prevalent (55% of claims) Obviously if a damaged area subjected to a higher MM intensity had been studied the incidences of damage to each of the groups of chattels would be expected to be significantly increased. It would be an interesting exercise to split the whole region up and do this exercise with a larger sample and compare the results. The difficulty with this is that the claim files are located throughout the country in the offices of those Risk Assessors who were acting for the Earthquake and War Damage Commission. It is hoped that in future a centralized data base might be able to be established so as all this type of information might be more readily available for analysis.

The payments for crockery, crystalware, furniture, glassware and ornaments represented 80% of the total payments. This is not surprising as they are the most "at risk" chattels in a house.

As already mentioned, due to the small sample and its specific location no extrapolation from this data should be made. The exercise was valuable, however, in confirming that no significant chattels had been overlooked in assessing chattels that are at risk.

Unfortunately no similar information on damage to commercial property has been forthcoming and so a similar exercise on office equipment has not been possible.

4.3 Survey of Houses.

A detailed survey of 15 homes was made in order to first get an appreciation of the value of chattels at risk, and secondly, to check that the restraint systems developed could be practically used in the actual situation. Because of the time consuming task of undertaking a survey of this type it was known that only a very small sample would be possible. Therefore at the outset the limited usefulness of the quantitative data was recognised. No attempt then was made to randomly survey Wellington City, but a convenient, well defined suburb, Karori, was chosen.

The suburb was divided into six equal areas and then streets and house numbers randomly chosen. Thirty-six letters were sent to householders requesting permission to survey their homes. Approximately eight replies were received so another 32 letters were sent. In all, 17 respondents gave their permission of which fifteen homes were surveyed. To help improve the response rate a press release had been made in the community newspaper (Appendix C). The response rate was 25%, which, as it turned out, was quite satisfactory.

Two senior students, a male and female, then visited each of the fifteen homes. Their task was to make a complete inventory of all "at risk" chattels in each house, take photographs, estimate age, vulnerability to earthquake shaking (loss ratio) and then to determine the replacement value of the chattels by getting current shop prices. From this information the expected earthquake losses and the indemnity value of the chattels could be obtained. An example of the data as collected is in Table 4.

Some comments on Table 4 are in order. Photographs were taken to assist with the determination of the replacement value of the items and also to refine the design of proposed restraint systems. The ages of the items were estimated, although sometimes the owner assisted. Regarding the value of each item, the owner was not asked unless the item could not reasonably be valued. Paintings and antiques fell into this category. In this case the owner's estimate was considered to be the actual replacement cost. The loss ratio was assessed subjectively on an item by item basis. Take appliances as an example. If the position of the appliance was such that it could not fall off a bench, or be damaged by falling objects from above the loss ratio would be low (say 10%). If on the other hand it was sitting on unstable supports on top of a refrigerator from which it could easily fall, the ratio would be in the order of 100%. Fragile chattels like glassware, crystal ware and ornaments were usually assigned loss ratios around 90%. The rate of depreciation also was difficult to assess so a despreciation guide provided by an insurance company was used. With the age and rate of depreciation set it was then possible to calculate the indemnity value. A summary is provided in Table 5.

PROTECTION OF CHATTLES FROM EARTHQUAKE DAMAGE (Research Project R67)
HOUSEHOLD SURVEY FORM:
ROOM:(Kitchen;kitchen/dining;dining;dining/lounge;lounge;bedroom;laundry;bathroom;hallway;
(1) (3) (5 (6) (7) (8) (9) (10)
shed;garage,other)
(11) (12) (13)

House No.	Space No.	Description of Chattels	No. off	Photo No.	Age: Yrs	Replacement Cost: Owner's est. $: (ea)	Actual $ (ea)	Loss Ratio %	Indemnity: % red./yr	Indemnity: value Act: $ (Total)	Comments
1	1	Appliance	1		5		400	50	7	260	Mixer
1	1	Appliance	2	1/12	5		50	50	10	50	Blender
1	1	Appliance	1		1		110	100	8	101.2	Food Processor
1	1	Appliance	1		5		85	10	15	21.25	Kettle
1	1	Appliance	1	1/13	8		70	10	10	14	Toaster
1	1	Bench Oven	1	1/10	3		1720	5	5	1462	
1	1	Microwave	1	1/10	3		440	100	15	242	
1	1	Refridgerator	1	1/10	2		1545	5	9	1266.9	
1	1	Dishwasher	1		7		900	5	10	270	
1	1	Crockery	40	1/11	10		3	100	10	0	
1	1	Kitchenware	5		5		40	100	4	160	
1	1	Picture	1		5		130	30	0	130	
1	1	Plants	1	1/10	1		20	50	0	20	
1	3	Crockery	110	1/8+9	12		15	100	0	1650	
1	3	Kitchenware	13	1/9	15		35	100	0	455	
1	3	Glassware	24	1/7	10		12	95	0	288	
1	3	Crystal	34	1/7	20		105	95	0	3570	
1	3	Vase	1		2		30	75	0	30	
1	3	Clock	1	1/8	20		120	50	5	0	
1	3	Picture	1	1/8	5	500	501	30	0	501	
1	5	Ornaments	25	1/5	20		55	90	0	1375	
1	5	Ornament	1		20	2000	4000	95	0	4000	
1	5	Pictures	7		10	1000	1001	30	0	7007	
1	5	Picture	1		12	14000	14001	30	0	14001	
1	5	Pottery	2	1/5	7	300	300	50	0	600	
1	5	Vases	4	1/5+6	6		50	95	0	200	
1	5	Clocks	2	1/6	50	400	1000	90	0	2000	
1	5	Mirror	1	1/6	10		100	95	3	70	
1	5	Plants	2		3		20	50	0	40	
1	5	Television	1		6		1300	75	8	676	
1	5	Stereo	1		1		150	10	15	127.5	
1	6	Pictures	11	1/14	10		150	30	0	1650	
1	6	Ornaments	4		4		22	95	0	88	

Table 4: Example of Data Collected in the Survey

House No.	SUMMARY Replacement Cost tot.	Total Loss	Indemnity Value
1	65848	30685	57822
2	15799	6505	11959
3	13555	7289	10270
4	35304	14921	31505
5	22018	10579	17842
6	32138	13396	25408
7	33770	21144	26878
8	75280	27790	69435
9	8708	4515	6600
10	15021	6970	12437
11	24910	9138	23754
12	8772	3950	5672
13	33429	17479	28926
14	13422	6860	10811
15	69670	42456	64877

Table 5: Summary of Survey Data

From the summary in Table 5 a large variation in the replacement cost of chattels per household is apparent, ranging from a maximum of $54,848 to $8,708. The ratio of total indemnity value to replacement cost for all houses of 0.86 appears too high. This could be due to a low estimate of the rate of depreciation. For may items, such as crystal, glassware, and ornaments where appreciation of value could have occurred, a depreciation rate of 0% was used.

The estimated average total loss of $13,980 is high; certainly when compared to the Whakatane figure of $1,102! The loss ratios used would be applicable to a very high intensity shaking, perhaps MMVIII and above. Even if the loss/house is 25% of that calculated above, representing a lower intensity of shaking, the average value of $3,500 is still very significant.

The summary also indicates that the maximum loss of chattels will probably be less than the indemnity value of all chattels.

Another summary of the data is presented in Table 6. Chattels are grouped and the average maximum loss/house is calculated. Some of the losses are high, for example for clocks. This is due to the influence of a collector's valuable collection of antique clocks. A similar situation occurs with crystal and paintings.

Groups of Chattels	No. of Houses	Average max. loss/house
Appliances	15	215
Clocks	14	843
Crockery	15	1313
Crystal	11	3300
Foodstuffs	15	358
Glass/glassware	15	746
Kitchenware	15	837
Lamps/Lights	13	65
Microwave	8	500
Mirrors	15	139
Ornaments	15	1608
Pictures/paintings	15	2360
Pottery	14	431
Refrigerator	15	45
Stereos	14	558
TVs	12	1309
Vases	13	312
Videos	8	283

Table 6: Groups of Chattels and Average Losses per House

It is interesting to compare in Table 7 the Whakatane damage cost to the average predicted loss per house in Karori. Apart from glassware, there is enormous variation.

Chattel Description	Average Payment ($) Whakatane	Max. Average Predicted Loss Karori
Crockery	411	1313
Crystal	276	3300
Glassware	623	746
Ornaments	155	1608
Stereos/TV	601	1867

Table 7: Comparison between Payments made in Whakatane and Maximum Average Predicted Losses in Karori

4.4 Survey of Commercial Premises.

As reported (Tailby) commercial premises were visited as well as several departments of the Wellington Public Hospital. The purpose of this survey was to identify light office equipment that is "at risk" and also any potentially hazardous features which could cause injury or damage other equipment.

A summary of the findings are presented in Table 8. The hazards are grouped under a number of element headings which were initially determined after surveying office and laboratory damage in the Bay of Plenty.

It was found that, on the basis of this very small sample size, almost no precautions have been taken to secure equipment in commercial buildings. Therefore there is a very large potential for damage to equipment and injury to people from the contents of these buildings. At the very least the damage experienced at the Bay of Plenty can therefore be expected to occur in Wellington, except that due to amplification of earthquake shaking in multistorey buildings the damage in Wellington would be greater for a similar intensity earthquake.

No costings were done to evaluate the probable direct and indirect costs due to office equipment damage, however in the next section examples of restraint systems that could be used to secure the equipment is given.

	BUILDING VISITED												
HAZARDOUS ELEMENT.	1	2	3	4	5	6	7	8	9	10	11	12	13
SUSPENDED CEILING													
UNBRACED	X	NA	NA	?	X	NA	?	?	?	?	?	?	?
LOOSE TILES	X	NA	NA	X	X	NA	X	S	X	X	X	X	X
CEILING FITTINGS													
LIGHTS	X	X	X	X	X	S	X	X	X	X	X	X	X
SPRINKLERS	X	NA	NA	X	NA	NA	X	X	X	X	X	X	X
WALL MOUNTED EQUIPMENT													
SHELVES	NA	X	X	NA	X	X	X	NA	NA	X	X	X	X
CUPBOARDS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	X	NA
LOOSE DESKTOP EQUIPMENT	X	X	X	X	X	X	X	X	X	X	X	X	X
FREE STANDING EQUIPMENT													
SHELVES	X	X	X	X	X	X	NA	X	X	X	X	X	X
CUPBOARDS	X	NA	X	NA	NA	S	X	X	X	S	S	S	NA
FILING CABINETS	X	X	X	X	X	NA	X	X	X	X	NA	X	X
PHOTOCOPIERS	X	X	X	X	X	NA	X	X	X	NA	NA	X	NA
COMPUTERS	X	X	X	X	X	NA	X	X	X	NA	NA	X	X
RAISED FLOORS	NA	NA	NA	X	NA	NA	NA	?	NA	NA	NA	NA	NA
SPECIAL HAZARDS													
AD-HOC STORAGE	NA	NA	NA	NA	X	NA	NA	NA	X	NA	NA	NA	NA
LOOSE MOBILE EQUIPMENT	NA	NA	X	X	X	NA	NA	X	NA	NA	X	X	X
LARGE APPLIANCES	NA	NA	X	NA	X	X	X	X	X	X	X	X	X

KEY

X HAZARD

NA NOT PRESENT

? UNABLE TO DETERMINE

S SECURE

Table 8: Summary of Earthquake Hazards

Source: John Tailby, ARCH 389 Research Report, October 1988

5.0 SYSTEMS FOR SECURING CHATTELS AND EQUIPMENT

In this section details are given of how to secure various items. Some of these details have been developed and tested as part of this study and others have been designed from a 'first-principles' approach. In some cases details have been drawn from other sources. First there are details primarily applicable to domestic situations, although with some application in office situations, and then systems for securing commercial equipment are presented.

This section concludes with a case study in which the restraints for chattels of a house are presented.

5.1 Household Chattels

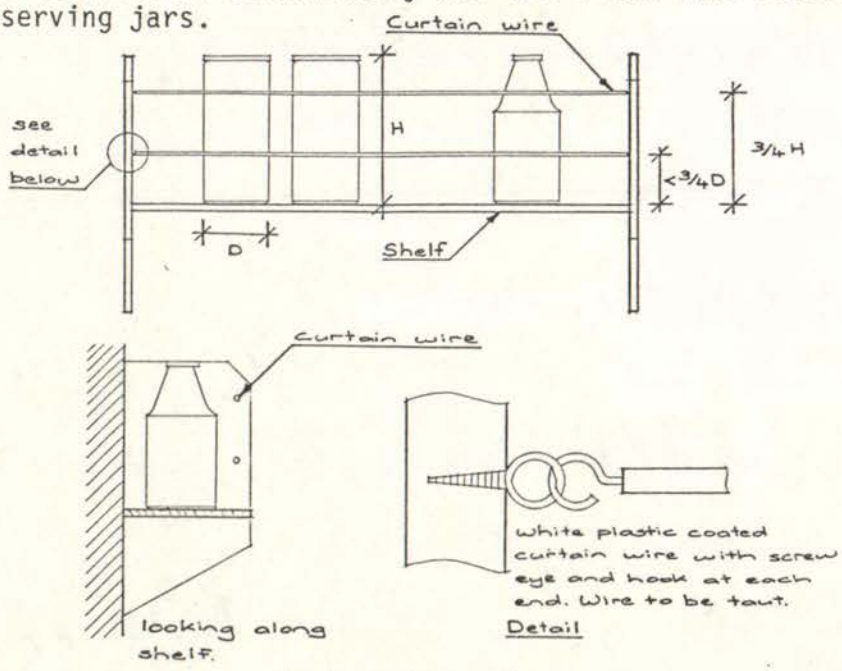
Before giving specific restraining details it needs to be restated that it is not proposed that all chattels be restrained. Only those chattels with sentimental and economic value warrant restraint. Further, it is important that any restraints are not visually obtrusive, and also that they do not affect the day to day functioning of the area. These principles have been applied in the design of the details which follow.

The details presented below cover the most frequently occurring situations where damage has, and will occur. Situations not specifically covered may require adaptation of one of the given details.

5.1.1 Space: Kitchen/Dining Room

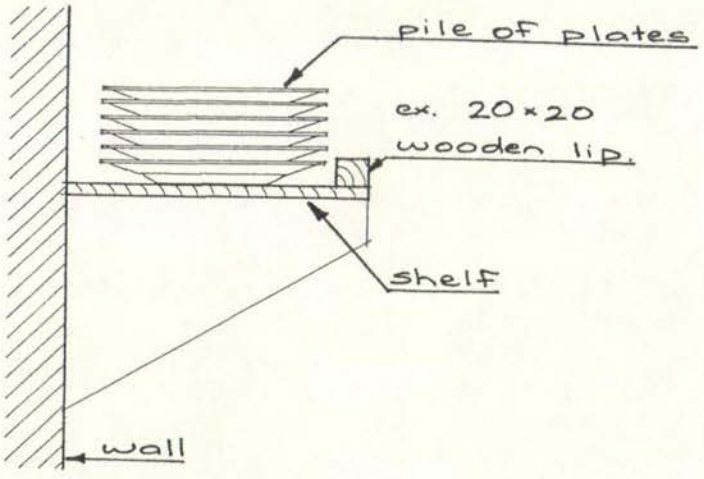
Items to be restrained:
Chattels stored in cupboards and on shelves

* Ensure cupboards and shelves are firmly attached to the wall.
* Shelves must be positively secured to the cupboard.
* Magnetic or spring catches can not be relied on to prevent contents from spilling out.
* This detail will secure heavy and tall items like bottles and preserving jars.



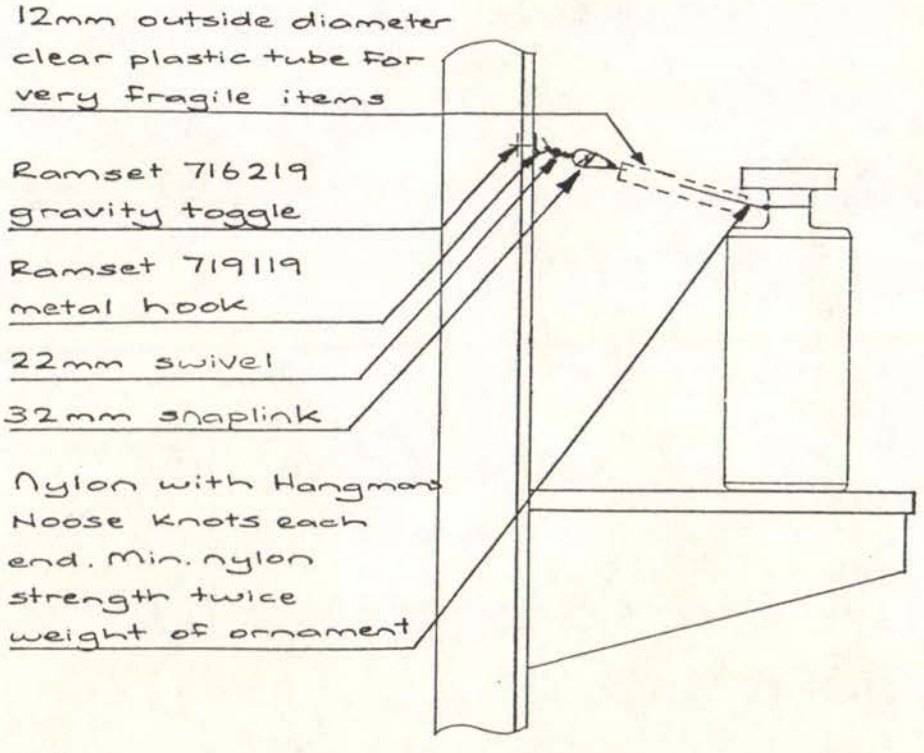
Restraint No. 1

* This detail is useful for frequently used shelves where squat objects like plates or short glasses are stored.
* Satisfactory for low to medium intensity shaking only.



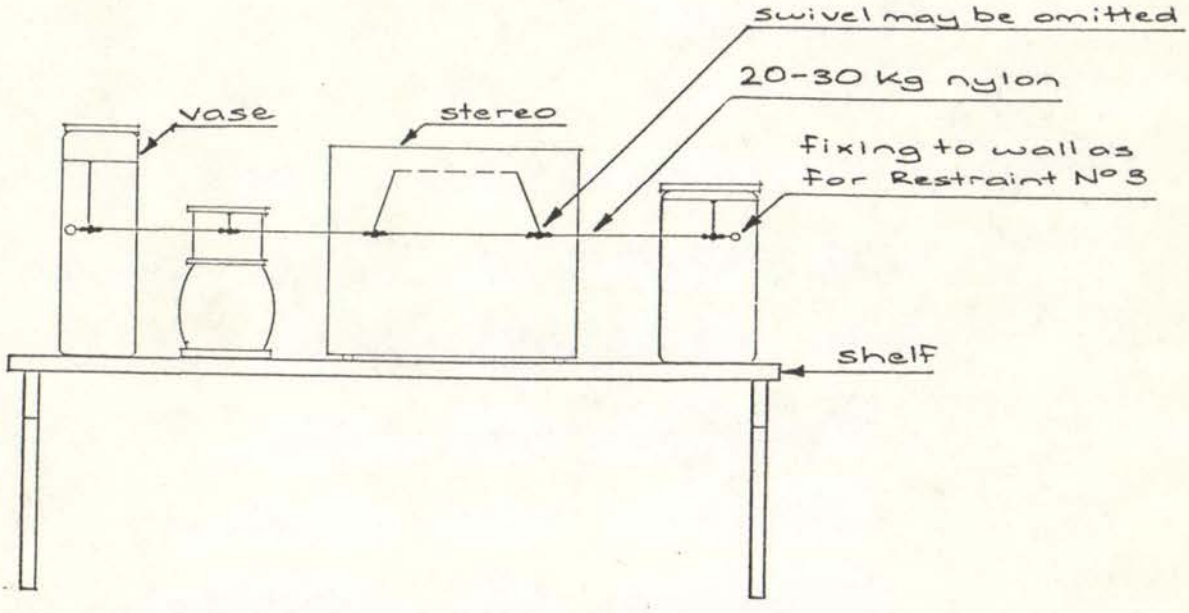
Restraint No. 2

Chattels on open shelves:
* For individual heavy items weighing more than 10 kg.
* Ensure positive fixing of the horizontal shelf to the supports using screws, clips or silicone sealants (for glass shelving).

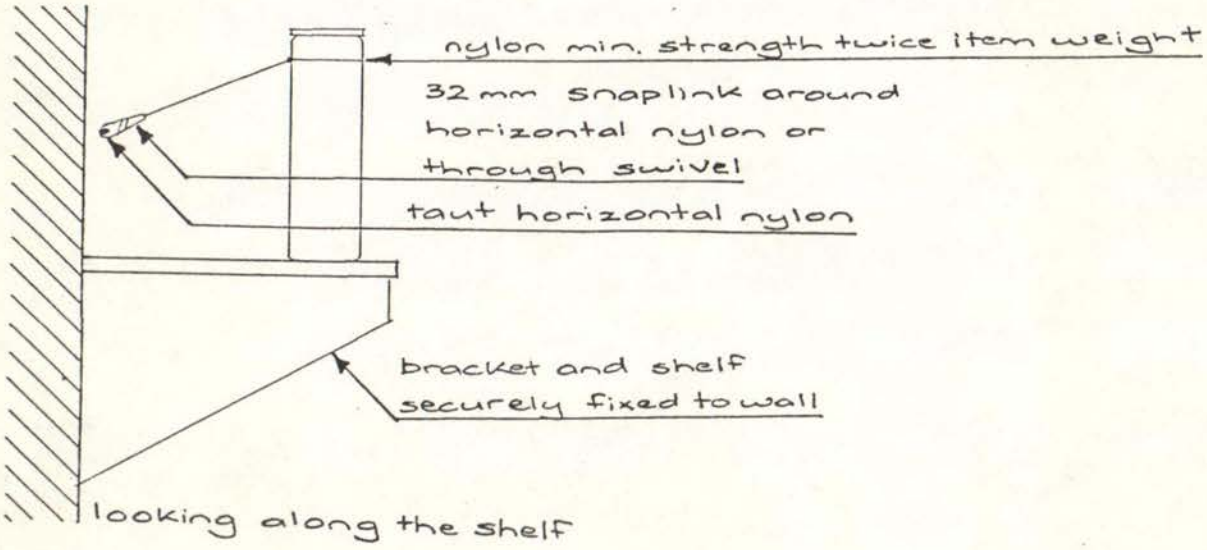


Restraint No. 3

* For the situation of several lighter items on a shelf.



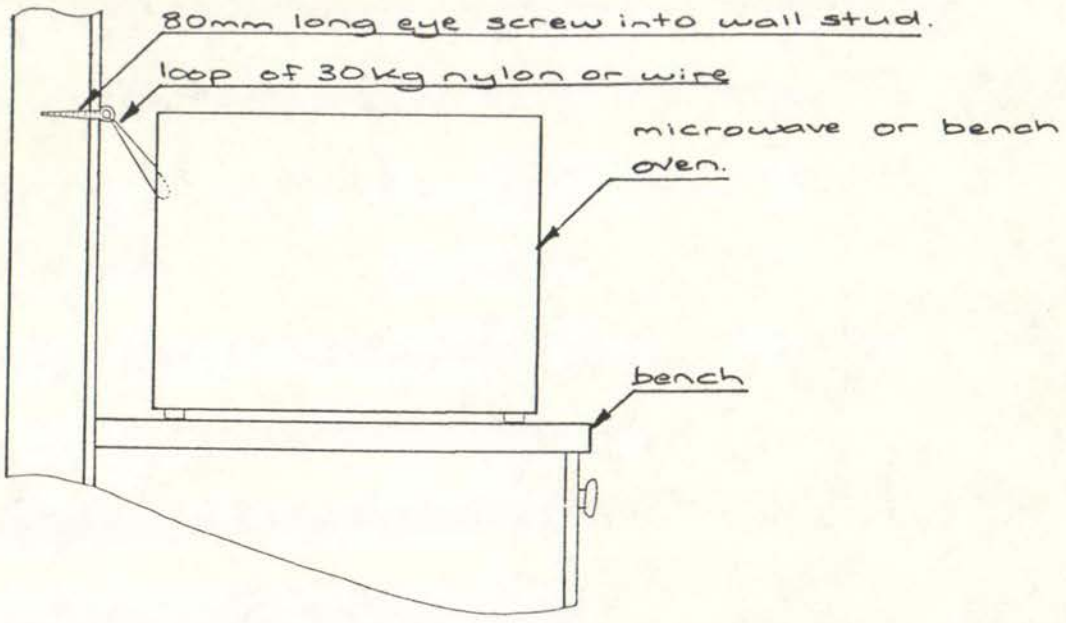
View from back of shelf into room



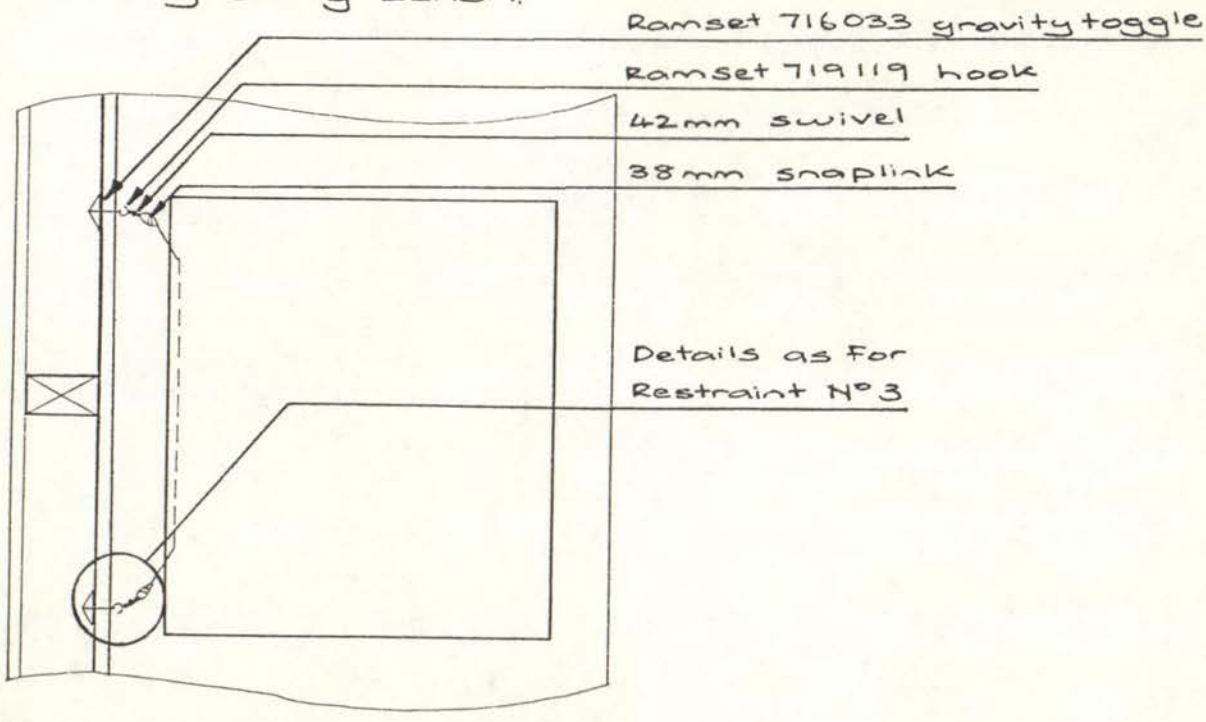
looking along the shelf

Restraint No. 4

Benchtop items:
Microwave/Benchtop oven.
* These can be very hazardous if placed quite high.
* The wire loop needs to be long enough so as the appliance can be moved out from the wall to disconnect the snap link.



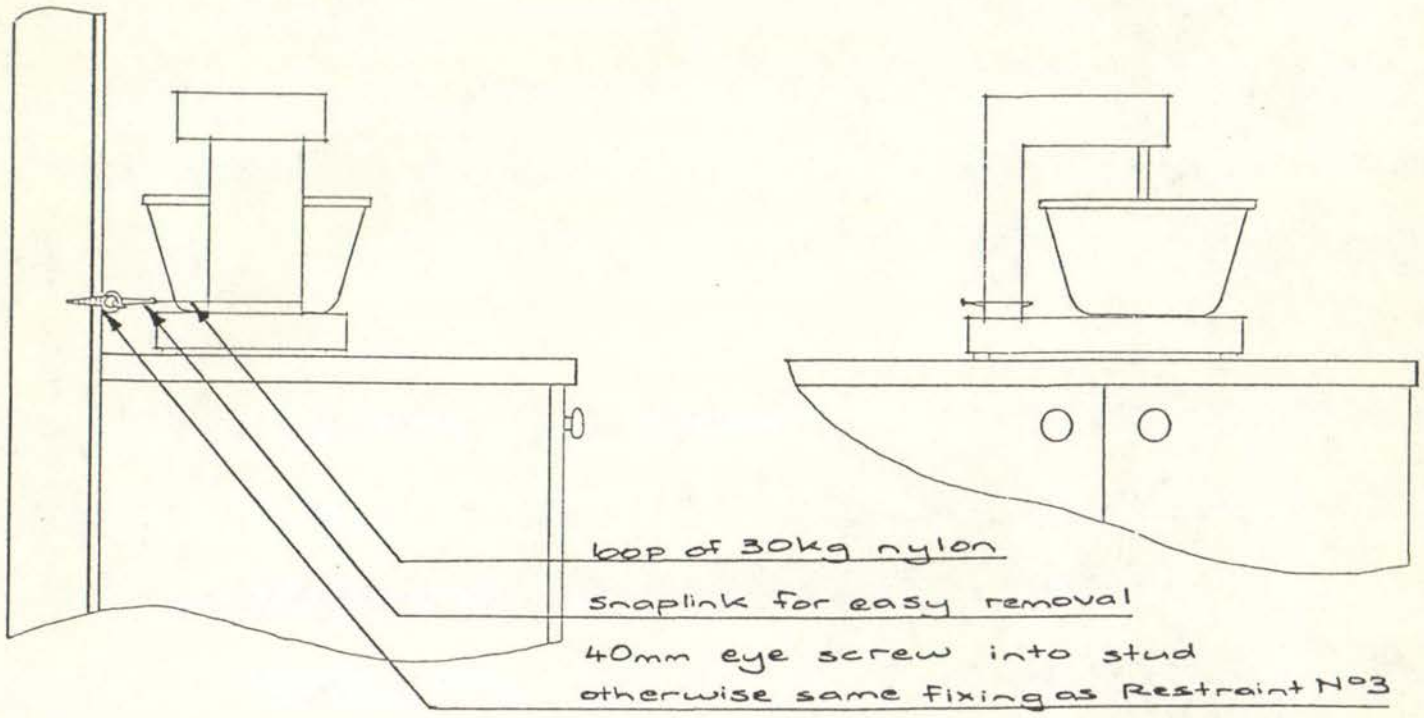
Looking along bench.



Looking down on microwave

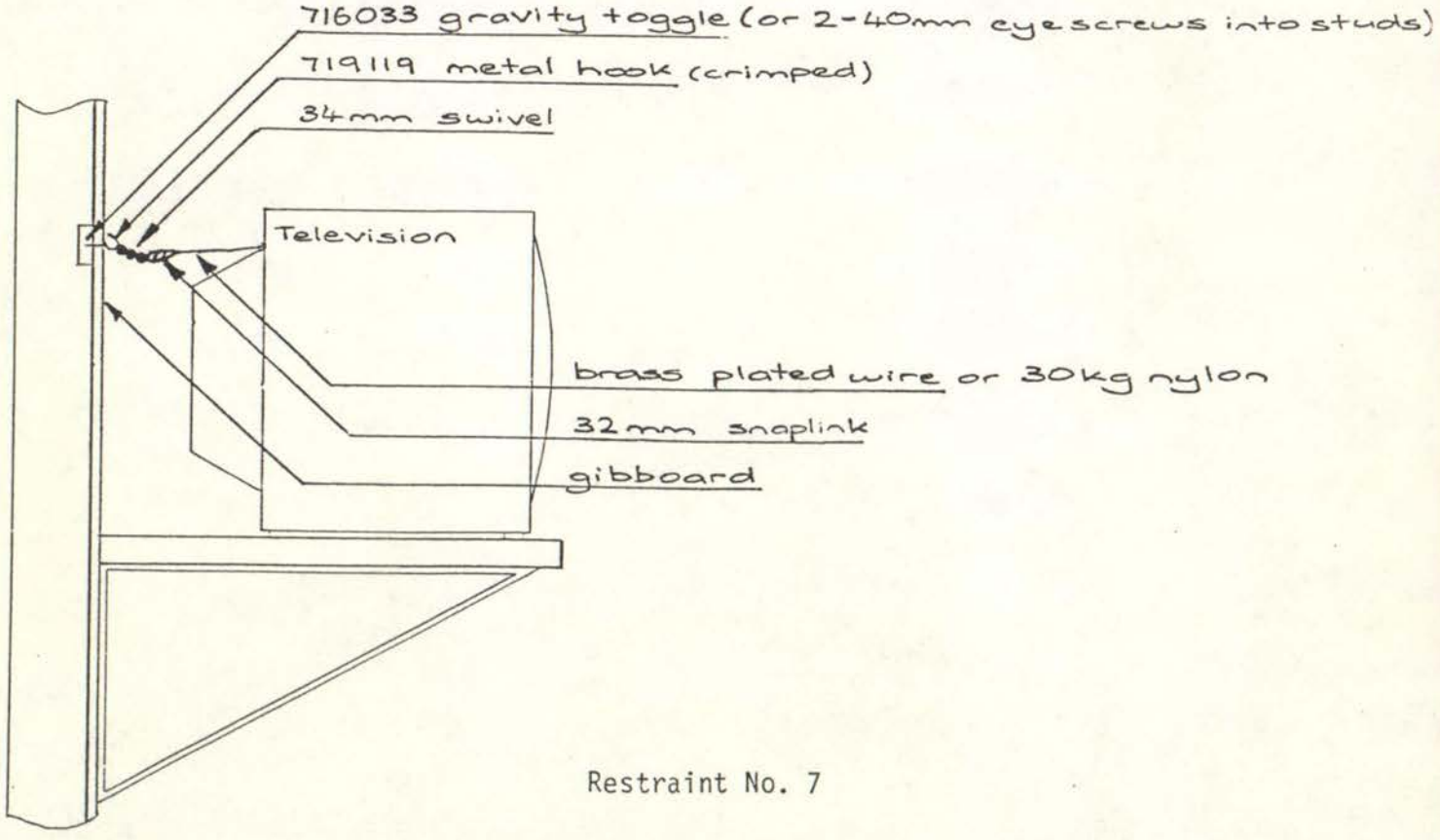
Restraint No. 5

Electrical Appliances:
* Electric beater, food processor.



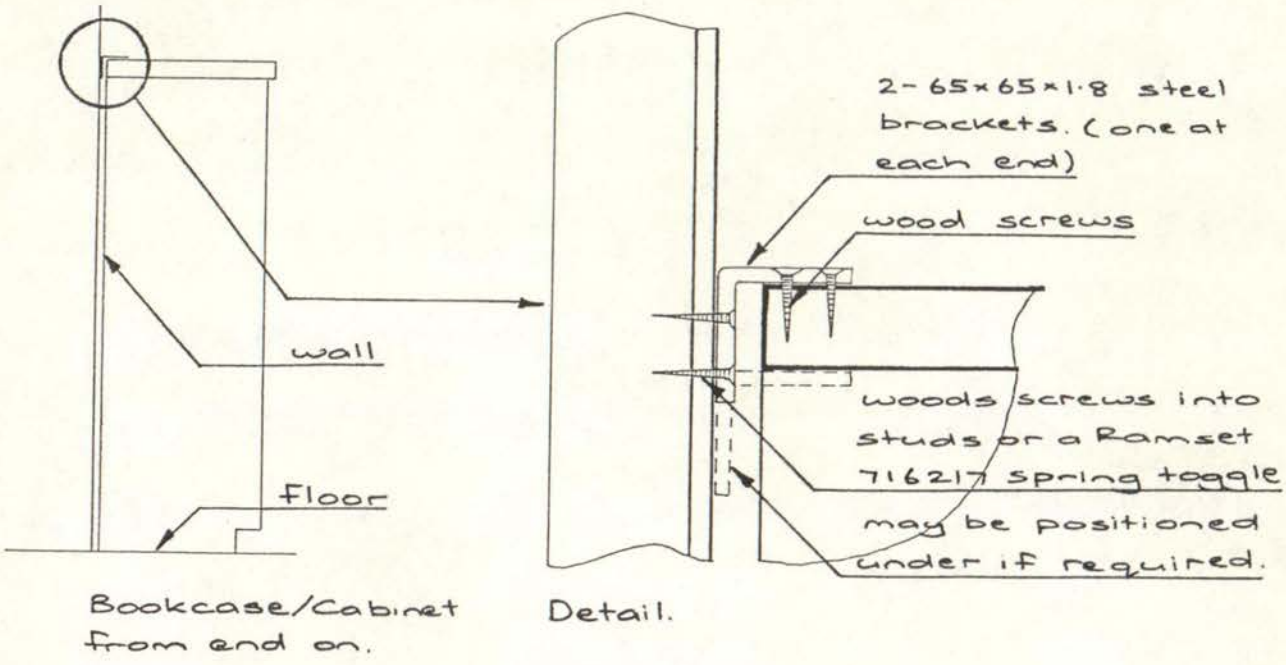
Restraint No. 6

* Television set



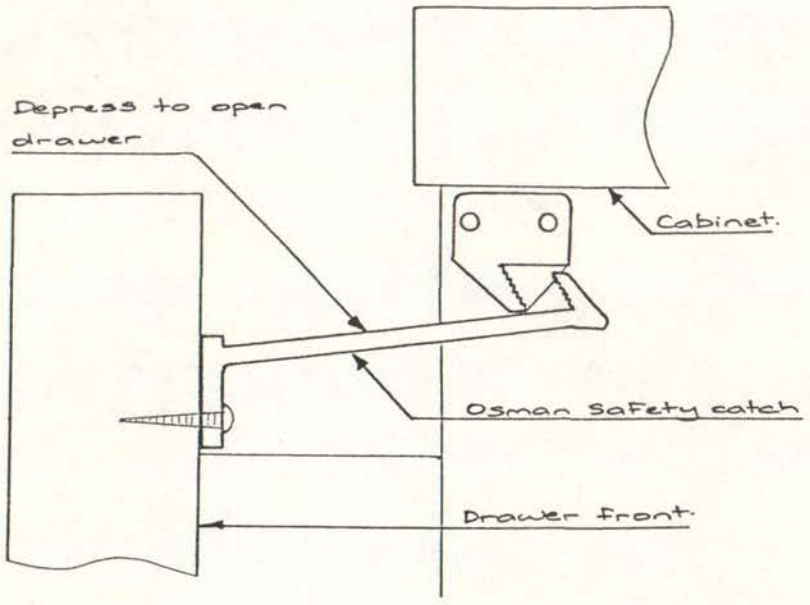
Restraint No. 7

Dining Room/Lounge:
Bookcase/Free Standing
furniture (clocks):
* Fixings only required at each end at the top.
* If items are displayed on top of the restrained bookcase, restraints No. 3 or 4 may be used.



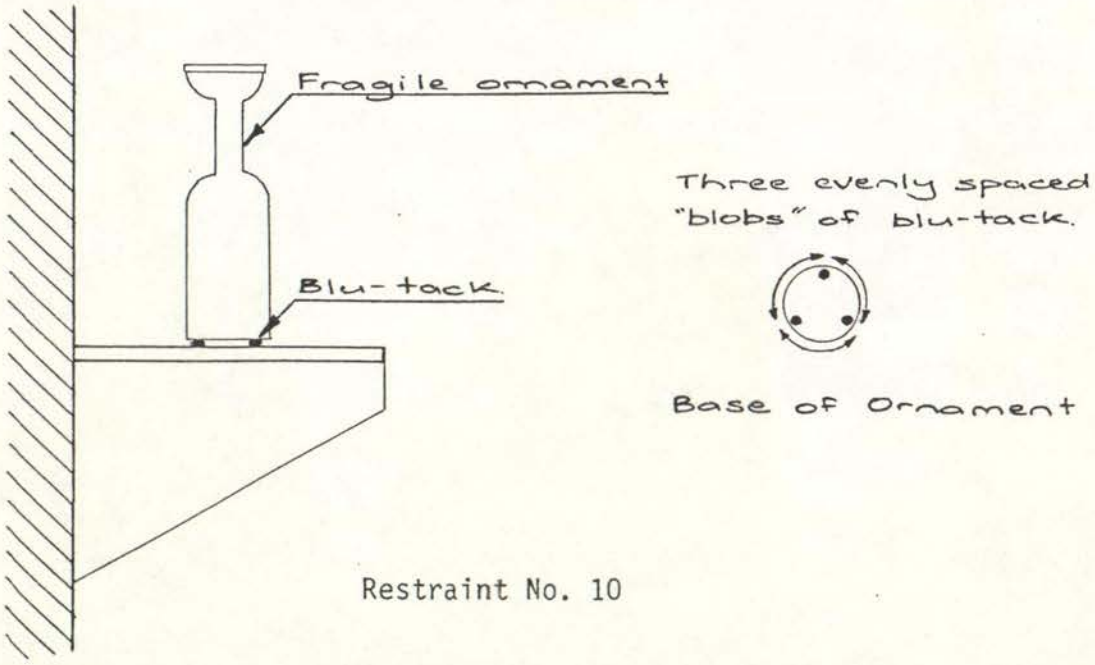
Restraint No. 8

Wall Cabinet/Display Cabinet:
Use Restraint No. 8 or screw directly into wall studs behind. Magnetic catches will not restrain items inside cupboards. Use either mechanical catches on cupboard doors, safety catches or Blu-Tack for individual items (Restraint No. 10). For drawers use safety catches to prevent them flying out. (Restraint No. 9).



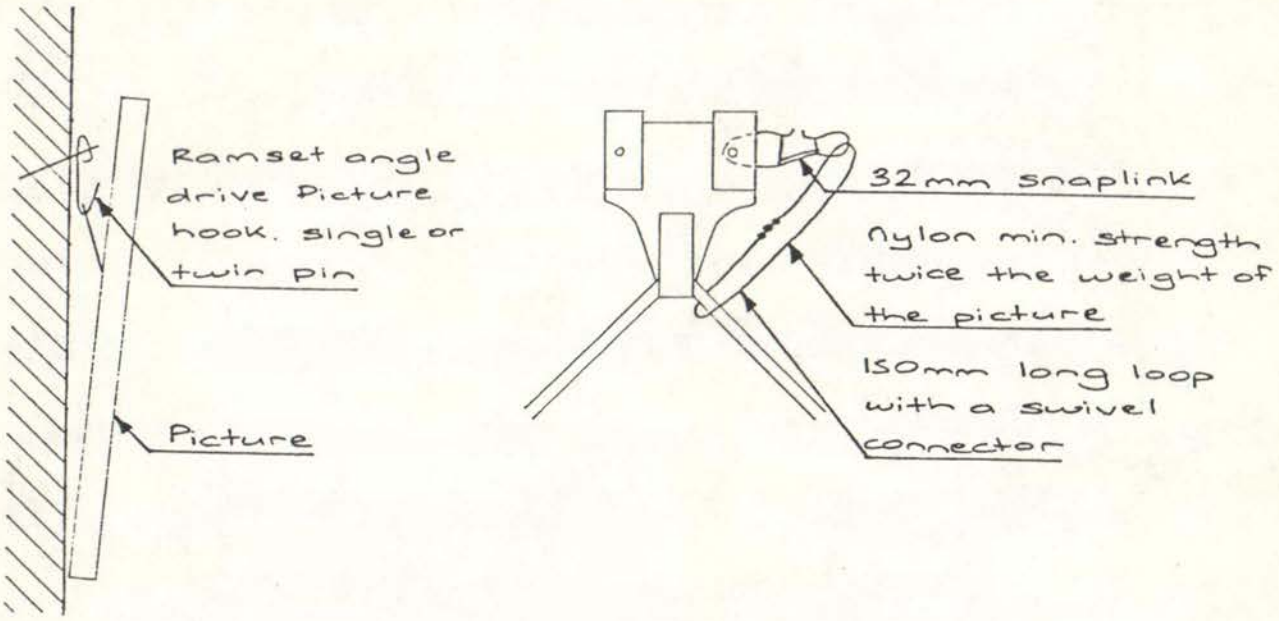
Restraint No. 9

Fragile items on display such as crystal, china, glassware, can be restrained using Blu-Tack. Using printed instructions, the squeezed diameters should be between 10mm and 20mm depending on the height and weight of the item. After application of Blu-Tack adhesion should be tested by gently applying pressure at the top of the item. An item will be protected even in intense shaking if the adhesion to the shelf is such that if the shelf were slowly rotated to the vertical position the item does not fall.



Restraint No. 10

Paintings/Prints:
Nails or pins are ineffective. Picture hooks are better but not fail-safe in intense shaking as the wire or string can become dislodged.

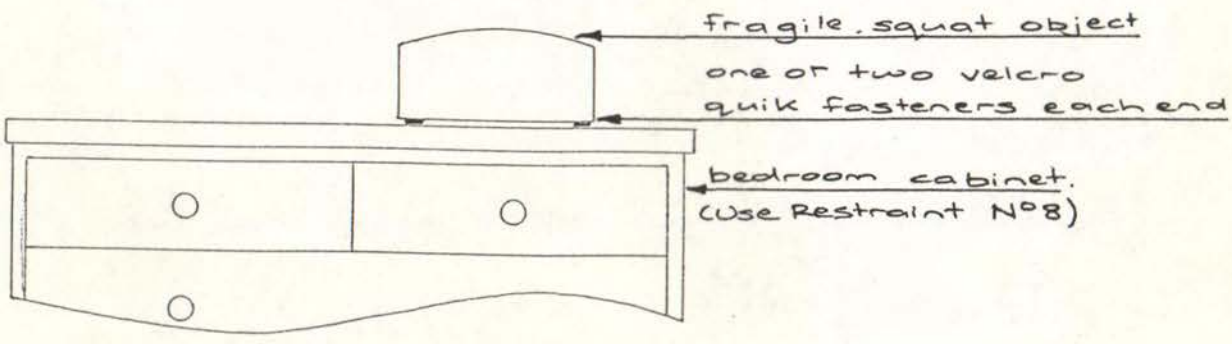


Restraint No. 11

Free-standing Fireplace:
Bolt to the floor. Details to suit each particular situation.

Light Fixtures:
The fixings must be able to hold, without pulling out due to the swinging action that occurs. More robust attachments may be required.

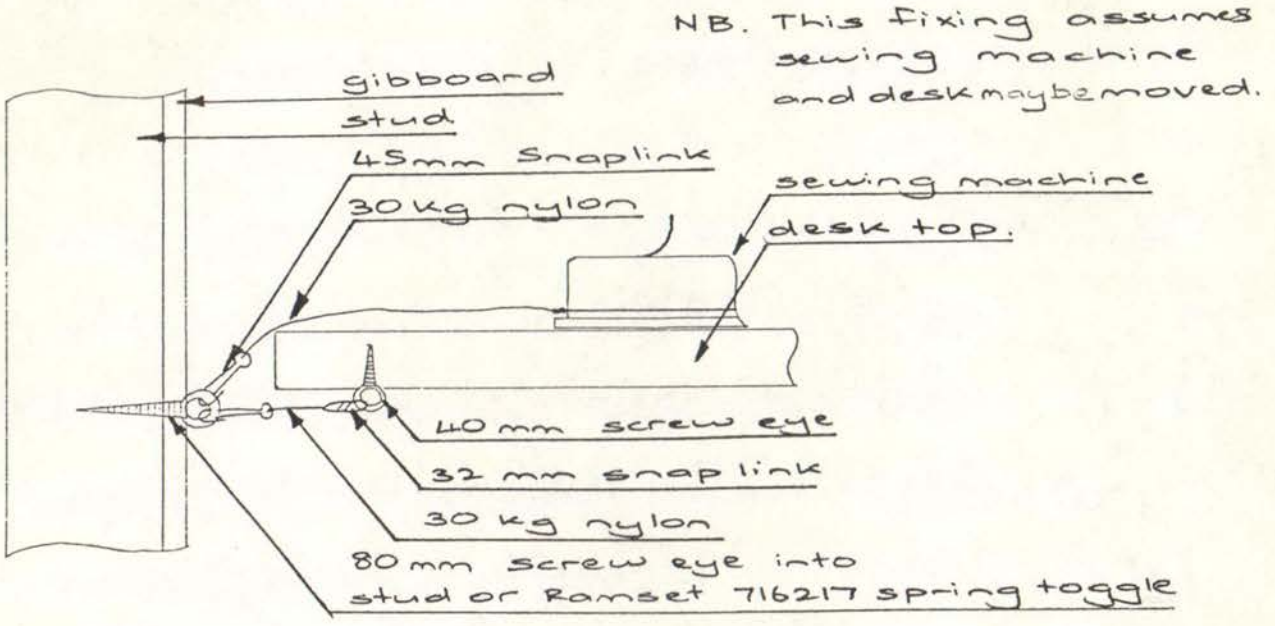
Bedrooms:
Most items can be secured using restraints already suggested. Squat objects may be restrained using Velcro Quick Fasteners. The adhesion should be checked from time to time.

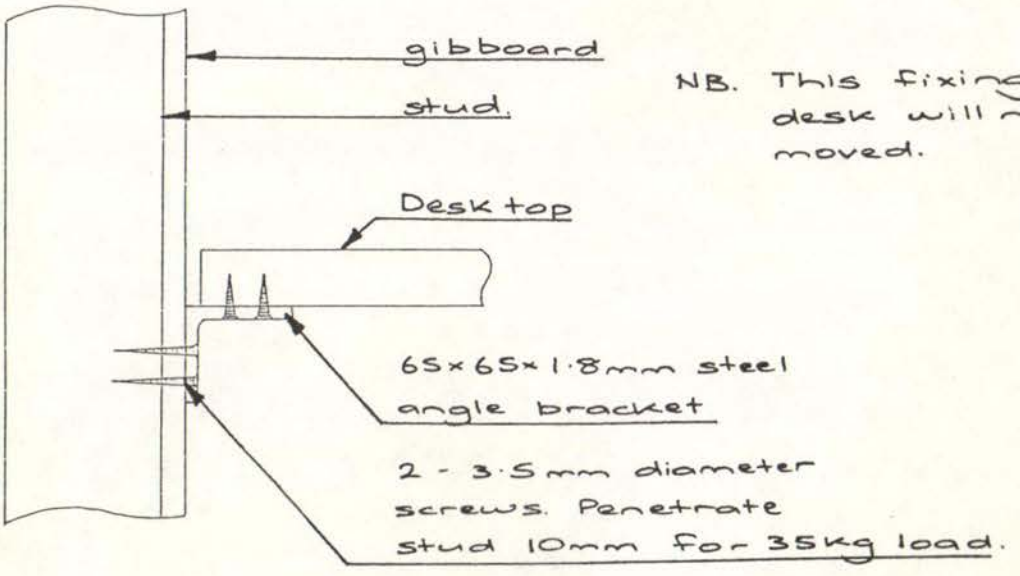


Restraint No. 12

Laundry:
Wall mounted driers should be positively secured to the wall to prevent falling. Restraint No. 8 may be applicable.

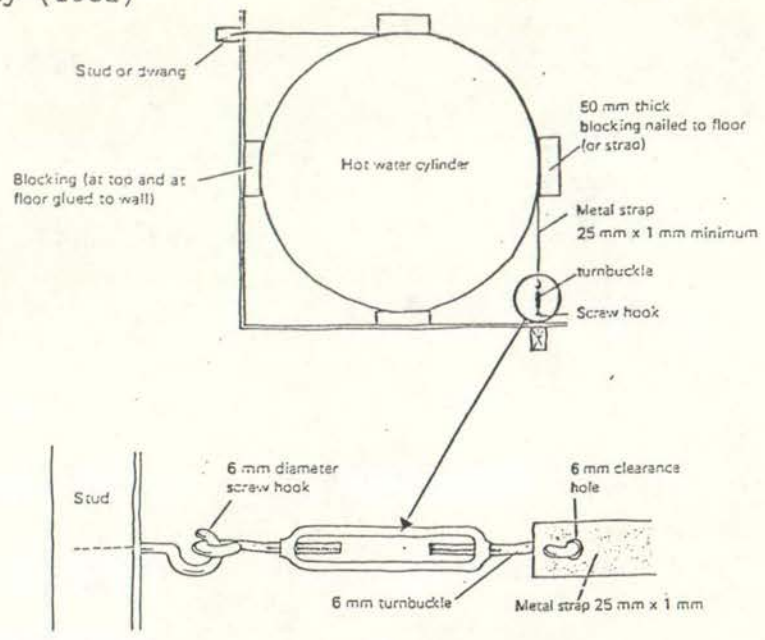
Miscellaneous:
Sewing machine should be secured to the bench or wall.





Restraint No. 13

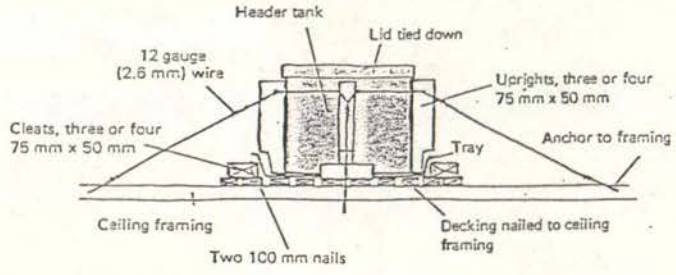
Hot Water Cylinder should be secured into the cupboard. Source Cooney (1982)

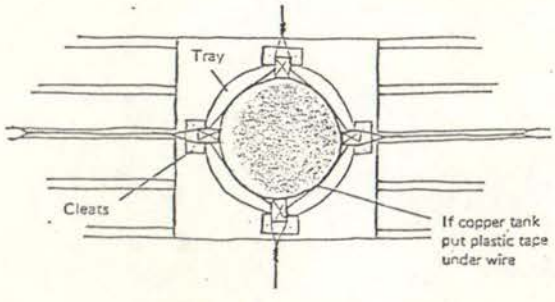


Fixing of hot water cylinder

Restraint No. 14

Header Tank
Source Cooney (1982)





Fixing of header tank

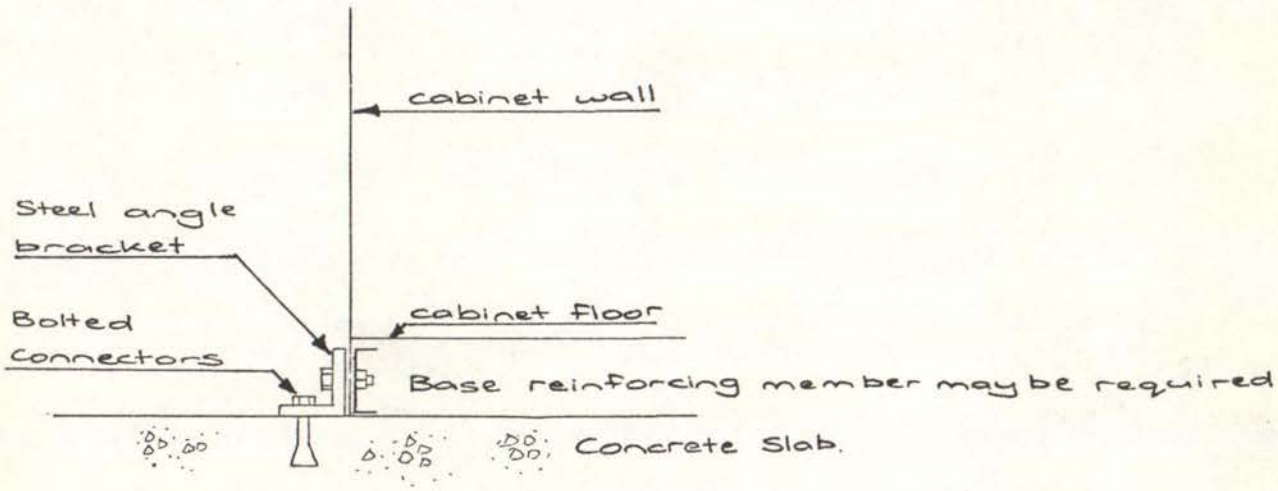
Restraint No. 15

Goods stored on walls of garage should be tied back to prevent vehicle damage in the event of them falling.

5.2 Commercial and Office Light Equipment:

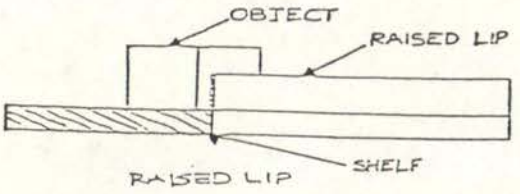
Applications similar to those in the domestic situation are not covered, but may be adapted from those already given.

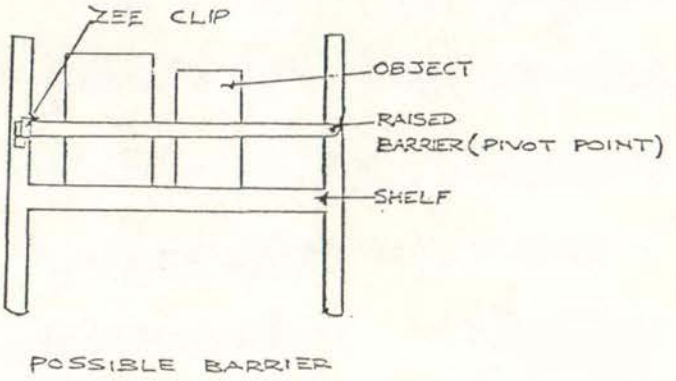
Type of Equipment:
Floor Mounted Equipment:
If equipment is not mobile it should be fixed to the floor so that sliding and toppling is prevented. Some reinforcement within the equipment near the anchoring points may be required for tall, heavy cabinets.

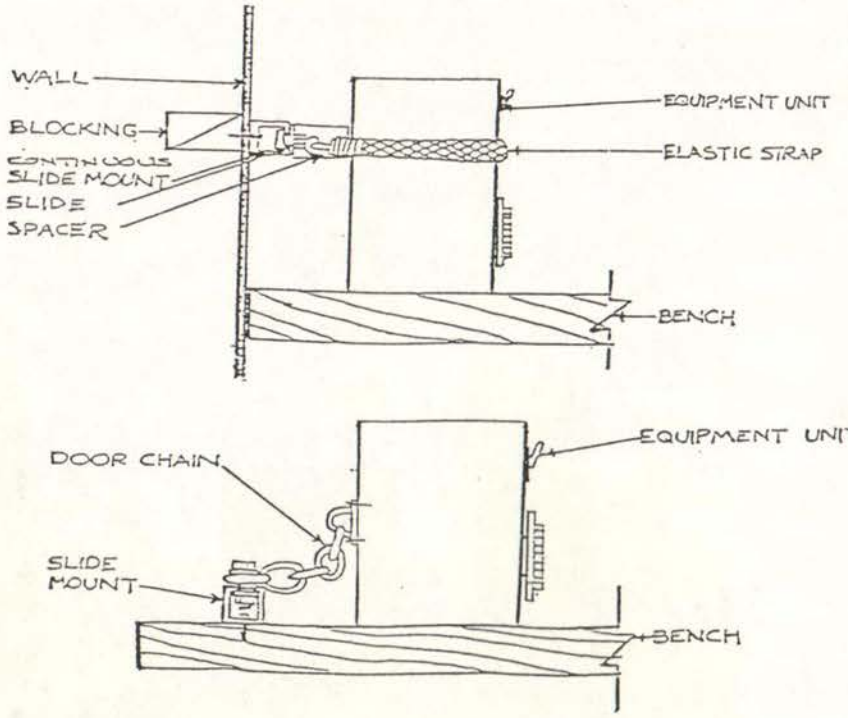


Restraint No. 16

Shelf Equipment:
Shelves to be secured to walls. (Restraint No. 8). Restraint No. 1 can be used, or else a larger raised lip or barrier can be used. These methods are particularly suited to storage of laboratory materials. Also elastic straps or flexible mounting can be used. The use of continuous slide mounts enables considerable flexibility to be achieved. The continuous slide mount could be screwed to the wall (preferable) or else to the desk, with all desk mounted equipment, such as micro computers and typewriters, attached to it.







Restraint No. 17

Equipment under Suspended Ceilings:
If the ceiling is not braced then there is a likelihood that falling tiles and dust will damage equipment. Also it is possible the movement in the ceiling might damage fire sprinkler heads causing flooding. Heavy lighting units or air conditioning grills may fall. Restraint is needed for these. The ceiling and fire sprinklers and other fittings must be checked.

Computers/Computer Floors:
Mainframe computers on computer floors need special attention. Adequate bracing of the floor must be provided and computer manufacturer's recommended fixing details for seismic regions should be used. The base-isolation of computer floors is becoming more common, especially in Japan.

Other equipment must have restraint systems especially designed for that situation. Design loads would be obtained from the appropriate New Zealand Codes of Practice.

5.3 Case Study of Systems for Securing Household Chattels.

In the author's house a number of chattels have been secured. Photographs of the methods used are presented below with explanation of each fixing type. Apart from personal reasons of wanting these chattels protected, the exercise of doing the securing enabled the costs of such work to be readily estimated based on personal experience.

In Figures 7 and 8 dining room shelves are shown. All the significant items are restrained. In both these situations a horizontal length of nylon has been run along the back of the shelf and all the heavier items are attached by snaplinks to it. Figures 9, 10 and 11 show the restraint details. In Figure 9 the gib-board fastener and hook is seen. Because it is placed behind the case it cannot be seen from the room, but if it were it could be painted white to make it less obtrusive. The bookcase and television set in Figure 7 are also restrained. The TV is attached to a large snap link (strong enough to take the weight of the set) which clips into a brass coated 40mm eye screw fastened to the shelf bracket. This restraint can just be seen.

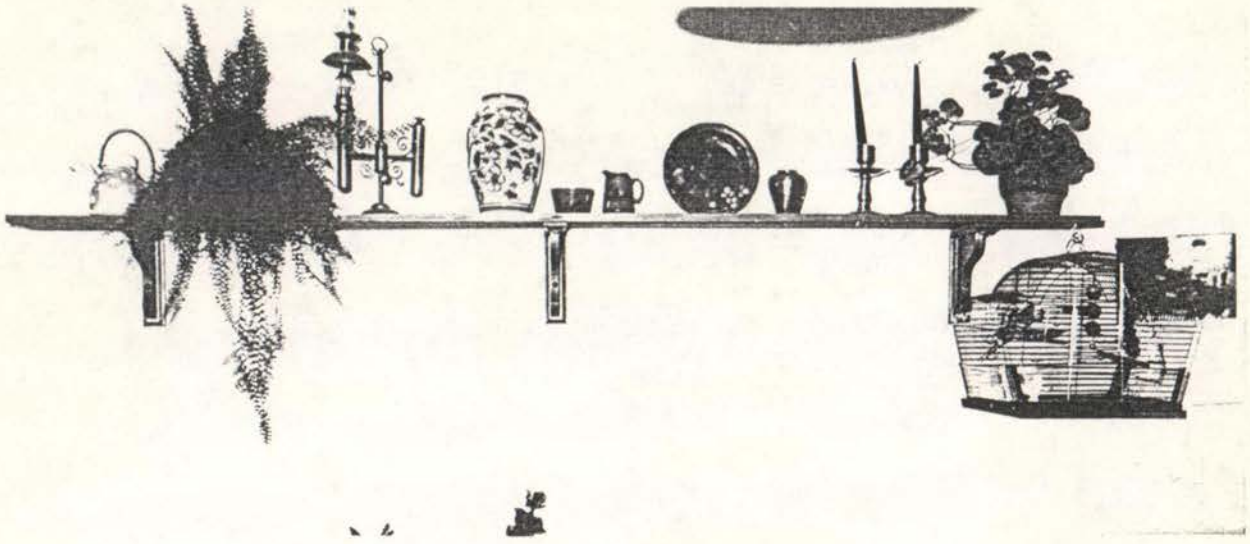


Figure 7: Dining Room Shelf with Restrained Chattels using Blu-Tack or Nylon.

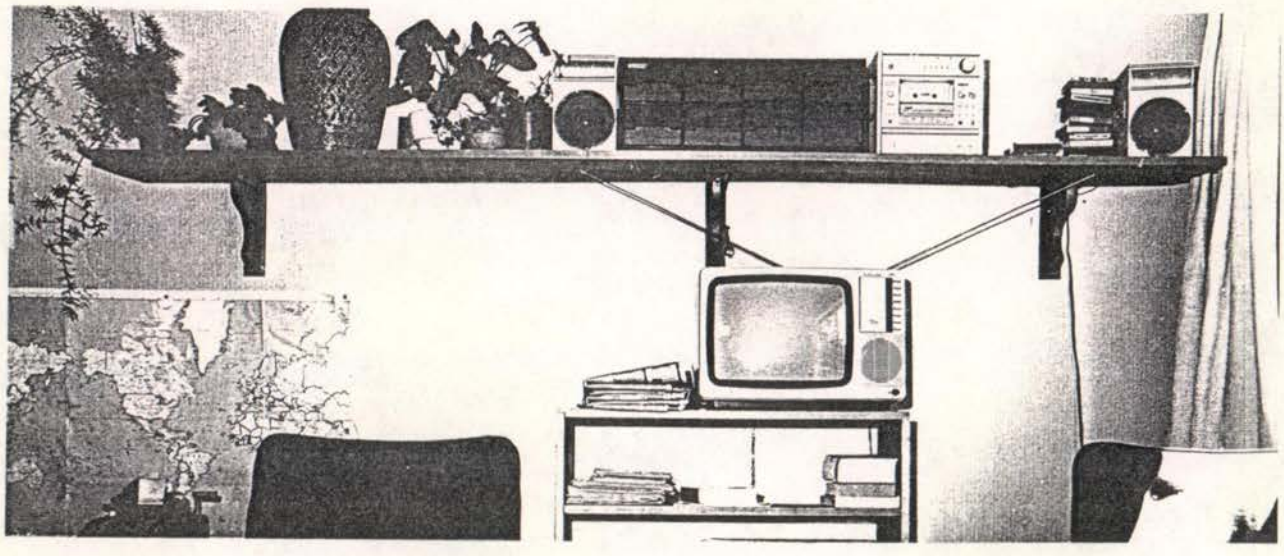


Figure 8: Dining Room Shelf with Restrained Chattels

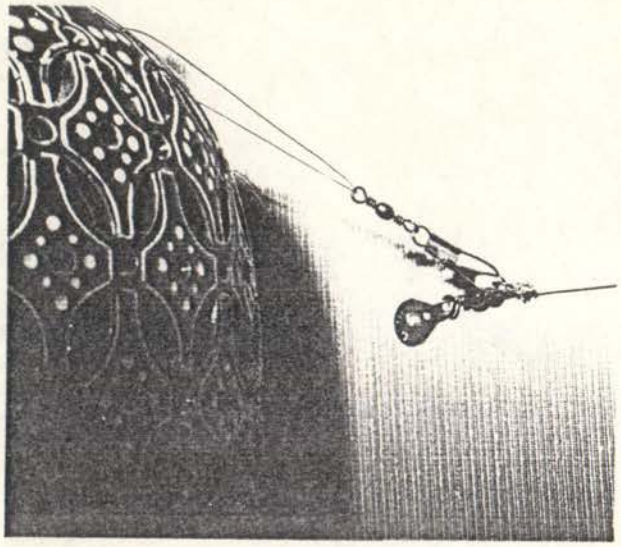


Figure 9 Securing of a Vase Figure 10

An example of the use of Blu-Tack is given in Figure 12. All three ornaments are fixed to the window sill each with three blobs of Blu-Tack. The sill is above eye level so the Blu-Tack is not able to be seen. In another situation (Figure 13) an ornamental vase is restrained using nylon and a snaplink to a small eye screw. The vase has been moved aside so as the details can be seen.

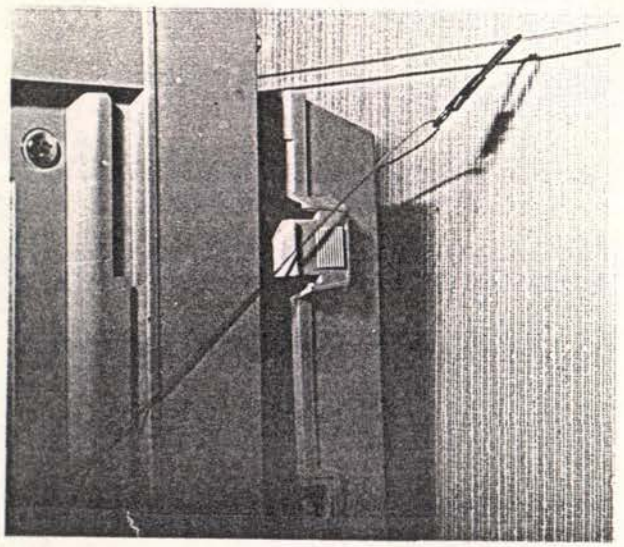


Figure 11: Restraint for Stereo Equipment

Figure 12: Ornaments secured with Blu-Tack

The use of curtain-wire is illustrated in Figure 14. The magnetic catches on the cupboard doors would be ineffectual in restraining the preserving jars so the curtain-wire is necessary. As a result of the findings of the shaking table tests an extra wire is required for each shelf.

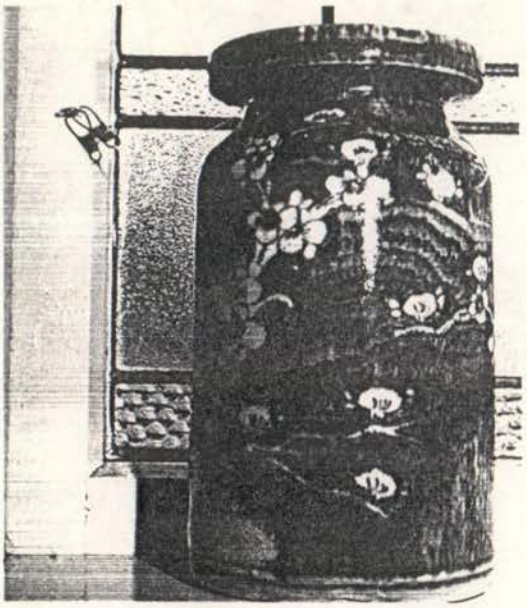


Figure 13: Restraint of a Vase

Figure 14: Use of Curtain-Wire

In Section 5.1 of this report a restraint detail is given for hot water cylinders. In Figure 15 the cylinder is restrained at the top by blocking nailed to the top of the cupboard, and at mid-height by ex 75x50 timber, and a particle board diaphragm shelf. There are many ways, depending on the situation, of restraining hot water cylinders.

Figure 15: Restrained Hot Water Cylinder

6.0 COST-BENEFIT CONSIDERATIONS

6.1 Probability of Occurrence of Earthquakes.

For locations within New Zealand the expected average return periods of various intensities of shaking have been calculated by Smith & Berryman (1983) and are shown for the major cities in Table 9.

City	Mean Return Period (years)			
	MMVI	MMVII	MMVIII	MMIX
Auckland	62	260	1400	-
Wellington	6	21	67	220
Christchurch	14	48	160	600
Dunedin	31	130	500	2200

Table 9: Mean return periods at Selected Cities (Source Smith and Berryman)

Eiby (1966) describes what MMVI intensity shaking is like and writes: "Windows, glassware and crockery broken. Objects fall from shelves, and pictures from walls". If earthquake occurrence is assumed, as is usual, to be a random event then the probability of MMVI and MMVII shaking in Wellington in a 10-year period is 81% and 38% respectively. There is therefore a very high probability that in Wellington chattels and light equipment will experience damage over such a modest time frame. The seismic risk in other centres is less, but there is a considerable area between Wanganui in the north to Kaikoura in the south that has essentially the same risk as that of Wellington.

6.2 Costs of Securing.

As can be seen from the details given in the previous section, the cost of hardware to secure chattels is not high. It is estimated that the cost for an average home would be between $40 and $80. If householders did the work themselves that would be the total cost. The cost of employing a person to do it would be between 10 and 15 hours times the hourly rate of say, $25/hour, i.e. between $300 and $500 including the cost of materials.

6.3 Benefits.

There are two parties who benefit from securing chattels and office equipment. First, there are the insurers who are covering the cost of damage (to a specified degree), and secondly there are the owners.

The benefit to insurers in encouraging securing is that they lower the value of property at risk. If for example the Bay of Plenty claimants had secured their chattels themselves at a cost of $60 the insurers would have saved approximately $1100 and this is for only MMVI to MMVII shaking. How much more would be saved if greater intensities occurred! If the 15 Karori households surveyed had their chattels secured a reduction of the maximum average probable loss per household of approximately $11,000 would occur. The cost of this reduction would be between, say, $60 and $500. This would suggest that insurers should introduce a scheme such as reimbursing any securing costs previously incurred at the time of paying out for earthquake damage.

The benefits to owners in securing are as follows:-

(a) Items of sentimental value are not lost.
(b) The cash short-fall resulting from the difference between replacement cost (which could be highly inflated after an earthquake due to shortages) and the indemnity value is greatly reduced.
(c) Less dependence upon the unknown ability of the insurers, particularly the Earthquake and War Damage Commission, to meet the full cost of a major earthquake affecting a larger metropolitan area.
(d) Reduction in post-earthquake shock and trauma.
(e) Reduction in potential earthquake hazards in the home and office.

6.4 Summary.

Due to the small sample size of the data collected it is not realistic to attempt a comprehensive cost-benefit analysis. More data is required to make that worthwhile. However, it can be said that in several areas of the country there is high probability of damage to chattels and equipment occurring in a ten year period for moderate intensity shaking, with high damage costs involved.

Since the cost of securing, relative to the cost of potential damage claims is so low, securing should be strongly encouraged. There are substantial benefits to all interested parties.

7.0 RECOMMENDATIONS:

7.1 That due to the difficulty of obtaining information useful to the insurance industry and the community regarding the costs of damage to chattels, equipment and buildings, a computer data base be set up to facilitate management and analysis of claims following a damaging earthquake.

7.2 That due to the extremely favourable cost/benefit ratio achieved by securing chattels and light office equipment:

(a) the Earthquake and War Damage Commission in conjunction with the private insurance industry actively promote the benefits of securing, beginning in those areas of the country with the highest seismic risk.

Suggested means of promotion include:-

(i) The production and circulation, with insurance premium invoices, of an attractive and simple brochure outlining how to go about securing.

(ii) The production of a more detailed and extensive booklet (say 10 pages) for those requiring further information such as collectors (of antiques etc) and businesses.

(iii) Providing a financial incentive such as allowing the cost of any previous securing up to a certain sum, to be paid for at the time of making a claim for earthquake damage; or at the very least waiving the excess if there is evidence of some securing having been implemented.

(iv) Advertising not only in the media, but also in collectors journals/magazines of the availability of technical resource information about securing.

It should be noted that some financial assistance for the production of literature could come from several of the companies whose products would be used in a securing programme.

The author would be pleased to assist in the achievement of recommendations 7.2(i) and 7.2(ii).

8.0 CONCLUSIONS

The conclusions of this study are as follows:

(i) There are a large number of chattels and items of office equipment currently at risk from earthquake damage. With inexpensive, tested, practical and visually acceptable methods it is possible to dramatically reduce the level of risk.

(ii) The benefits of securing these items are very considerable, both to the insurance industry and the community as a whole and so it is very important that the recommendations herein are implemented.

REFERENCES

Cooney, R, 1982, Strengthening Houses Against Earthquake. Technical Paper P37. Building Research Association of New Zealand, Judgeford.

Eiby, G.A. 1966, The Modified Mercalli Scale of Earthquake Intensity and its use in New Zealand. New Zealand Journal of Geology and Geophysics, Vol.9, Nos 1 and 2, July 1966.

Hungerford, R., 1979, Anglers Omnibus. 15th ed. Jack Pollard, Publishing Pty Ltd, USA.

Leslie, P.D., 1988, Second International Earthquake Conference, April 6-10 1987, Los Angeles, California, USA. Bulletin of the New Zealand National Society for Earthquake Engineering, Vol.21, No.2, Wellington.

Lowry, M.A., Ede, S.C. and Harris, J.S., 1988, Edgecumbe Earthquake Seismic Intensities. Under publication. Seismological Observatory, Wellington

McGavin, G.L. 1981, Earthquake Protection of Essential Equipment, Wylie, New York.

Merz, K.L. 1975, Non-structural Hospital Systems in the Earthquake Environment. Proceedings of the U.S. National Conference on Earthquake Engineering, Ann Arbor.

NZS 4203: 1984, Code of Practice of General Structural Design and Design Loadings for Buildings, Standards Association of New Zealand, Wellington.

NZS 4219: 1983, Specification for Seismic Resistance of Engineering Systems in Buildings, Standards Association of New Zealand, Wellington.

Selvaduray, G., 1986, Develoment of Earthquake Hazard Reduction Equipment in Japan. Proceedings of the U.S. National Conference on Earthquake Engineering (Charleston, S.C.: 1986). Earthquake Engineering Research Institute, El Cerrito, California.

Smith, W.D. and Berryman, K.R., 1983, Revised Estimates of Earthquake Hazard in New Zealand. Bulletin of the New Zealand National Society for Earthquake Engineering, Vol.16, No.4, Wellington.

Tailby, J., 1988, Earthquake Resistant Fixings for Architectural Elements. ARCH 389 Research Report, School of Architecture, Victoria University of Wellington, Wellington.

Wellington Civil Defence, 1987, Counter Disaster Wellington 87, Wellington City Council, Wellington.

Yanev, P., 1974, Peace of Mind in Earthquake County - How to Save your Home and Life. Chronicle Books, San Francisco.

APPENDIX A

Quake research leads to book

Information collected from local people by a Victoria University research team on a recent trip will provide the basis of a booklet on securing possessions in earthquakes.

A senior lecturer with the Victoria University School of Architecture, Mr Andrew Charleson, is hoping to have the booklet ready within a year.

It will make suggestions on how to secure household possessions and office equipment cheaply to prevent them being knocked over in an earthquake.

During his visit to the Eastern Bay of Plenty Mr Charleson and one of his senior students interviewed 15 householders and visited the Tasman Pulp and Paper Mill, the Whakatane Hospital and businesses in Kawerau.

The information and photographs collected were proving useful for the study, said Mr Charleson.

He intends to do laboratory tests on vases secured by screw fittings on to a shaking table, simulating an earthquake.

Further research depended on financial assistance from the Earthquake and War Damages Commission, however, said Mr Charleson.

Mr Charleson first became interested in the project when visiting Edgecumbe a few days after last year's earthquakes.

As a structural engineer he had come to examine structural damage in buildings but found that the damage to personal effects was far greater.

Securing possessions was not an area that engineers or architects were usually interested in, so he decided to investigate it himself, he said.

He and a senior student are working on the project part-time and hope to be joined by another student if finance is available.

Source - Whakatane Beacon,
5 April 1988.

Keeping them safe in quake

A booklet detailing inexpensive methods of securing possessions against earthquakes may be produced by a small research team visiting the Eastern Bay.

A senior lecturer with the Victoria University School of Architecture, Mr Andrew Charleson, and one of his senior students arrived in Whakatane last week to pursue their part-time research project.

The project is about six months old and was devised when Mr Charleson observed an "astounding" amount of damage to personal belongings after the Edgecumbe earthquakes.

At the end of August he announced his intention to try to find inexpensive and practical ways of safeguarding valuable possessions. People with information which might help the researchers were asked to contact him, and send photographs if possible.

Mr Charleson recently said that while he and his fellow researchers were in the Eastern Bay, they intended to contact the 12 residents who wrote to them last year.

The pair are also keen to speak to business people who lost office equipment during the earthquake.

At the moment, the team's intention is to design simple "fixings" which will prevent items being knocked over in an earthquake.

"We're building up a collection of information. A lot of research doesn't seem to go anywhere. Hopefully we're going to produce a booklet for home owners to plan how to cheaply secure their home possessions," he said.

Source - Whakatane Beacon,
19 February 1988.

APPENDIX B

CHATTEL DAMAGE INFO FROM WHAKATANE.

File	Description of Chattels	$ Paid
211	ornaments	195
211	crystalware	40
211	glassware	200
211	crockery	360
213	HWC	500
217	crystalware	90
297	oven	150
297	HWC	25
297	furniture	100
367	HWC	200
590	crockery,glassware,crystalware	1500
590	wine	30
590	lamp stand	110
590	picture frame	30
590	stereo equipment	1400
592	crockery	563
592	glassware	8
592	crystalware	18
592	furniture	525
592	food	40
608	HWC	100
608	furniture	500
608	food and alcohol	150
608	ornaments,crockery,crystalware	5200
640	shop food losses	617
641	TV	500
641	crockery	125
641	glassware	570
641	furniture	120
641	ornaments	130
641	cystalware	230
642	furniture	80
642	food	30
642	furniture	330
642	glassware	183
642	ornaments	100
644	ornaments	950
644	glassware	250
644	crockery	625
644	crystalware	185
646	furniture	80
646	misc	210
646	food	240
646	crockery	130
646	glassware	10
649	chattels,antiques	500
650	glassware,liquor,ornaments	520
650	antique dogs	2730
650	furniture	250
654	glassware,crockery,pottery	5738
665	food	65

APPENDIX C

CHATTEL DAMAGE INFO FROM WHAKATANE.

File	Description of Chattels	$ Paid
1656	alcohol	15
1659	alcohol	120
1808	alcohol	490
805	antique	400
1709	antique	60
650	antique dogs	2730
1656	antiques	80
2558	antiques	245
758	chattels	65
990	chattels	168
2579	chattels	300
2592	chattels	145
649	chattels,antiques	500
211	crockery	360
592	crockery	563
641	crockery	125
644	crockery	625
646	crockery	130
665	crockery	50
692	crockery	2570
765	crockery	55
794	crockery	335
804	crockery	40
805	crockery	145
810	crockery	275
819	crockery	444
968	crockery	420
986	crockery	1560
990	crockery	400
1509	crockery	110
1633	crockery	850
1644	crockery	421
1645	crockery	70
1656	crockery	580
1670	crockery	50
1711	crockery	170
1733	crockery	25
1779	crockery	330
1793	crockery	220
1808	crockery	150
1816	crockery	110
2561	crockery	220
2572	crockery	60

APPENDIX D

Earthquake survey in Karori

Thirty Karori homes are to be surveyed to determine how much damage would be done in a moderate earthquake.

The survey is part of a research project aimed at lessening earthquake damage to possessions and light office equipment. It is being conducted by Senior Lecturer of Architecture at Victoria University, Andrew Charleson, with the help of five senior students and is partly funded by the Earthquake and War Damage Commission.

Karori has been chosen for the survey, taking place between August 22 and September 3, because it is an easily identifiable area and accessible to the students helping out, Mr Charleson says.

Mr Charleson began his research after seeing the damage done to household contents following the 1987 Bay of Plenty quake.

"I was horrified at the damage to personal possessions," Mr Charleson says.

Objects fall off shelves in an earthquake with a modified mercalli intensity of VI, Mr Charleson says.

This intensity of quake happens on average in Wellington every six years.

This means in a 10 year period there is an 80 per cent chance of an earthquake knocking things off shelves, he says.

The survey will help identify the type of chattels which need restraints. Once developed restraints will be tested on a shaking table in the school laboratory.

Restraints will be made of a type of nylon, Mr Charleson says. He has already tried this on some of his own vases and says it is virtually invisible.

A wide range of unwanted ornaments and crockery are needed for the experiment and Mr Charleson would appreciate anyone able to donate such items to contact him at Victoria University.

Source - Karori News, August 16, 1988.