

NEW ZEALAND STANDARD

SEISMIC RESTRAINT OF BUILDING CONTENTS

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STANDARDS NEW ZEALAND

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COMMITTEE REPRESENTATION

This Standard was prepared by Joint Technical Committee BD/79 under the direction of the Joint Building Standards Policy Board and the Structures and Contracts Joint Standards Advisory Committee of Standards New Zealand and Standards Australia.

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RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS

- | | |
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| NZS 4103:0000 | Design for safety in the commercial and service workplace (in preparation) |
| NZS 4203:1992 | General structural design and design loadings for buildings |
| NZS 4219:1983 | Specification for seismic resistance of engineering systems in buildings |
| NZS 4607:1989 | Installation of thermal storage electric water heaters: valve-vented systems |
| NZS 7421:0000/AS 2918:0000 | Domestic solid fuel burning appliances — installation (in preparation) |

OTHER DOCUMENTS

New Zealand Building Code, 1992.

CHARLESON A. W. Mitigation of Earthquake Damage to Household Chattels and Light Office Equipment. Proceedings of Pacific Conference on Earthquake Engineering, Auckland, November 1991, pp. 281-290.

COONEY R. Strengthening Houses Against Earthquake, Technical Paper P37, Building Research Association, Judgeford, 1982.

SMITH W. D. and BERRYMAN K. R. Revised Estimates of Earthquake Hazard in New Zealand. Bulletin of the New Zealand National Society for Earthquake Engineering, Vol. 16, No. 4, 1983, pp. 259-272.

QUAKESAFE SYSTEMS LTD. Product information, Wellington, 1992.

NEW ZEALAND LEGISLATION

- Building Act 1992
- Dangerous Goods Regulations 1958
- Dangerous Goods Act 1974
- Toxic Substances Act 1979
- Toxic Substances Regulations 1983

The users of this Standard should ensure that their copies of the above-mentioned New Zealand Standards or of overseas Standards approved as suitable for use in New Zealand are the latest revisions or include the latest amendments. Such amendments are listed in the annual Standards New Zealand *Catalogue* which is supplemented by lists contained in the monthly magazine *Standards* issued free of charge to committee and subscribing members of Standards New Zealand.

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FOREWORD

This is a new Standard which draws upon requirements of NZS 4203:1992 *The Loadings Standard*. It may be considered as an extension both of that Standard and NZS 4219:1983 *Specification for seismic resistance of engineering systems in buildings*. This Standard, together with the other two, have as their primary objectives the maintenance of function and safety to people during and after a damaging earthquake. With the proposed incorporation of complete seismic restraint requirements for suspended ceilings, access floors and full-height partitions into another new Standard, all aspects of personal safety and building element performance for seismic conditions will be included in New Zealand Standards.

This document is intended to set out and help promote what is considered to be good practice and help fulfil the goals and objectives of a number of pieces of current legislation and current societal trends including the Health and Safety in Employment Act and the Building Act. It is seen as being a pro-active document.

This Standard has two aims. First, to reduce the risk of injury to people and to ensure access to and from a building after an earthquake, and secondly, to reduce the risk of damage to building contents. The first aim can be achieved by the user of this Standard specifying that building contents be provided with Type 1 restraint. Reduction of damage is to be achieved by specifying Type 2 restraint.

This Standard is intended to be used by non-specialist people (i.e. the owners or occupiers of a building) who have the responsibility for improving the seismic safety of a building interior.

Some limitations on the application of this Standard are:

- (a) The contents of domestic dwellings are excluded unless specifically requested by an owner or occupier.
- (b) Type 1 and 2 restraint is mandatory for the contents of all Category I and III buildings (refer Appendix A).
- (c) Type 1 restraint only is mandatory for the contents of upper storeys of Category II and IV buildings and all other buildings, except where there is less than a 30 % probability of MMVII or greater intensity shaking occurring within a 25 year period. (Refer table B1 and figure B1).
- (d) Restraint is not the only means of limiting injury and damage. Items may be relocated or isolated to achieve the aims of this Standard.

Public acceptance of this Standard is reliant upon the public being made more aware of the potential danger of unrestrained contents during an earthquake, the need for egress to be maintained, and the likely serious effect damaged contents (especially equipment) will have on the viability of business and institutional functioning. There is low public awareness of the danger posed by building contents in New Zealand as compared to California as there has not been a damaging earthquake seriously affecting a New Zealand metropolitan centre for over 50 years.

Another factor in the acceptance of this Standard will be the sensitivity associated with its use. For example, the public will more readily accept its requirements if restraints are installed so that they are not visually obtrusive and do not significantly affect day to day functioning. Industry sources indicate that a wider range of proprietary products will be introduced onto the New Zealand market to assist in this area.

These requirements are considered to be a minimum for an office, home, retail or commercial environment. Where hazards exist, additional to falling objects or the effects of fallen objects (for instance hazardous materials including inflammable materials) more stringent requirements will be appropriate. These are outside the scope of this document and will require specific design.

It is expected that the cost of restraining contents will not be a barrier to the general acceptance of this Standard. Compared to the value of the items themselves, (and in the case of many communication and computer systems, the value of their continued functioning post quake) the cost of restraint is usually minimal.

This Standard is the first of its kind and any suggestions for improvements which could be made will be welcomed. They should be sent to the Chief Executive, Standards New Zealand, Private Bag 2439, Wellington 6020.

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NEW ZEALAND STANDARD

SEISMIC RESTRAINT OF BUILDING CONTENTS

1 SCOPE AND GENERAL CONSIDERATIONS

1.1 Scope

1.1.1

This Standard specifies requirements to reduce risk of injury to people and damage to the contents of buildings during earthquake shaking, and to ensure maintenance of the means of access into and from a building after an earthquake.

C1.1.1

To achieve a consistently high level of seismic protection in a building, attention must also be paid to building components whose seismic restraint requirements are outside the scope of this Standard.

Some components, such as suspended ceilings, partition walls, access floors and especially the equipment on them, pose considerable threat of injury to building users. At present there is no New Zealand Standard covering the construction and installation of these components, so in the interim existing industry standards should be used. Existing and new construction should be checked for compliance using these standards until a New Zealand Standard has been published.

Other components which include mechanical and electrical equipment should be restrained in accordance with NZS 4219. Although some of the potential seismic damage to this equipment may not result in direct risk of injury to building occupants, the continuing functioning of the building will rely upon the equipment being undamaged after an earthquake.

This Standard is intended to be used by non-specialist people (i.e. the owners or occupiers of a building) who have the responsibility for improving the seismic safety of a building interior. If there is any doubt as to the structural adequacy of a fixing or the building element being fixed to, then specialist advice should be obtained.

1.1.2

The maximum weight of an item requiring Type 1 or Type 2 restraint and defined as a building content shall be 300 kg. Seismic restraint of any item which is heavier shall be provided and be the subject of specific design in accordance with NZS 4203 and NZS 4219 as appropriate.

1.1.3

The weight of an item shall be its self-weight plus, in the case of items which have a storage function, an allowance for stored weight of 0.6 times the maximum weight likely to be stored.

1.1.4

This Standard is to apply to non-hazardous substances which are not highly toxic, chemically reactive, explosive or inflammable. Storage and restraint of such items will require specific design and may come within the coverage of the Dangerous Goods Regulations.

1.2 Applications

1.2.1

This Standard is applicable to the contents of new and existing buildings of any size, function and Category except Category V (Appendix A).

1.2.2

This Standard applies in the following situations:

- (a) The contents of domestic dwellings are excluded unless specifically requested by a building owner or occupier;
- (b) Type 1 and 2 restraint is required within all Category I and Category III buildings (refer Appendix A);
- (c) Type 1 restraint is required for the contents of both Category II and Category IV buildings (refer Appendix A), where there is greater than a 30 % probability of MMVII or greater intensity shaking occurring within a 25 year period. (Refer Appendix B).
- (d) Type I restraint is required on the seventh floor and above for both category II and IV buildings, where there is a less than 30 % probability of MMVII or greater intensity shaking occurring within a 25-year period. Refer Appendix B and table 3.1.

C1.2.2

In many buildings the seismic restraint of all contents that are included under 3.2.1 will be required to comply with this Standard; however in other buildings, due to reduced geographical seismic risk or the low intensity of occupancy, only some of the building contents will need to be seismically restrained. See figures 1.1 and 3.1.

Although domestic dwellings are excluded, the principles of this Standard can be advantageously applied within domestic dwellings.

The probability of earthquake shaking sufficiently intense to create a hazard to injury and damage to contents varies throughout the country. Refer to table B1 in Appendix B for the probabilities of occurrence of this level of seismic activity for some selected locations in New Zealand.

In establishing the intensity of occupancy of a part of, or of a whole building, factors such as the number of occupants and the daily duration during which the space is occupied should be considered. The value of the contents to the building occupier should also be included in this evaluation.

1.3 Types of seismic restraint**1.3.1**

Two Types of seismic restraint are provided for by this Standard as described in 1.3.2 and 1.3.3.

1.3.2

Type 1 protection is to reduce risk of injury to building users and to allow access from and into the building.

C1.3.2

Not only is protection necessary from items which may be flung around during an earthquake, but means of egress and entry, both essential after a damaging earthquake, need to be maintained. In moderate to severe earthquake shaking, it is common for objects to be flung around, to topple and to fall to the floor. If this damage occurs near a doorway it may not be possible to open the door. Occupants, some of whom might require medical attention, may be prevented from being evacuated or receiving assistance.

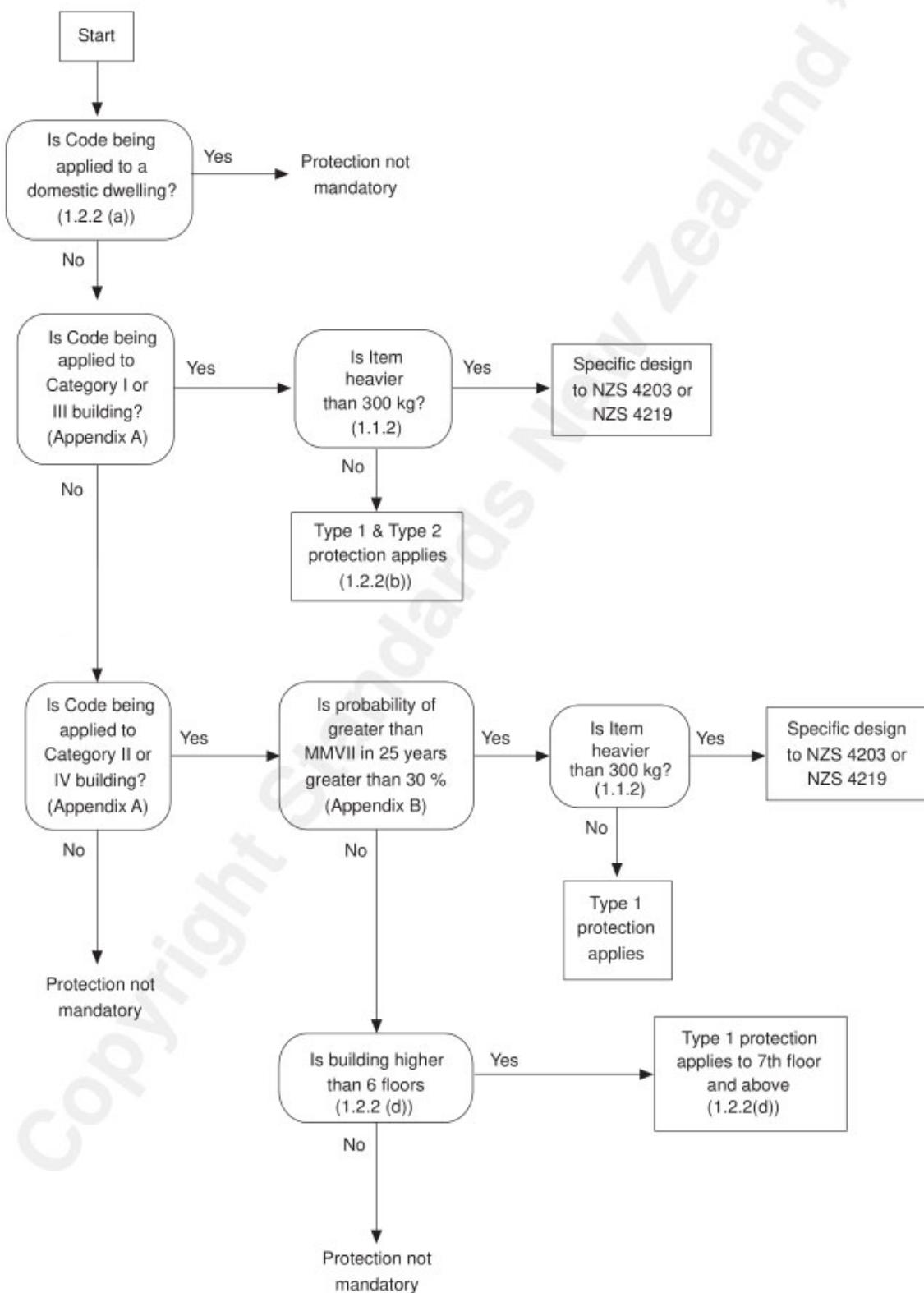
1.3.3

Type 2 protection is to reduce damage to contents.

C1.3.3

Some items to be provided with this level of protection will be smaller than items receiving Type 1 restraint. Frequently contents to be given Type 2 protection will be located in or on a larger item which requires Type 1 restraint. The Type of restraint for each item in the building should be specified.

Seismic Restraint Requirements



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Figure 1.1 – Flow chart for determining need for seismic restraint

Type 2 seismic restraint is particularly relevant in the following situations:

- (a) Where items are valuable or are irreplaceable;
- (b) Buildings which are to remain functional after a damaging earthquake;
- (c) Where loss of contents will affect the efficient functioning of the building or enterprise.

It has been established that business survival is seriously affected by seismic damage.

2 INTERPRETATION AND DEFINITIONS

2.1 Interpretation

2.1.1

For the purposes of this Standard the word "shall" refers to practices which are mandatory for compliance with the Standard. The word "should" refers to practices which are advised or recommended.

2.1.2

Subject to 2.1.1, clauses prefixed by "C" and printed in italic type are intended as comments on the corresponding mandatory clauses.

2.2 Definitions

For the purposes of this Standard the following definitions shall apply:

CONTENTS. Goods including items on shelves, equipment and non-permanently fixed furnishings of a building. Excluded are suspended ceilings, full-height partition walls, access or raised floors, mechanical systems and plant, and other non-structural elements such as precast panels. A list of items for which examples of seismic restraint systems are given is listed in the Contents section of this Standard.

FASTENER. A device used to form a seismic restraint.

FREQUENTLY OCCUPIED AREA. An area in a building where an item to be restrained may fall and in which one of the following forms of use occur:

- (a) A person is seated for more than 10 hours per week;
- (b) People may queue or gather;
- (c) People pass-by more frequently than one person per minute more than 10 hours per week.

ITEM. An individual content weighing more than 5 kg that may be seismically restrained. Includes aggregations of items such as bundles or pallets which are handled or stored as a unit.

SEISMIC RESTRAINT. The system to restrict movement or to connect a restrained item to a load resisting element like a wall or floor that can resist inertial forces generated by earthquake shaking.

3 SEISMIC RESTRAINT REQUIREMENTS

3.1 General

3.1.1

A seismic restraint of an item shall be capable of resisting the specified force, acting at the centre of gravity of the item in any horizontal direction, as determined from 3.2.5.

C3.1.1

Earthquake forces are considered to be directionally random. In keeping with NZS 4203, effects of vertical accelerations on the stability of contents may be neglected.

3.1.2

A restraint shall connect the item to the building structure, such as the floor, or to secondary elements such as walls which shall be capable of withstanding the additional seismic forces acting on them from the restrained item.

C3.1.2

Items may not require direct connection to the building structure. For example, where items are stored in cupboards fixed to the building, it may not be necessary to have each item restrained individually but rather to prevent them from falling off the shelves.

3.1.3

Consideration shall be given in the design and installation of a restraint system to any possible detrimental effects that the horizontal deflections in vertical members such as columns nearby, or the horizontal movement of one floor relative to another might have during earthquake shaking.

C3.1.3

Horizontal movement of building elements, such as columns or walls, as a result of floors moving horizontally relative to each other may induce additional forces on restraint connections. This may occur, for example, where an item is connected to both the floor and a wall.

3.1.4

Any restraint systems that rely on attaching members from one floor to another shall also be prevented from attracting forces as a result of structural members such as beams or floor units deflecting under gravity loads.

C3.1.4

It is good practice when interconnecting two floors to allow for some relative vertical movement between floors due to changes in floor loads etc.

3.2 Type 1 Protection

3.2.1

The following items satisfying both of the following conditions shall be provided with Type 1 restraint:

- (a) Items whose maximum height above floor level is greater than 1.2 m;
- (b) Items within a Frequently Occupied Area or within 3 m of an escape route;

except that items weighing more than 40 kg and located closer than 2.0 m from the nearest door jamb shall be restrained, irrespective of their height.

C3.2.1

Figure 3.1 is a flow chart which summarizes 3.2.1.

It is not intended that desks, one, two or three drawer filing cabinets and other contents stored at or near floor level which do not pose significant hazard to injury be restrained. However, heavy desk mounted items which are potentially dangerous are included within the scope of this clause.

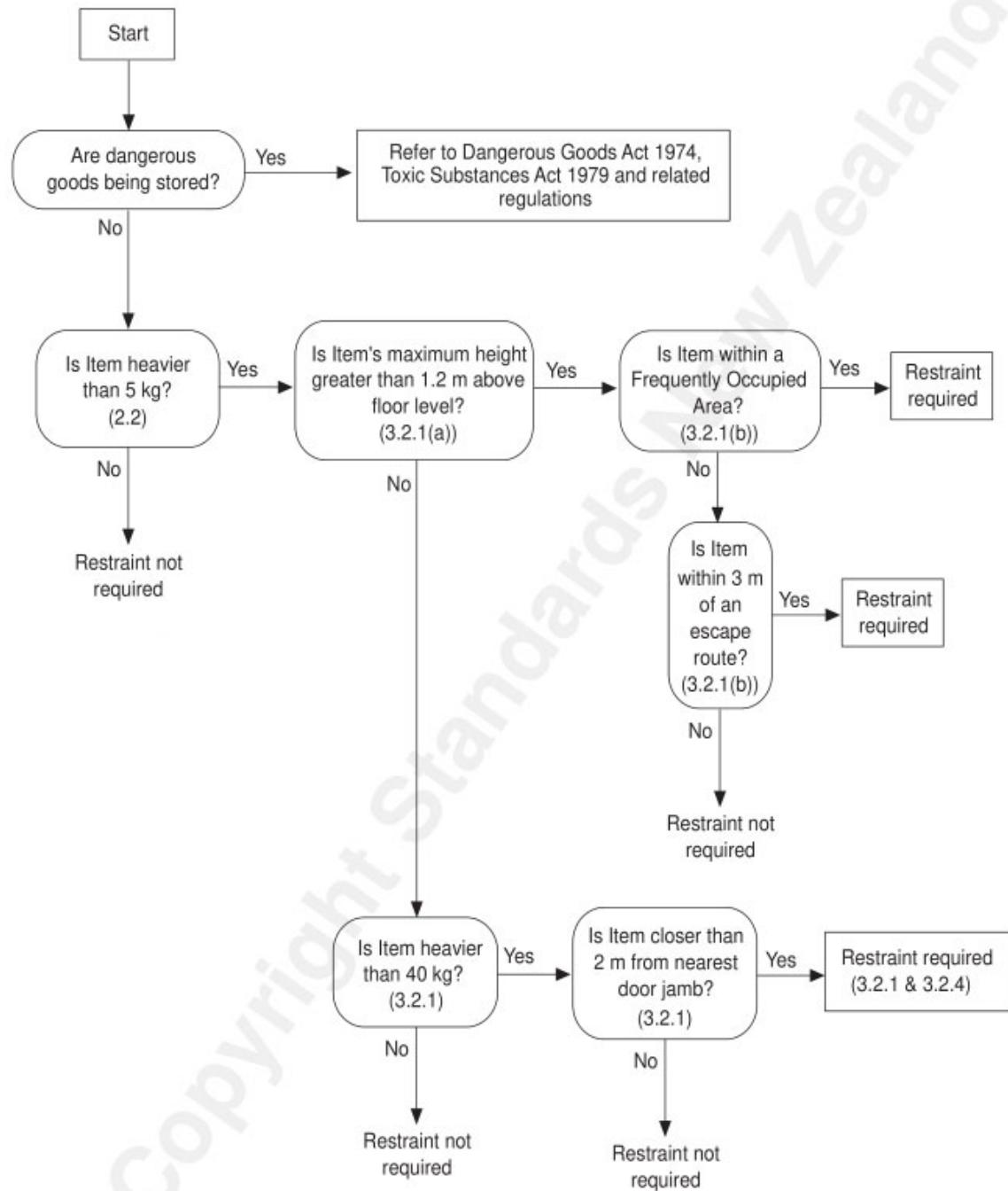
3.2.2

Restraint shall be provided to prevent the item from causing injury by being flung horizontally, falling or overturning. Sliding of floor supported items is permitted provided test results show that sliding will occur before overturning, and that sliding will not be prevented by any obstruction. If sliding will not, or may not occur before overturning, the item shall be fully restrained.

C3.2.2

Items which are relatively squat, such as inter-connected desks with light-weight screens (workstations) are permitted to slide at a force level which may be less than that specified in this Standard. Where

Type 1 Protection



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Figure 3.1 – Flow chart for Type 1 protection

the coefficient of friction between the item and the floor surface is quite low, such as for plastic feet on low to medium depth carpet pile, sliding will occur before overturning. Provided the strength of connections between the various components of furniture are adequate for the design forces, positive fixings to the floor are not required.

Where there is likelihood of sliding being prevented by other installations such as wiring or mechanical services overturning may occur and full restraint is required.

3.2.3

Where fasteners are required to resist an item overturning they shall also be capable of resisting the design horizontal force without reliance upon the friction between the item and the floor surface. A minimum of two fasteners shall be used for floor mounted items.

C3.2.3

If only one fastener is used, under some directions of seismic force, the item could swing about in an uncontrolled manner.

3.2.4

Sliding of an item heavier than 40 kg along a floor is not permitted where it is placed within 2.0 m of a door jamb.

3.2.5 Required design restraint strength

3.2.5.1

The design strength of a Type 1 seismic restraint shall be determined by one of the following methods:

- Application of NZS 4203 requirements for parts of buildings with the relevant design and construction Codes of practice. This method shall be used for restraints of contents in all Category I, II and III buildings as defined in Appendix A.
- The restraint system for an item on any particular floor shall be capable of withstanding a horizontal force equal to the multiplying factor given in table 3.1, times the weight of the restrained item. The weight of an item shall, if appropriate, allow for stored materials as defined in 1.1.3.

Table 3.1 – Multiplying factor dependent on floor level

Floor	Multiplying factor
Ground and below	1.0
First	1.5
Second and above	2.0

C3.2.5.1

- The first method, 3.2.5.1(a), which will require structural engineering calculations is the most accurate. In many situations it will allow for a lower restraint strength as it takes into account the lower seismicity of large areas of the country and the more gradual increase of seismic force on restrained items with increasing height up a multistorey building.*
- Represents a simplified approach which is generally conservative except in some cases for the few uppermost floors of a multistorey building. Design force values have been adapted from NZS 4203. A value of $S_p = 1.0$, appropriate to a single peak response which may damage contents has been assumed. The additional factor of 1.5 which NZS 4203 requires for connections, which in the event of failure represents a risk to people, has therefore not been incorporated.*

The specified force (ultimate limit state) shall not exceed the strength of any component of the restraint

system. Where safe working loads of fasteners, which include factors of safety are used, an overly conservative design will result.

The design force level has its basis in NZS 4203 which has among its objectives the protection of life. By adopting this level of seismic force the risk of injury from building contents is similar to that from structural and non-structural elements.

3.2.6 Determination of the strength of a restraint system

3.2.6.1

The strength of a restraint system shall be determined using one, or a combination of the following methods:

- Application of relevant New Zealand Codes of practice and accepted engineering design principles.
- Fastener strengths and strengths of restraint system components as given in section 4.
- Test results of restraint systems or of individual components from a Building Certifier as defined in the Building Act 1992.

3.2.7 Restraint system configuration

3.2.7.1

Restraints should generally be distributed to the peripheral of the item being restrained provided the specified horizontal restraint forces from the item can be resisted without damaging the item or the supporting structure to the extent of endangering occupants or detrimentally affecting egress. Excessive movement that could pose a threat of injury or cause damage to other items shall be prevented.

3.2.7.2

For units with height to width ratios greater than 4 use wall and floor restraints (figure 6.3) or provide bracing along tops of units to load-bearing structures. Such bracing will require specific design.

3.2.7.3

Examples of some suggested restraint configurations for a selection of various building contents are given in section 5.

3.3 Type 2 protection

3.3.1

Type 2 protection shall be provided where risk of damage to any item, irrespective of weight, is to be minimized.

3.3.2

The restraint strength shall be determined as for Type 1 protection.

3.3.3

The possibility of an item requiring protection being damaged by unrestrained contents falling from above shall be considered.

4 STRENGTH OF FASTENERS

4.1 General

Fastener and component strengths in table 4.1 may be used in the design of seismic restraints for building contents where data for proprietary fixing systems is not available.

Table 4.1 – Strength values for commonly used fasteners and components

Fastener description	Fixing situation	Tension or pull-out strength
Curtain-wire		kg kN 18 0.18
Wall-mate™	Into wall lining	15 ⁽¹⁾ 0.15
Spring toggle™ (3.1 and 4.7 mm screw dia.)	Through wall lining	30 ⁽¹⁾ 0.30
Ramtoggle™	Through wall lining	25 ⁽¹⁾ 0.25
Hollow wall anchor	Through wall lining	25 ⁽¹⁾ 0.25
Wood screw 6 gauge (min. length 32 mm)	Into timber stud or dwang	45 0.45
Wood screw 10 gauge (min. length 63 mm)	As above	160 1.6
Steel bolt 6 mm with washer (min. dia. 20 mm)	Through timber member	250 2.5
Bolt 6 mm through steel	Through steel member	600 6.0
Expansion anchor 6 mm dia hole: E ⁽²⁾ between 40 mm and 50 mm	Into concrete	250 2.5
E greater than 50 mm	Into concrete	500 5.0
Expansion anchor 8 mm dia. hole: E between 50 mm and 65 mm.	Into concrete	400 4.0
E greater than 65 mm	Into concrete	800 8.0

NOTE –

(1) These values from Charleson, 1991 are based on 9.5 mm Gibraltar board™ wall linings.

(2) E - Embedment depth below concrete surface.

4.1.1

The tensile strength of curtain-wire is limited by the material strength of the closed eye screws. At the point that eye failure occurs the wire has stretched to 5 times its original length. At a tension load of 11 kg the stiffening effect of the plastic sheath is lost and a 50 % extension of the wire has occurred.

4.1.2

The shear strength of an expansion anchor may be taken as equal to the tension strength.

4.1.3

Where expansion anchors fix into reinforced concrete masonry walls the minimum depth of penetration shall be 25 mm into the hardened grout.

C4.1

These values are based on dependable strength values from test results and engineering calculations. They are to be used in conjunction with the ultimate limit state forces specified herein and therefore will be considerably greater than usual safe working load values.

4.2 Tensile strength of wire and nylon monofilament

4.2.1

The strength of wire and other restraint materials shall be as required by section 3. The strength of nylon monofilament shall be taken as 0.5 times the manufacturer's stated breaking strength.

C4.2.1

Static load testing has shown that nylon monofilament is generally weaker than strengths stated by the manufacturers. An allowance also has been made for possible reduction in strength due to ultraviolet light embrittlement. This effect has not yet been quantified, so nylon should be tested for deterioration at least every 2 years by giving it a sharp tug, especially if it has been exposed to sunlight.

4.2.2

Connections between lengths of wire or nylon shall be at least as strong as the line material itself.

C4.2.2

With correct connections or knots the wire or lines themselves will break. Figure 4.1 shows knots for nylon monofilament which are capable of developing the full line strength.

4.2.3

The strength of any other hardware such as snap links or swivels used to construct a seismic restraint system shall exceed the required restraint strength.

5 INSTALLATION OF SEISMIC RESTRAINT SYSTEMS

5.1

Where proprietary products are used in a seismic restraint system the latest manufacturer's written instructions shall be used.

5.2

Where screwing into wall studs or dwangs it shall be ensured that the screw is located within plus or minus 10 mm of the centre line and no closer than 20 mm from the end of the timber member.

5.3

Verification of strengths of knots and other connections whose strength values are not provided by this Standard shall be carried out during installation of seismic restraint systems.

C5.3

Restraint systems for light items (weight less than 20 kg) should be given a sharp tug to check that there are no obvious weaknesses.

5.4

Before drilling holes for fasteners into concrete the location of any high strength reinforcing steel shall be verified so as to prevent it being damaged.

6 SUGGESTED EXAMPLES OF TYPE 1 PROTECTION SEISMIC RESTRAINTS

6.1 General

6.1.1

Suggested examples of a selection of Type 1 protection restraints in this section are given as a guide. Where specific details are provided they have been designed in accordance with 3.2.5.1(b) for ground floor location and therefore will require modification for higher level floors.

6.1.2

It is expected that some of the details in the examples will require modification to suit the physical circumstances. Any modifications made shall ensure that the final installed seismic restraints meet all

the requirements of this Standard. There will often be a number of acceptable methods for providing satisfactory seismic restraint for an item.

6.1.3

Suggested details of Seismic Restraints for a number of common items are shown in the figures referred to in table 6.1 below.

Table 6.1 – Figures showing suggested Type 1 seismic restraint details

Item	Figure	Notes
Floor mounted appliances	6.1	
Bench and shelf mounted appliances	6.2	
Bookcase, cabinet or shelves restrained by wall	6.3	
Free-standing shelves cupboards and lockers	6.4	
Low cabinet or desk supporting heavy equipment	6.5	
Heavy storage shelves and cabinets	6.6	
Ornaments on shelves	6.7	Allows toppling but prevents ornament falling
Wall hung items	6.8	
Hanging items	6.9	Restraint of luminaires is covered in NZS 4219
Upright piano restrained by wall	6.10	
Electric hot water cylinders	6.11	
Equipment on desks, benches or shelves	6.12	
Free standing equipment	6.13	
Items in storage racks	6.14	May be used with supermarket shelving and storage
Items in cupboards and draws	6.15	
Filing cabinets	6.16	1, 2 and 3 draw filing cabinets may be unrestrained unless within 2 m of door jamb (3.2.1)
Office screens and workstations	6.17	The effect on suspended ceilings needs to be considered. Falling ceiling tiles may result from wall or screen support posts providing either unexpected restraint or additional horizontal loads.
Emergency battery power racks	6.18	
Hazardous materials	6.19	

6.2 Solid fuel burning appliances

Refer to NZS 7421/AS 2918.

7 SUGGESTED EXAMPLES OF TYPE 2 PROTECTION SEISMIC RESTRAINTS

7.1 General

7.1.1

In most cases Type 2 protection, to reduce damage to building contents, may be achieved by Type 1 seismic restraint systems. Several suggested examples of Type 2 protection to contents not already covered in figures 6.1 to 6.19 are given in table 7.1.

7.1.2

Some sensitive equipment, for example computers, will also require restraint which will isolate the item from damage due to shock or impact effects in addition to restraints which prevent the item falling.

Table 7.1 – Figures showing suggested Type 2 seismic restraint details

Item	Figure
Fragile ornaments on benches or shelves	7.1
Fragile items in cupboards on shelves	7.2
Domestic water header tank	7.3

APPENDIX A
DESCRIPTION OF BUILDING CATEGORIES (adapted from NZS 4203:1992)

A1

Table A1 – Classification of buildings

Category	Description
I	Buildings dedicated to the preservation of human life or for which the loss of function would have a severe impact on society.
II	Buildings which as a whole contain people in crowds.
III	Publicly owned buildings which house contents of a high value to the community.
IV	Buildings not included in any other category.
V	Buildings of a secondary nature.

CA1*Examples of buildings for each of the 5 Categories are as follows:***Category I**

- (a) Designated civilian emergency centres and civil defence centres such as essential hospital facilities, (operating theatres and related treatment areas and their support facilities); ambulance, fire and police stations and buildings housing emergency vehicles and their fuel supply;
- (b) Radio and television transmitting facilities and telephone exchanges;
- (c) Power stations and sub-stations;
- (d) Maximum security places of restraint, such as blocks in some prisons and mental institutions;
- (e) Industrial plant of national importance, where production cannot readily be taken over by another plant;
- (f) Containment buildings for toxic and deleterious substances, the release of which could disrupt production in rural, forest or horticultural areas or cause serious illness.

Category II

Assembly halls, theatres, school classroom buildings, airport terminals, main railway stations, residential buildings containing more than 500 people and enclosed shopping malls and supermarkets.

Category III

Buildings with contents of particular cultural or historical significance, such as art galleries and archival record depositories.

Category IV

Other buildings such as office buildings, residential buildings, industrial buildings, or warehouses, where not included in any other Category.

Category V

Outbuildings, some farm buildings and temporary buildings such as offices on a construction site.

APPENDIX B

PROBABILITY OF SEISMIC DAMAGE TO CONTENTS OF BUILDINGS

B1 General

B1.1

The lowest intensity of earthquake shaking liable to cause damage is MMVI (i.e. step VI on the Modified Mercalli scale of earthquake intensity). At this intensity some objects, those most unstable, will fall from shelves. However, significant risk of injury from falling contents would not be likely. At earthquake intensities of MMVII and greater, extensive damage to contents and risk of injury resulting from falling, overturning and flung objects is expected.

B1.2

Table B1 gives the probabilities of MMVI and MMVII intensity shaking in selected locations during any 25 year period. The probabilities, expressed as percentages, will enable building users to appreciate the level of risk to injury and damage to building contents.

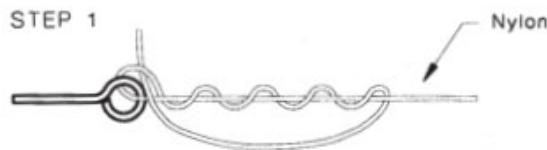
B1.3

Figure B1 divides New Zealand into 2 regions having either a greater than 30 % or a less than 30 % chance of a MMVII intensity earthquake being experienced within a period of 25 years. This map is derived from the information in table B1.

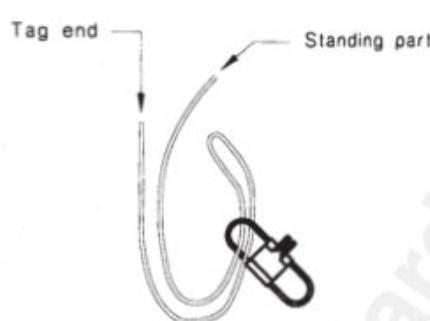
Table B1 – Probabilities of various earthquake intensities occurring at selected locations within a period of 25 years (expressed as a percentage)

Location	Probability MMVI %	Probability MMVII %
Kaitaia	10	3
Whangarei	14	3
Auckland	33	9
Tauranga	88	39
Hamilton	65	23
Whakatane	99	54
Rotorua	96	43
Taupo	99	46
New Plymouth	96	58
Napier/Hastings	96	45
Wanganui	99	77
Palmerston North	99	66
Masterton	96	62
Wellington/Hutt Valley	98	70
Nelson	99	79
Blenheim	99	77
Westport	96	62
Kaikoura	98	71
Greymouth	92	52
Christchurch	83	41
Mt Cook	83	41
Timaru	63	25
Milford Sound	88	33
Queenstown	88	37
Oamaru	60	22
Dunedin	55	17
Invercargill	83	39

NOTE – Adapted from Smith W. D. and Berryman K. R., 1983.



STEP 2

**HALF BLOOD KNOT**

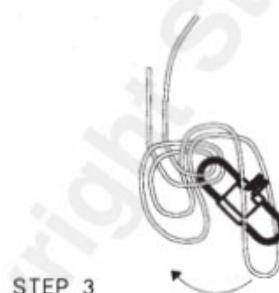
STEP 1

Double the tag end back against the standing part and insert the double line through the eye of the swivel or snaplink.



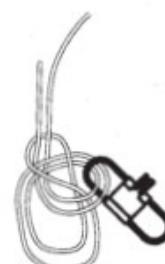
STEP 2

Tie a simple overhand knot with the double line, but don't tighten it.



STEP 3

Slip the loop over the swivel or snaplink while holding the overhand knot in place.



STEP 4

Hold the swivel or snaplink firmly in one hand and both the tag end and standing part of the line in the other. Pull steadily to tighten the knot, being careful that the loop slips past the eye before final tightening.

NOTE – When tied properly, this knot will achieve 95 % to 100 % of the line breaking strength.

PALOMAR KNOT**Figure 4.1 – Knots for tying nylon monofilament**

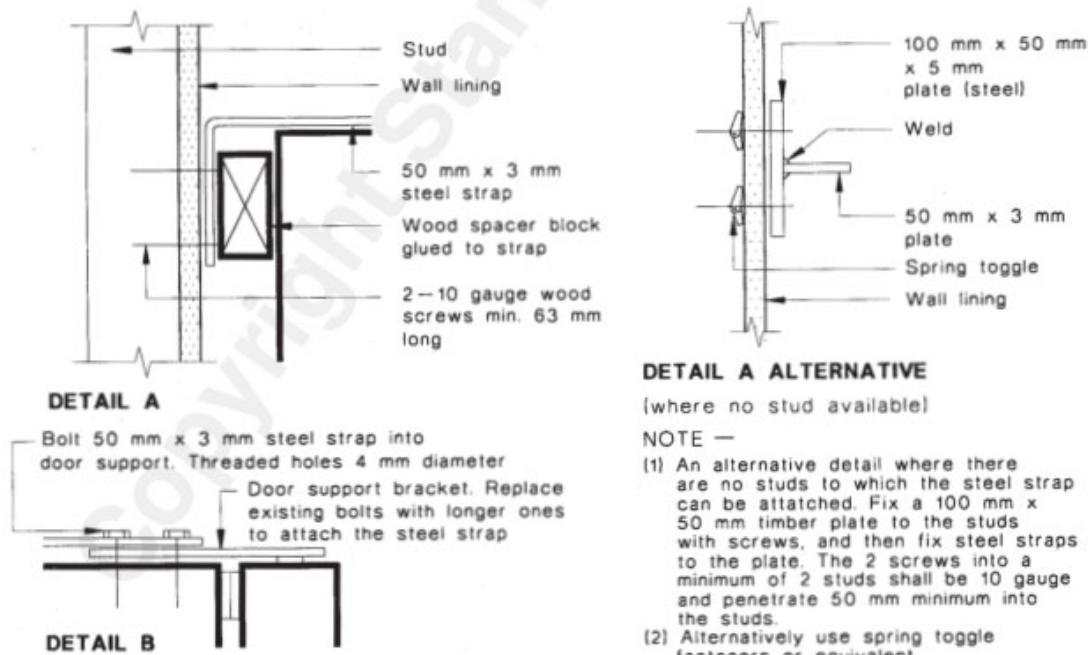
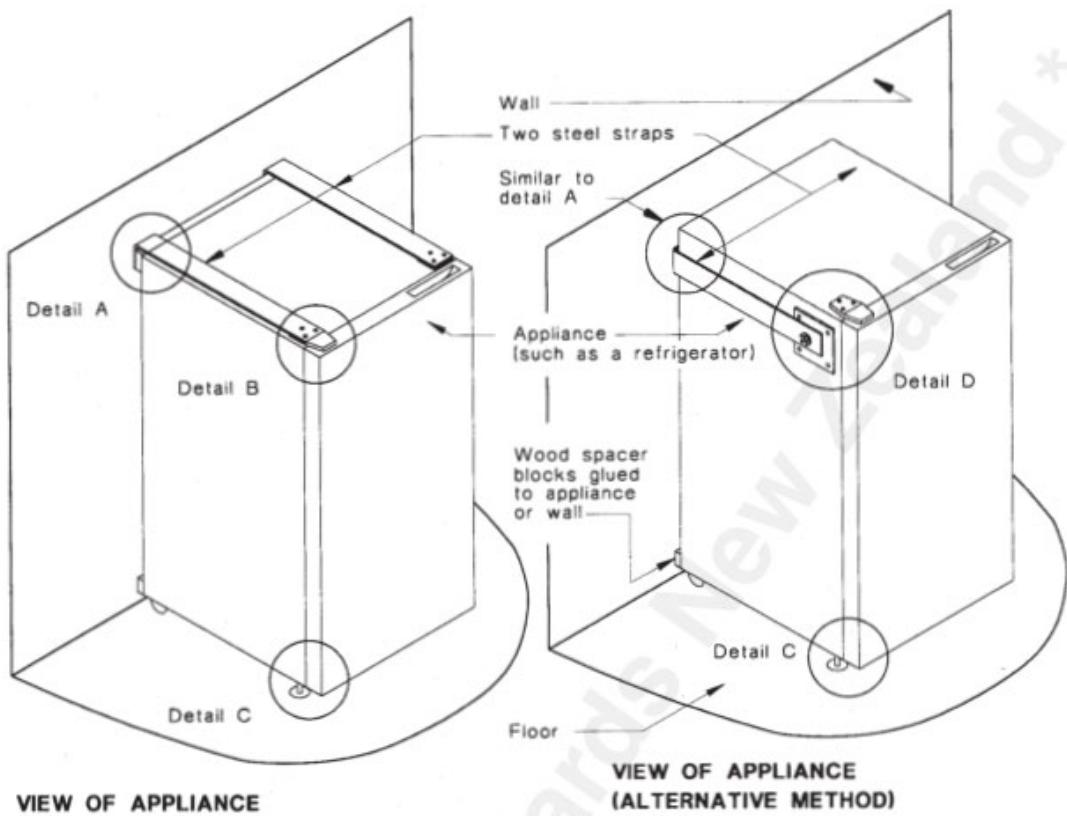
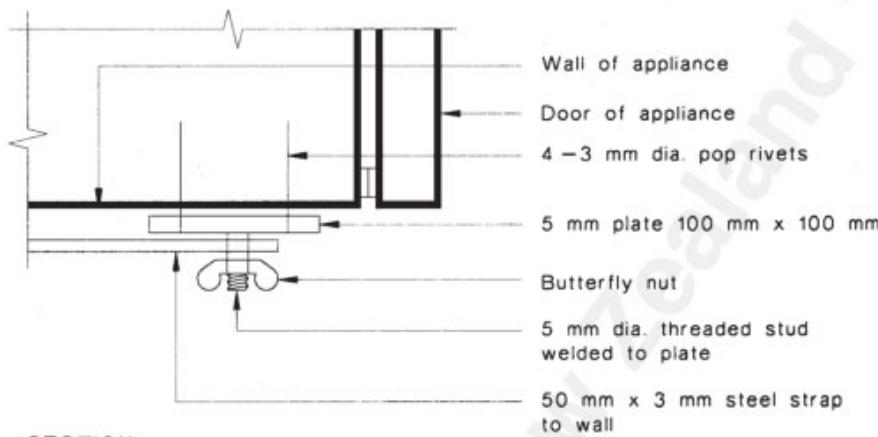
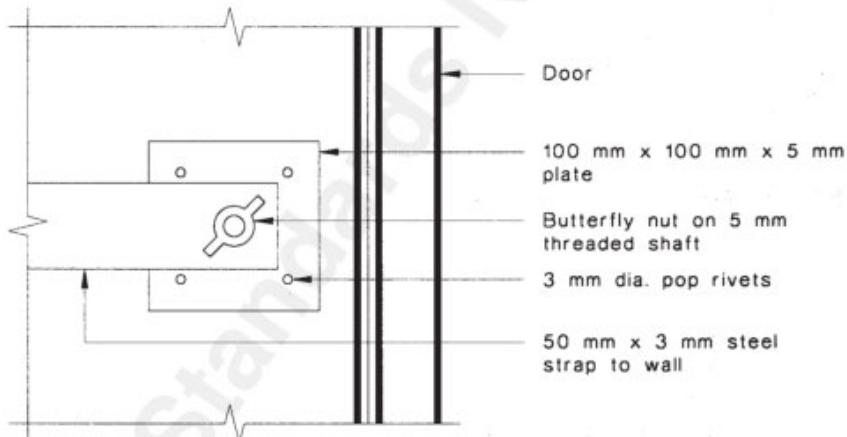


Figure 6.1 – Suggested seismic restraint of floor mounted appliances

**SECTION****ELEVATION****DETAIL D****NOTE —**

- (1) A template from the appliance manufacturer should be used when locating pop rivet holes to prevent damaging pipes or wires embedded in the wall insulation.
- (2) A mechanical latch should be provided on refrigerator doors to prevent contents being spilled. (Not to apply where there is a risk of a child being locked inside.)
- (3) Detail D is a possible alternative to detail B where there is sufficient side clearance.

Figure 6.1 – Suggested seismic restraint of floor mounted appliances (continued)

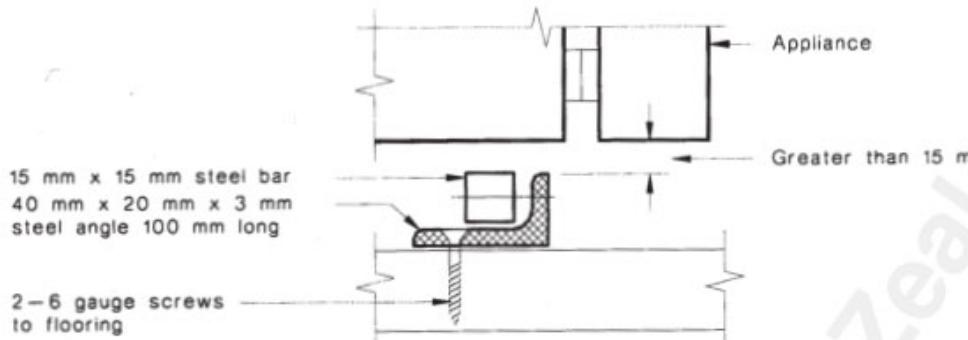
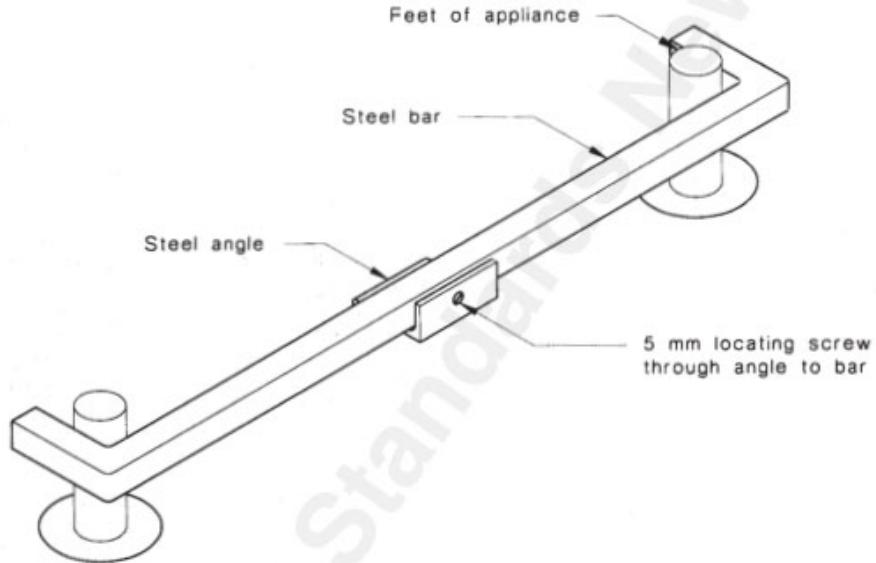
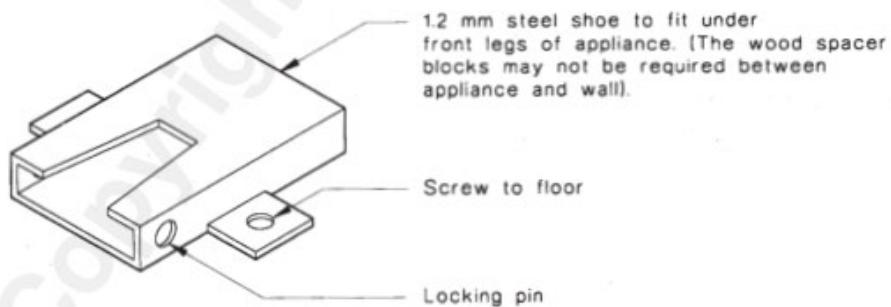
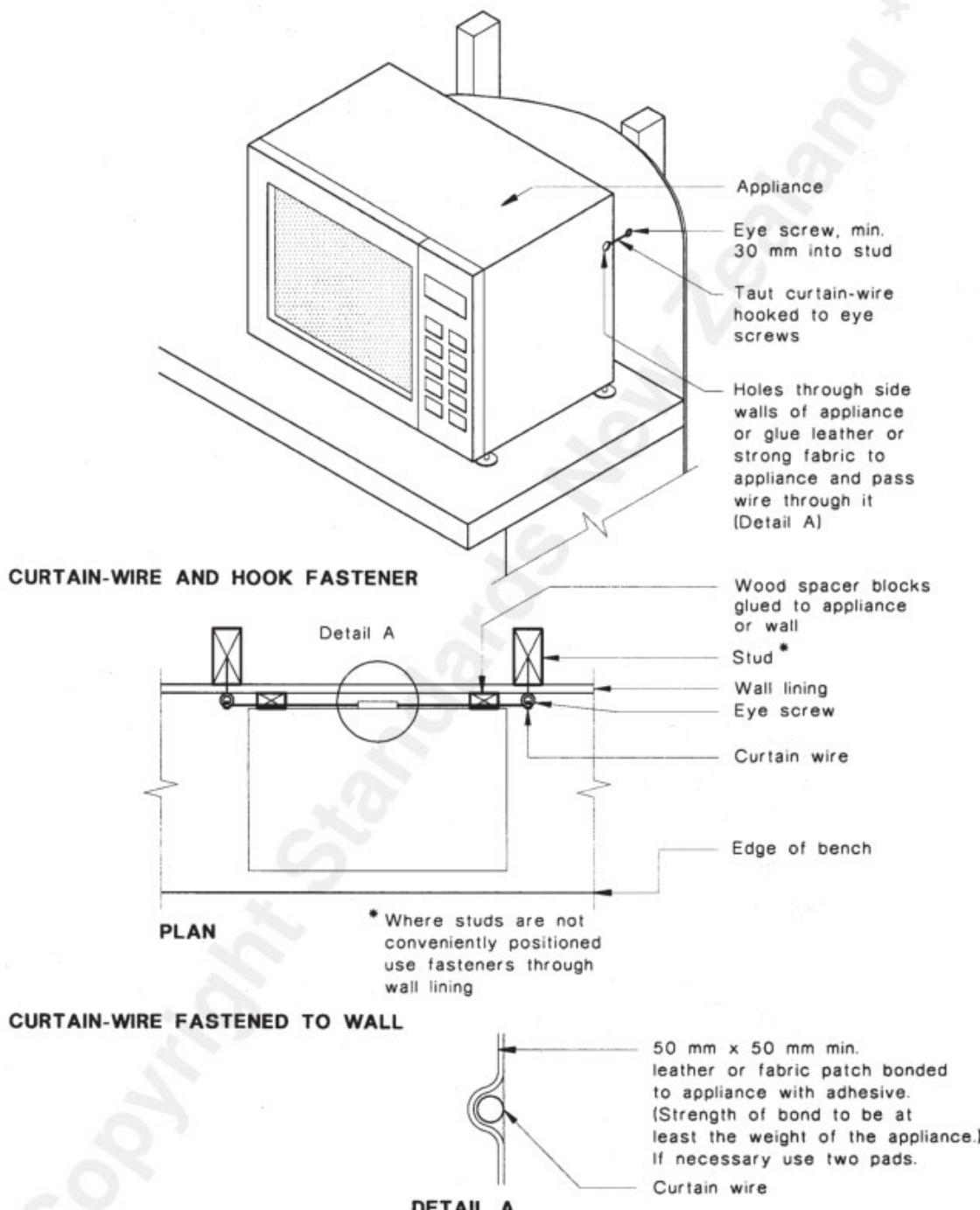
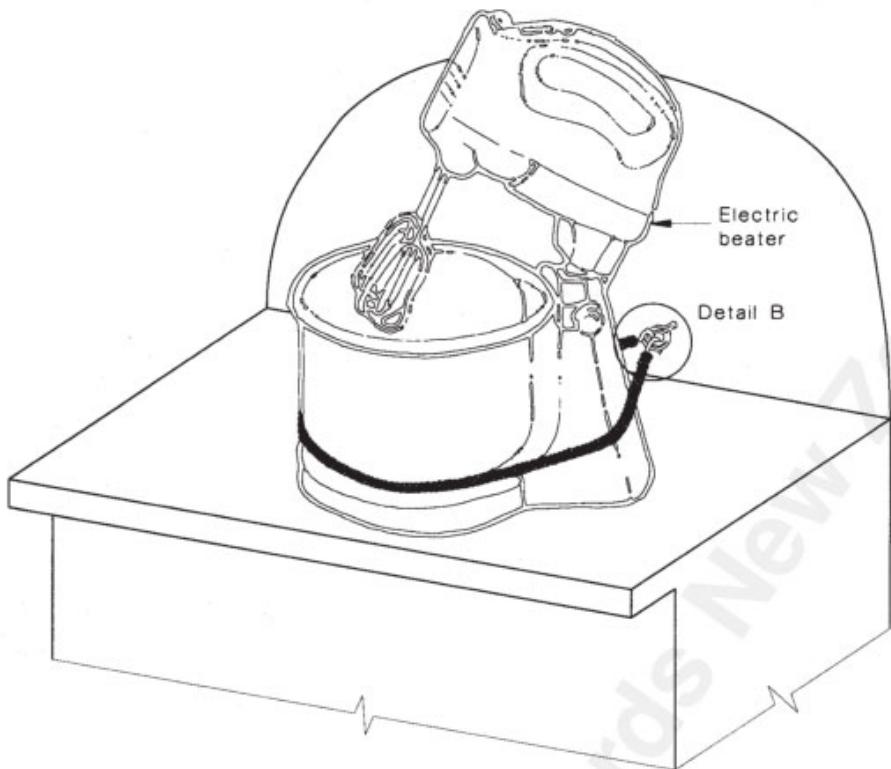
**SECTION****DETAIL C****DETAIL C ALTERNATIVE METHOD**

Figure 6.1 – Suggested seismic restraint of floor mounted appliances (continued)

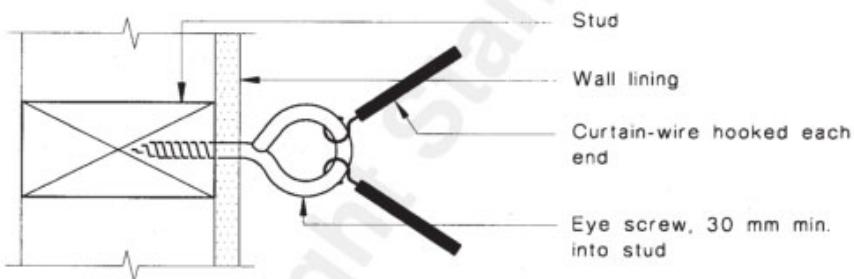


NOTE – Appliance weight of 15 kg is assumed.

Figure 6.2 – Suggested seismic restraint of bench and shelf mounted appliances



APPLIANCE ON A BENCH



DETAIL B

NOTE —When screwing into a cavity rather than a stud use a Wall-mate™ or equivalent and an eye screw into it.

Figure 6.2 – Suggested seismic restraint of bench and shelf mounted appliances (continued)

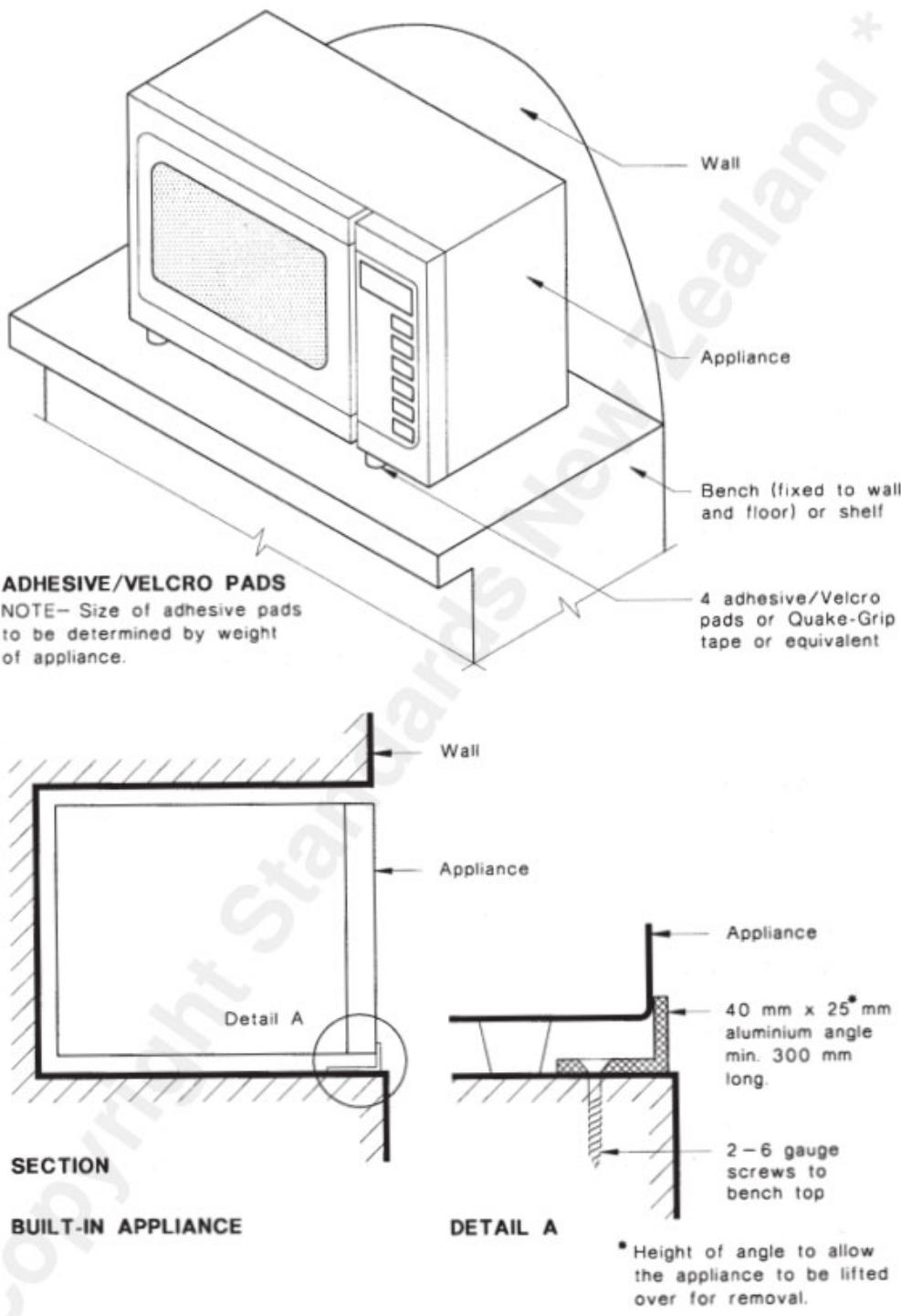


Figure 6.2 – Suggested seismic restraint of bench and shelf mounted appliances (continued)

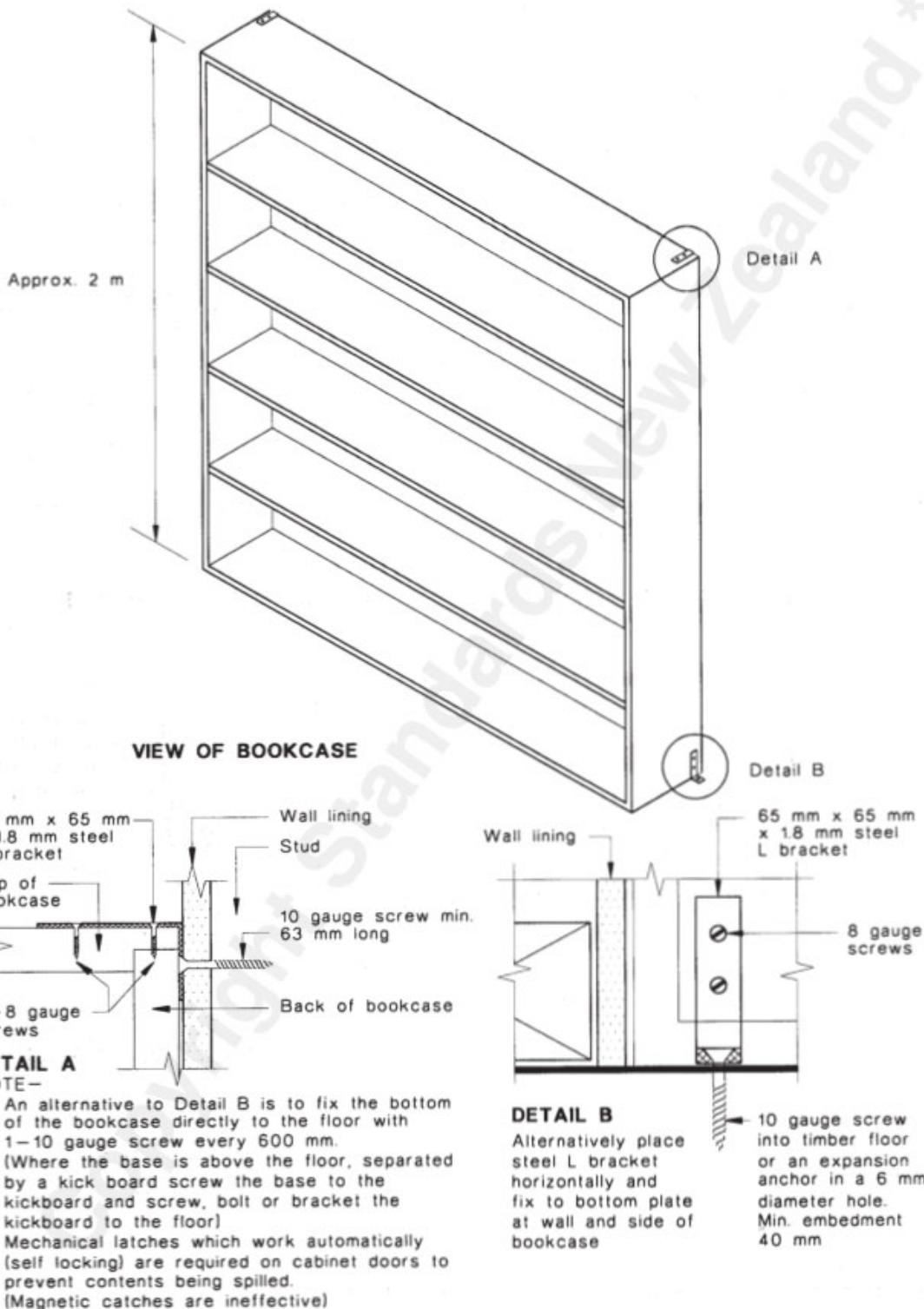
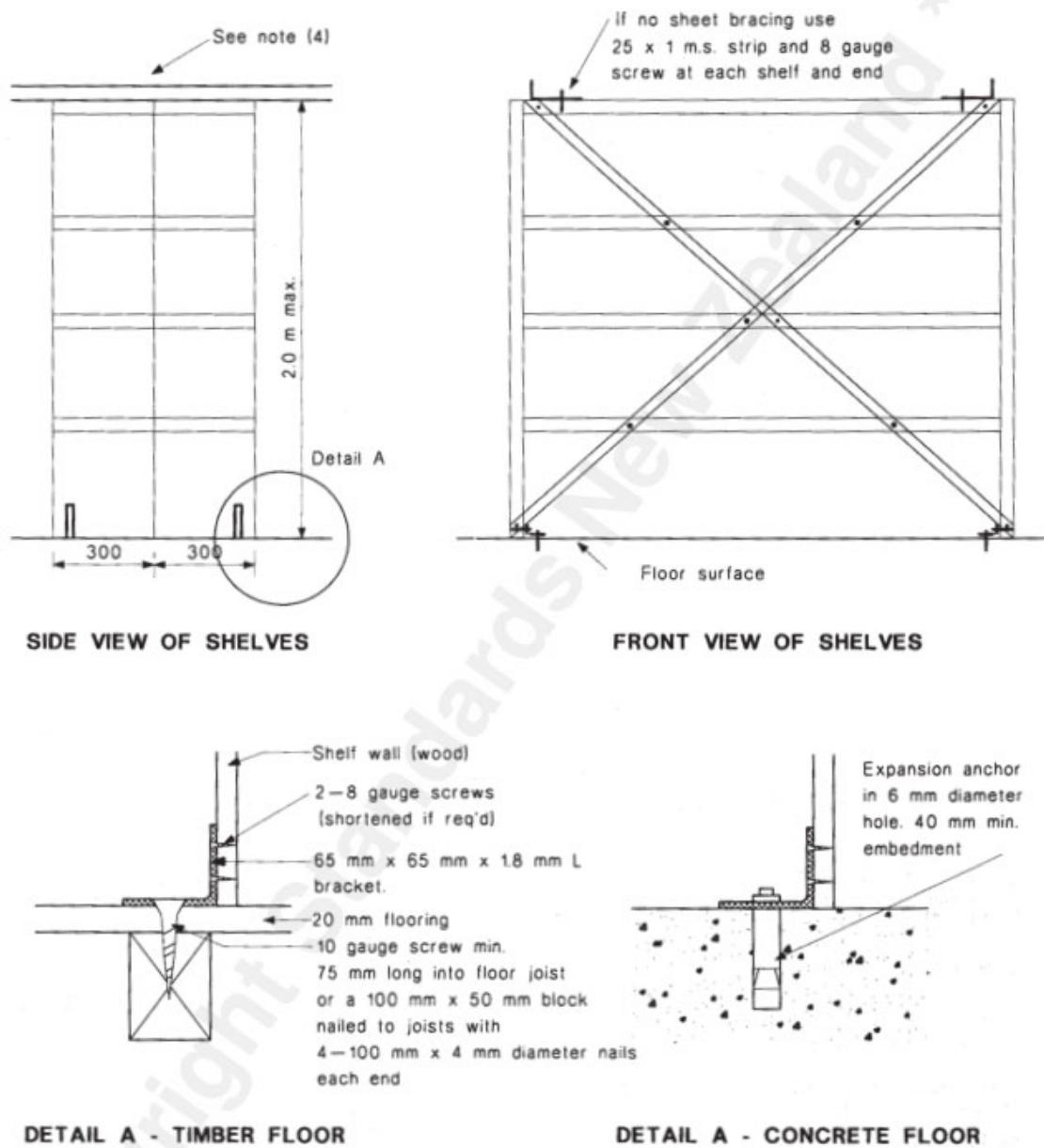


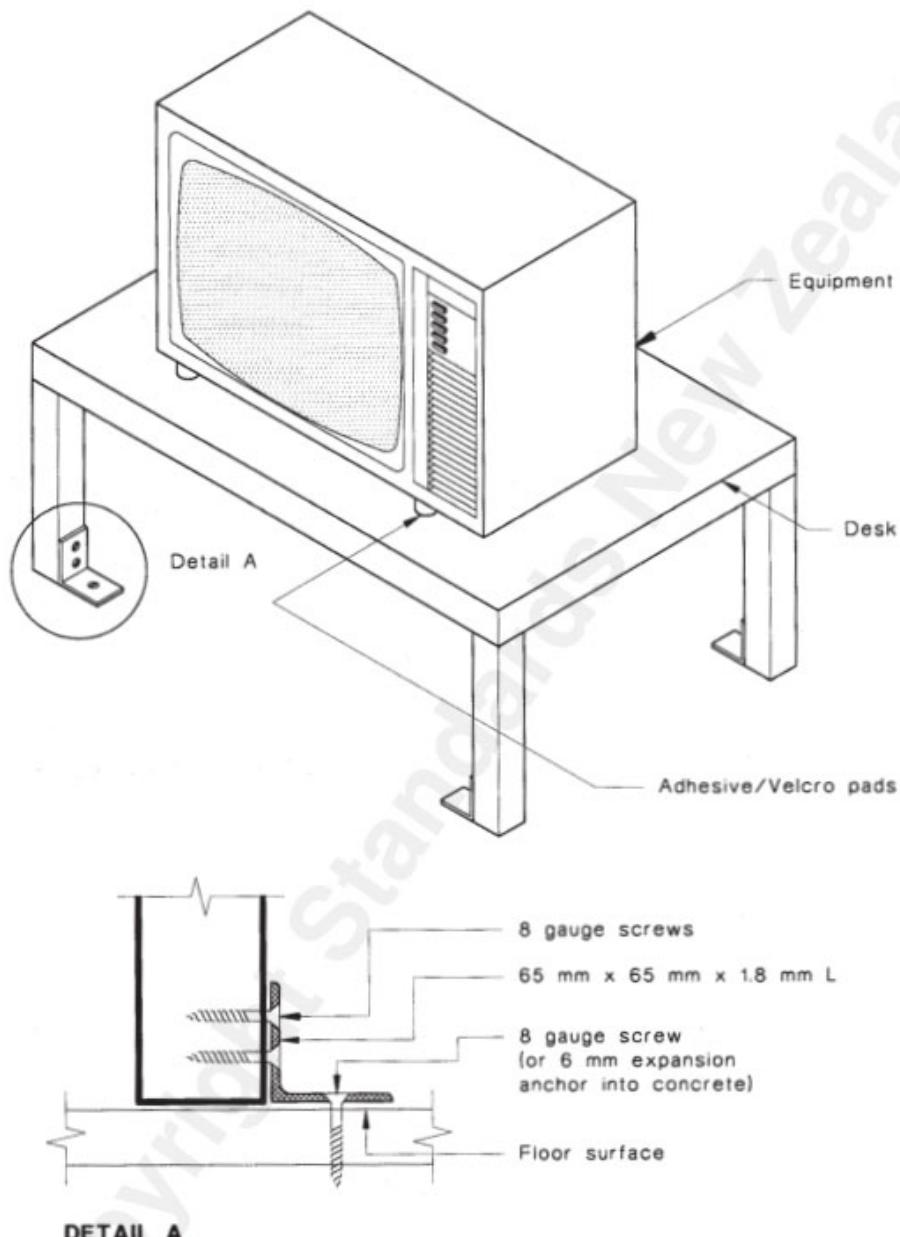
Figure 6.3 – Suggested seismic restraint to bookcase, cabinet or shelves restrained by wall



NOTE —

- (1) Weight of shelves plus contents assumed 200 kg.
- (2) When units are paired they must be screwed or bolted together so as they act as one unit under seismic loads.
- (3) For light steel cabinets and contents fix steel angles to steel walls with 2-5 mm diameter bolts.
- (4) For height/width greater than 4, use wall and floor restraints (figure 6.3), or provide bracing along tops of units to load bearing structure. (Requires specific design).

Figure 6.4 – Suggested seismic restraint of light free standing shelves, cupboards and lockers



DETAIL A

NOTE—

- (1) Desk and equipment weight assumed to be 30 kg each.
- (2) For lighter equipment could use only 2 points of restraint on diagonally opposite legs of desk.
- (3) To reduce visual impact of angle bracket place leg on top of the horizontal length of bracket.
As an alternative to adhesive Velcro pads/Thumb Lock™ or equivalent restraints may be used.

Figure 6.5 – Suggested seismic restraint of low cabinet or desk supporting heavy equipment

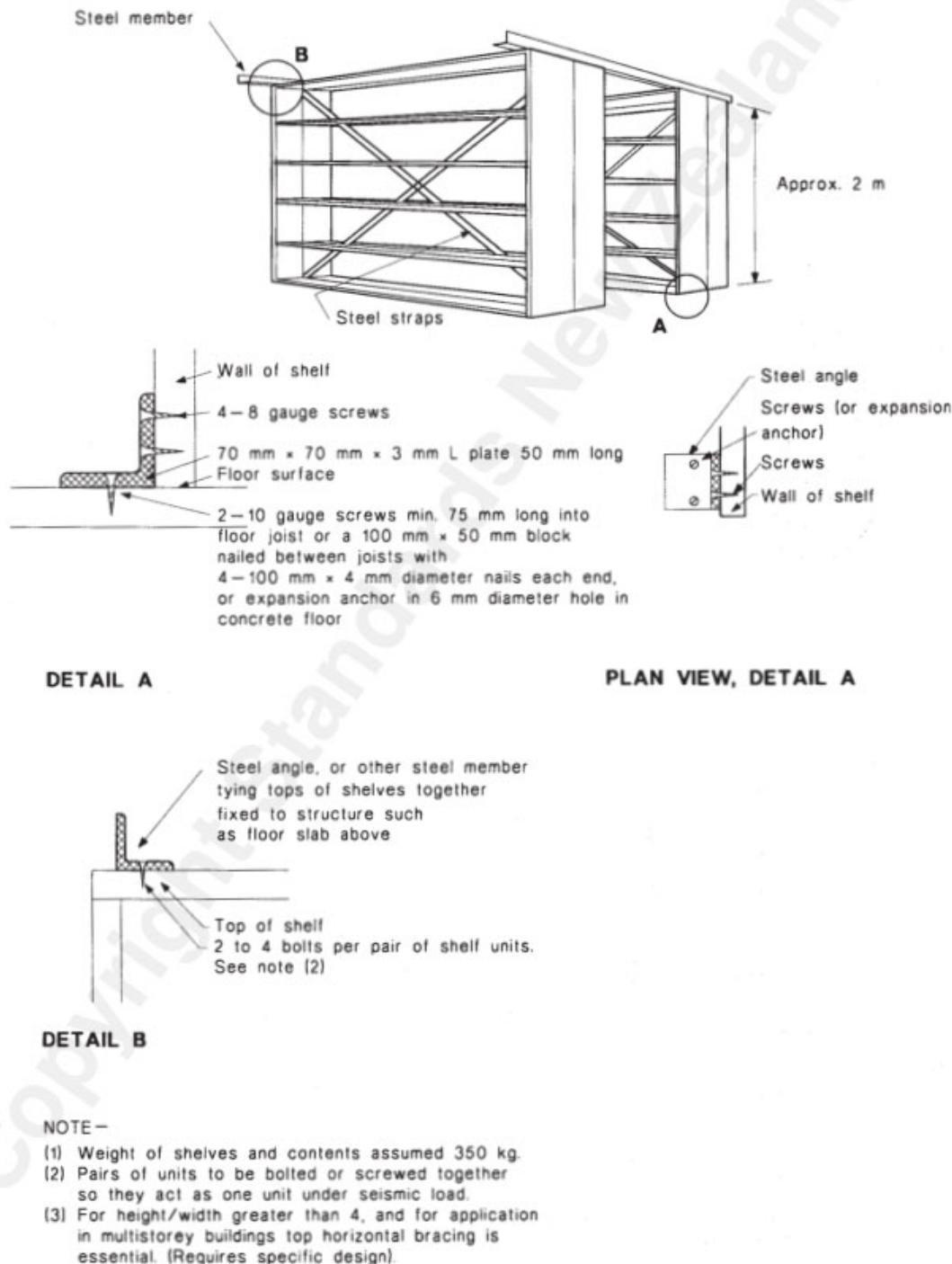


Figure 6.6 – Suggested seismic restraint of heavy storage shelves and cabinets

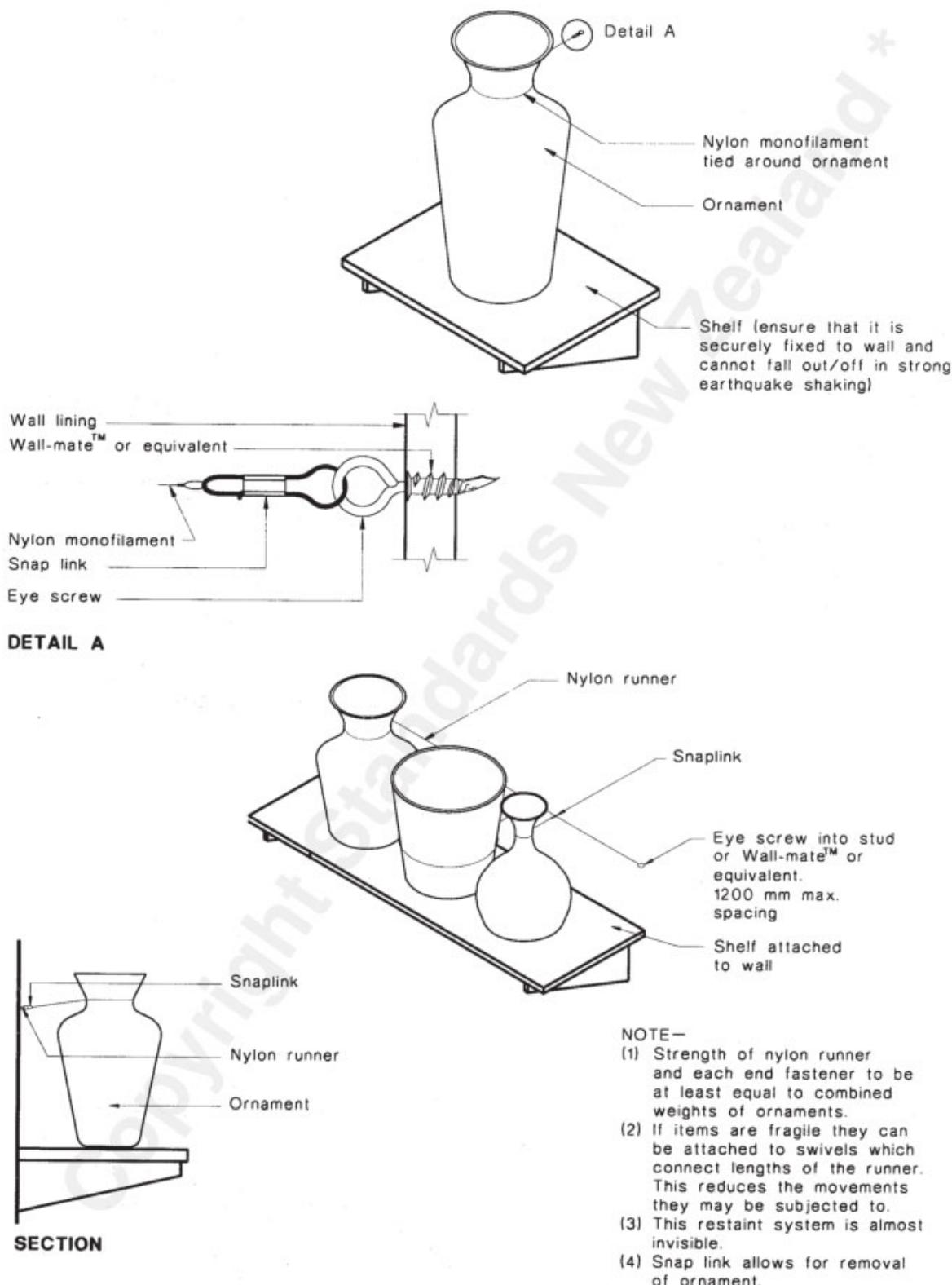
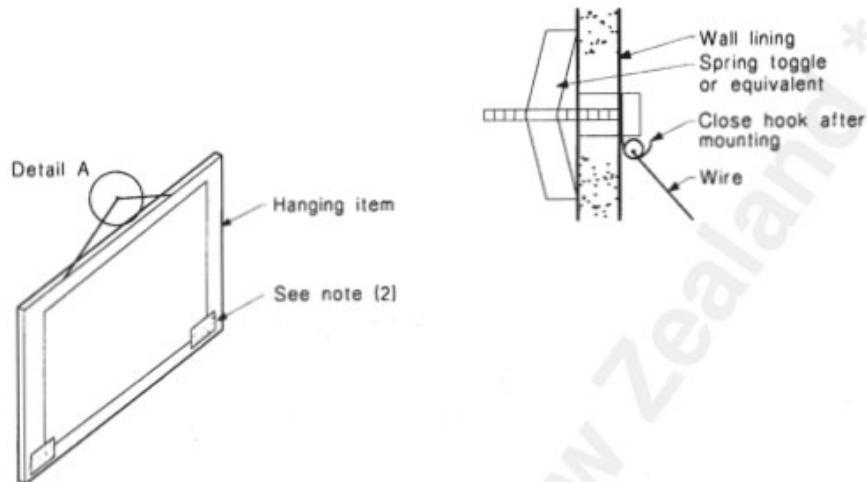
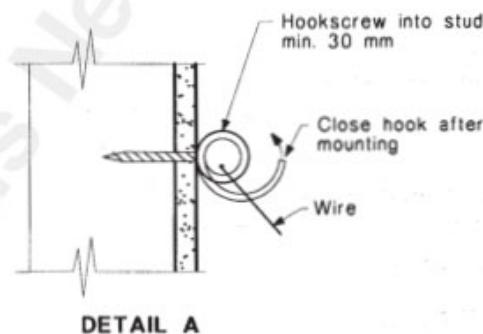


Figure 6.7 – Suggested seismic restraint of ornaments on shelves



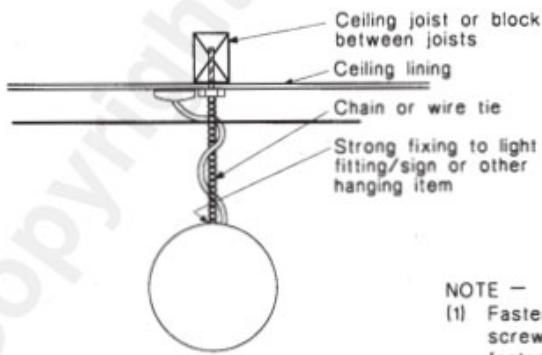
NOTE —

- (1) As wall fastener withstands both item weight plus seismic loads, choose fastener strength twice weight of item.
- (2) Swinging and bouncing of item can be prevented with adhesive/Velcro pads at the bottom two corners.
- (3) If swinging is not prevented ensure the hanging item will not dislodge other items within its vicinity.



DETAIL A

Figure 6.8 – Suggested seismic restraint of wall hung items



NOTE —

- (1) Fastener to ceiling is preferably a bolt or screw into ceiling framing, or a cavity fastener.
- (2) Strength of all components to be at least 4 times weight of hanging item.
- (3) For light fittings integrated with suspended ceilings refer to NZS 4219.
- (4) Check that damage/injury will not occur due to pendulum action/swinging of item.

Figure 6.9 – Suggested seismic restraint of hanging items

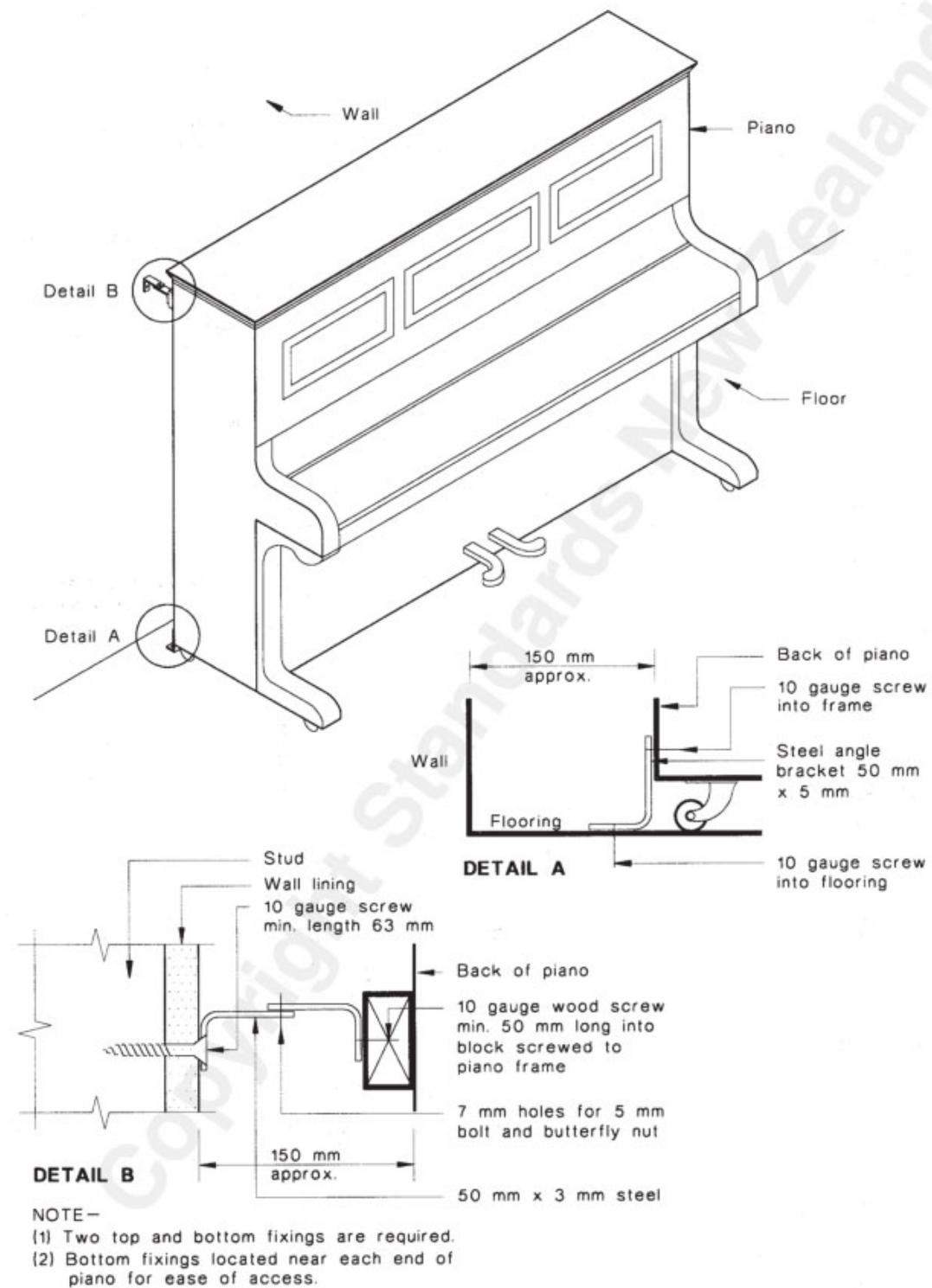
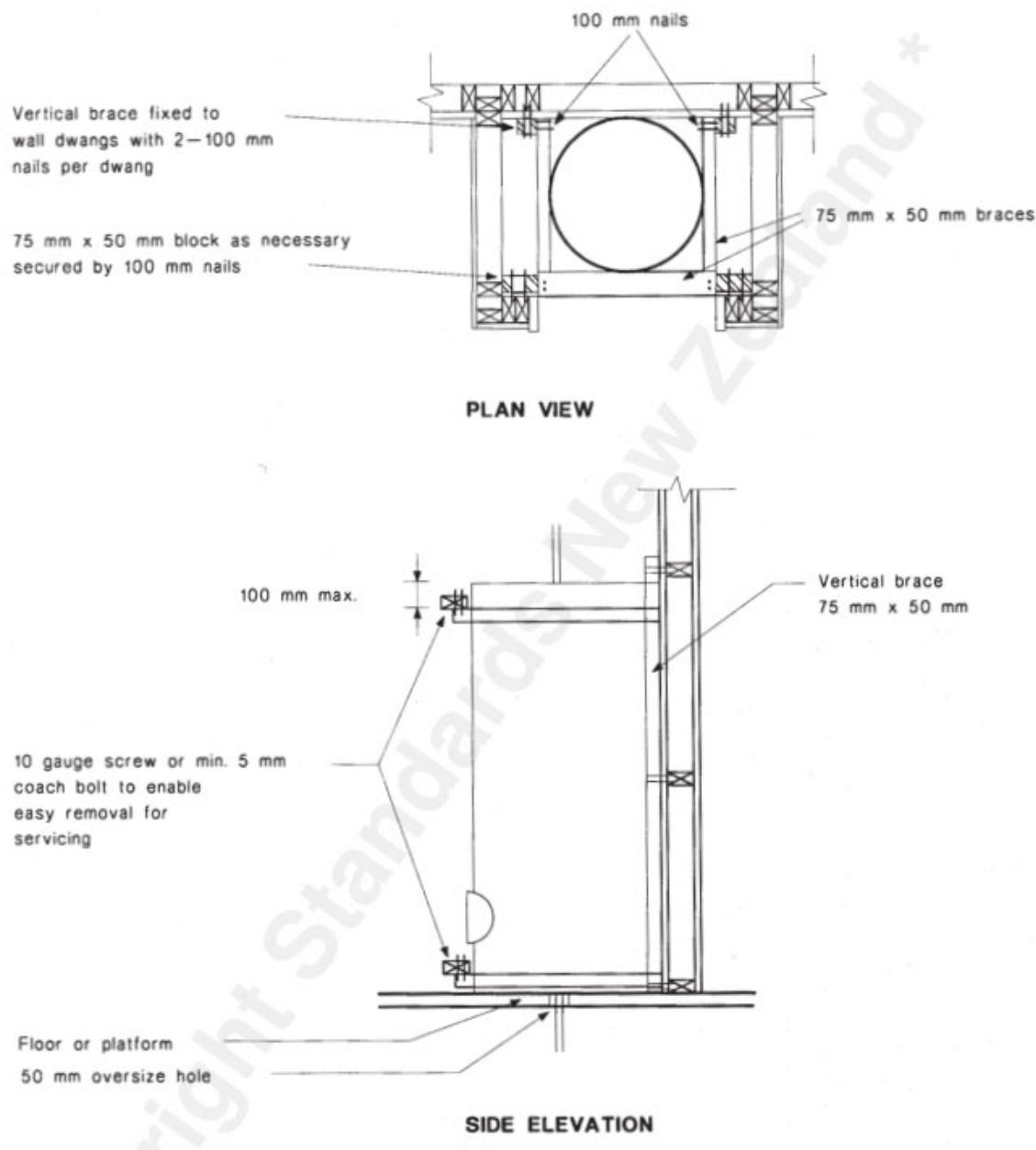


Figure 6.10 – Suggested seismic restraint of pianos



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Figure 6.11 – Suggested seismic restraint of domestic hot water cylinders

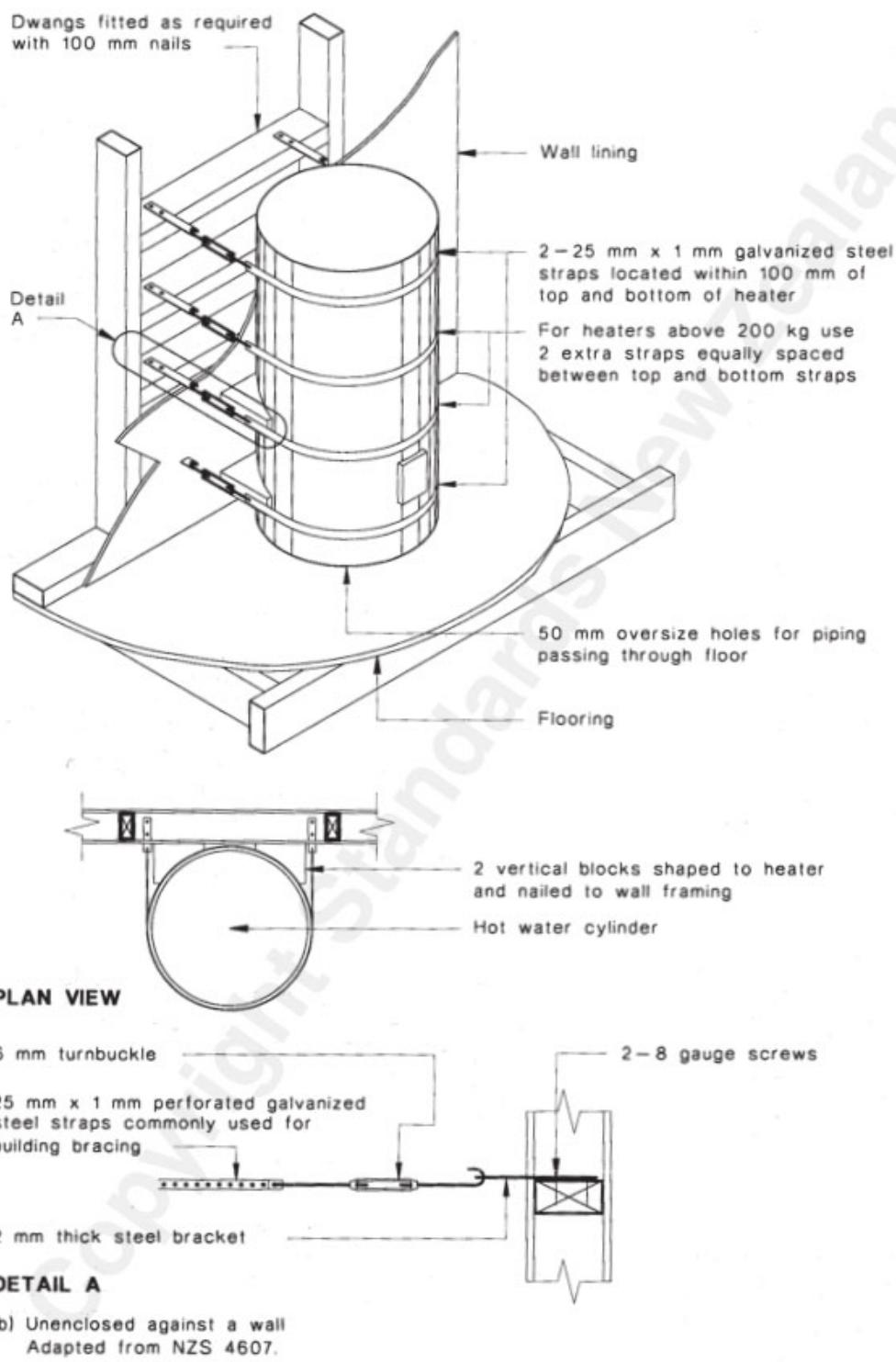


Figure 6.11 – Suggested seismic restraint of domestic hot water cylinders (continued)

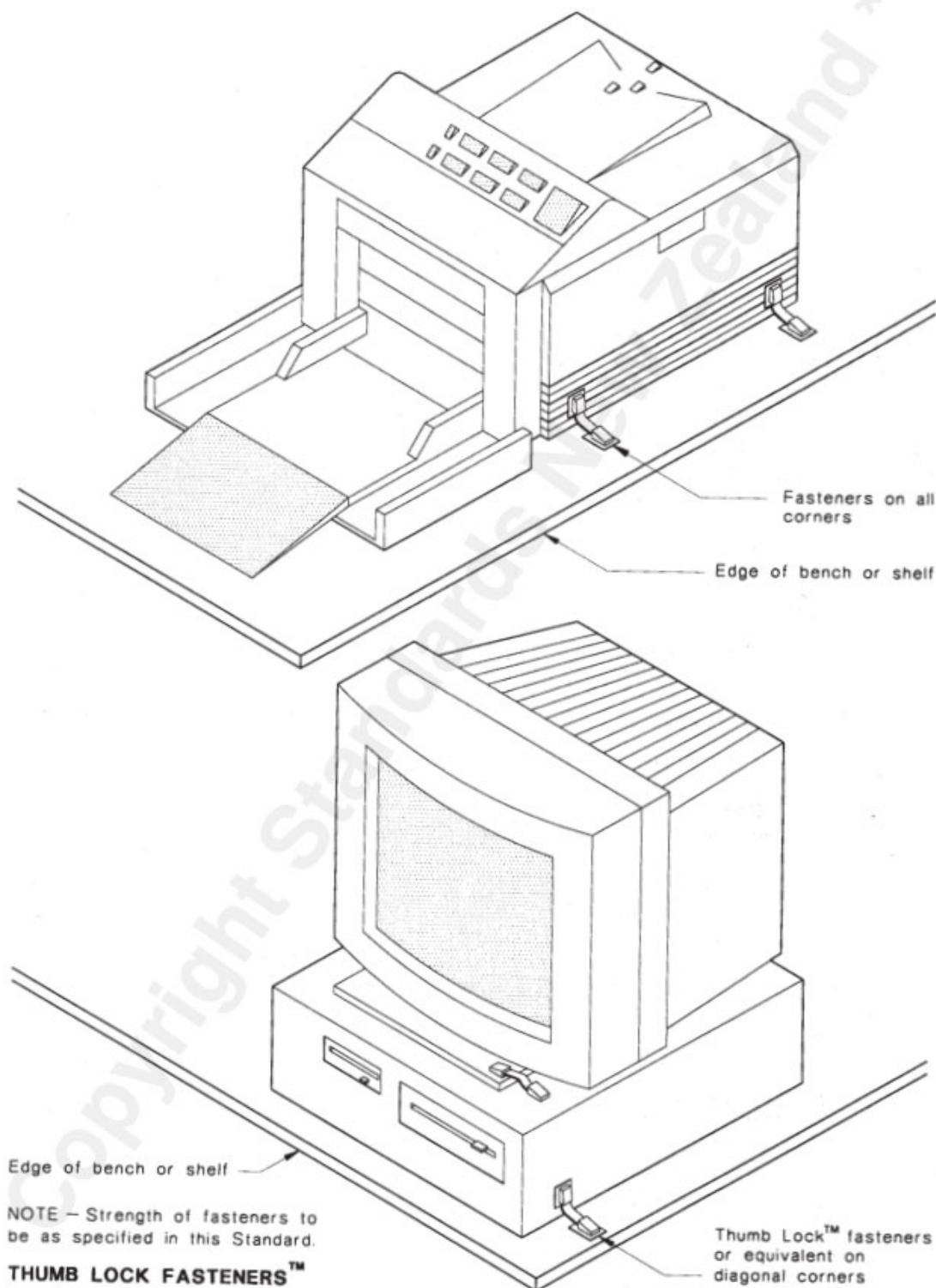


Figure 6.12 – Suggested seismic restraint of equipment on desks, benches or shelves

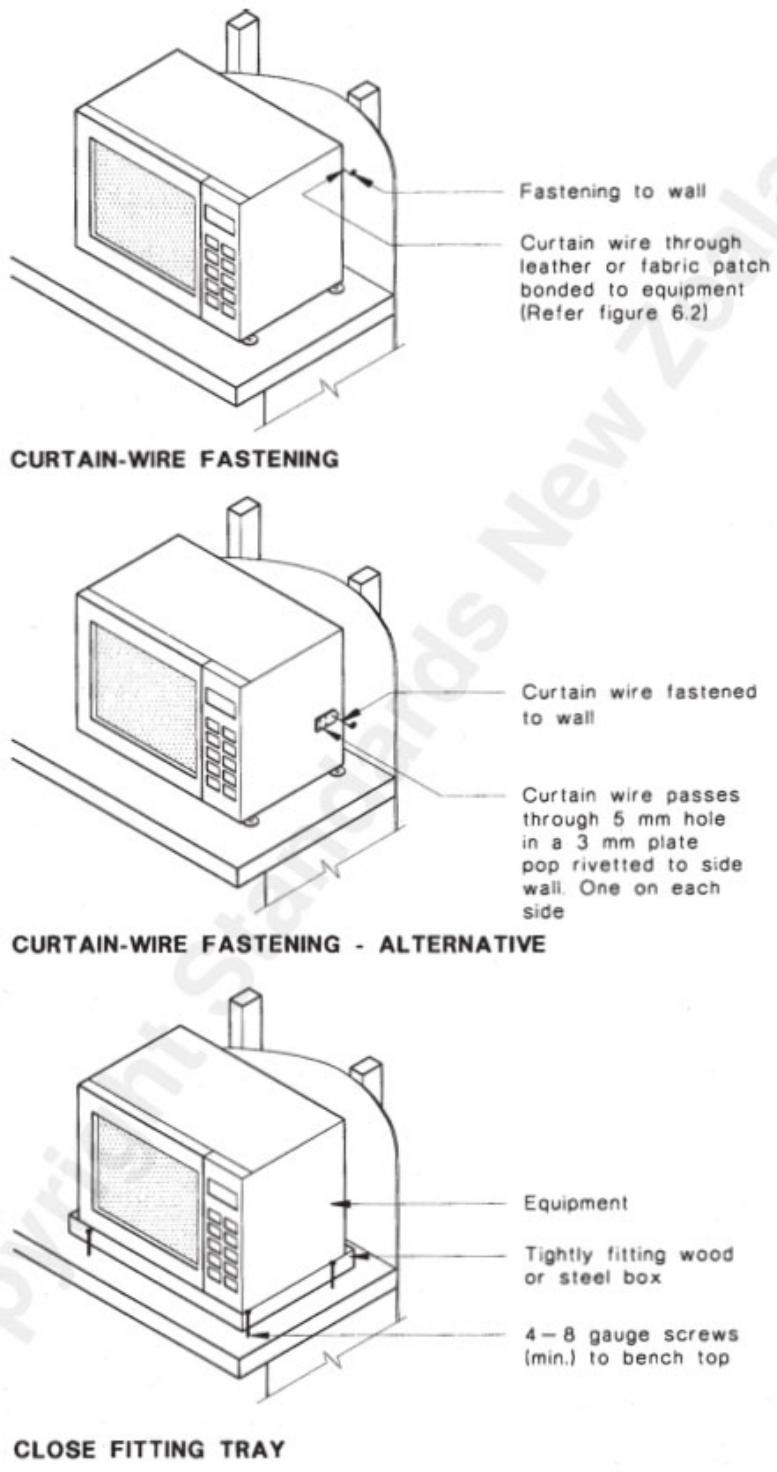


Figure 6.12 – Suggested seismic restraint of equipment on desks, benches or shelves (continued)

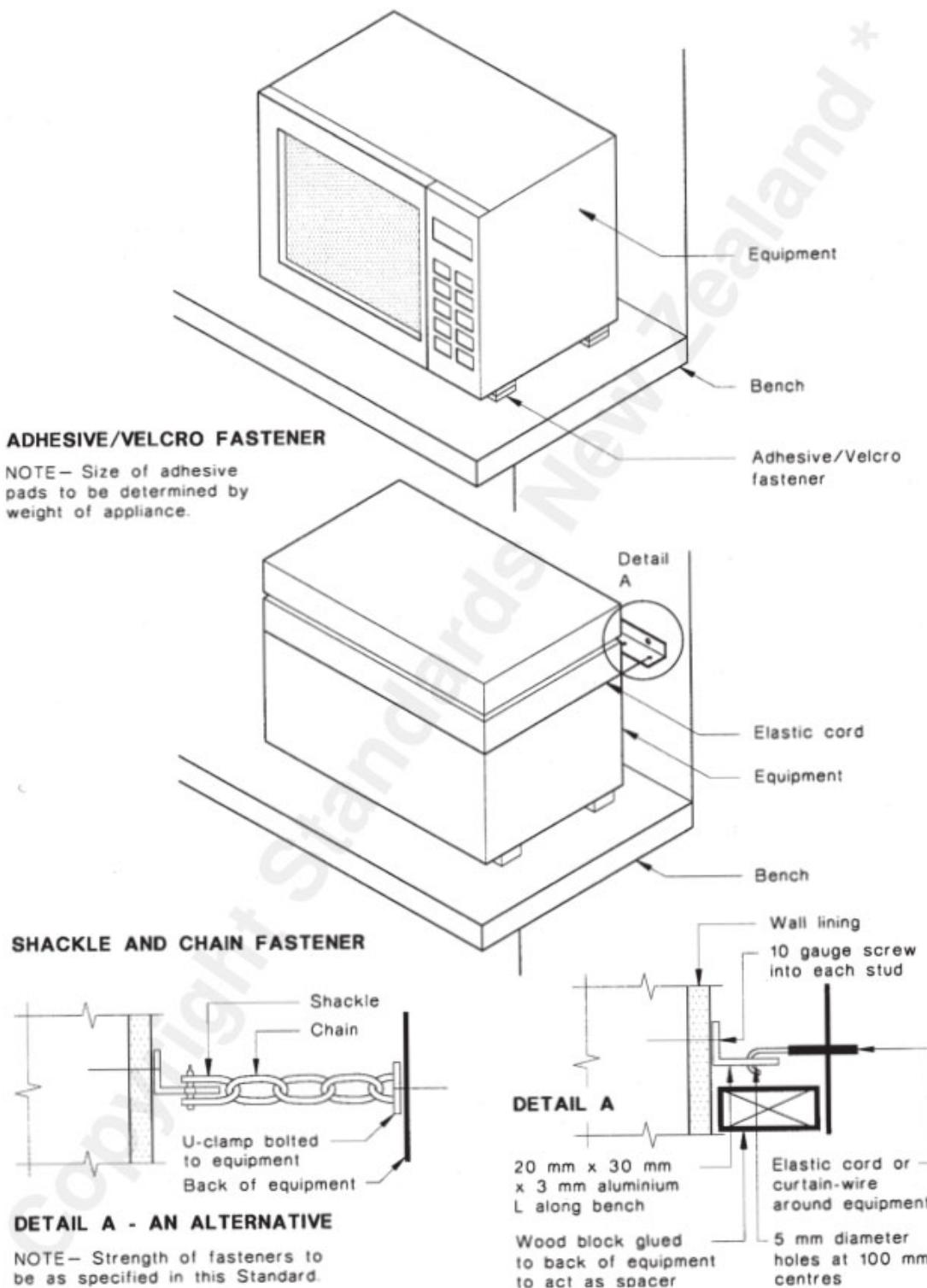


Figure 6.12 – Suggested seismic restraint of equipment on desks, benches or shelves (continued)

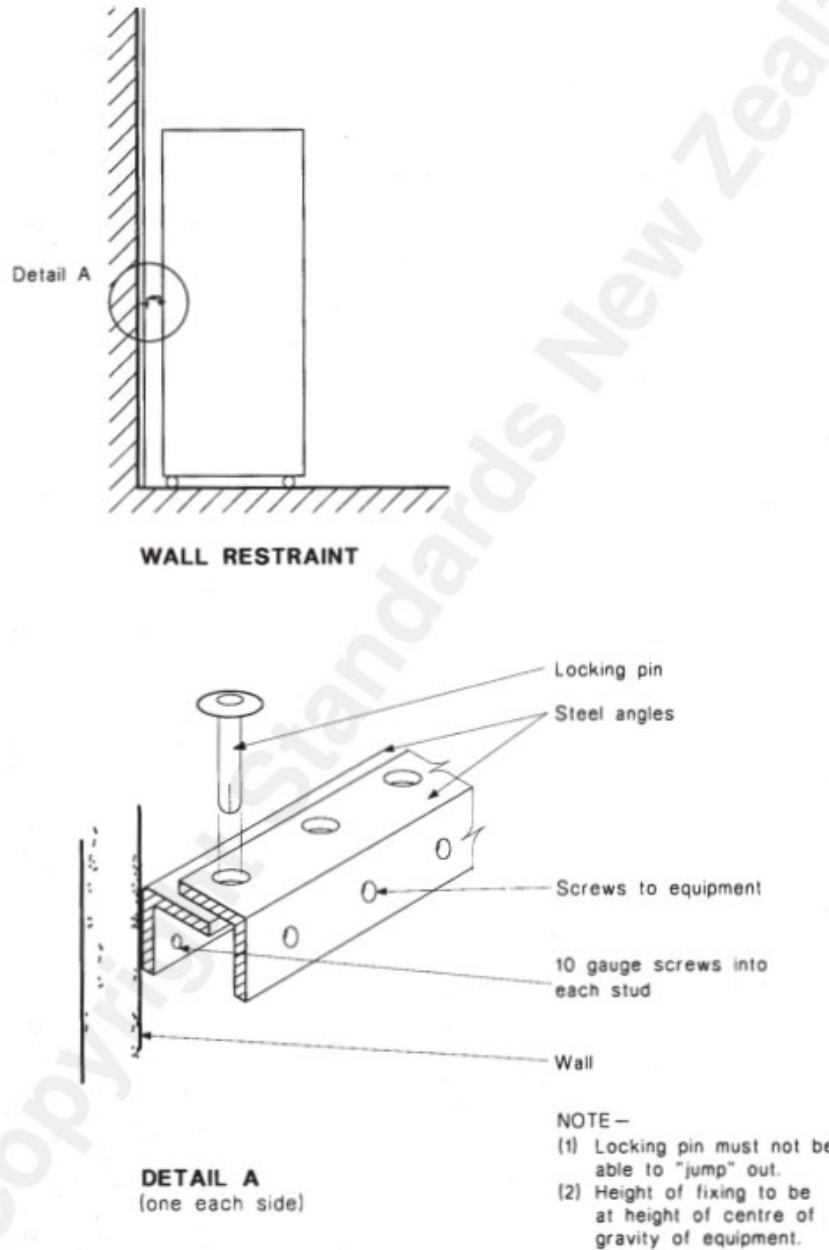


Figure 6.13 – Suggested seismic restraint of free standing equipment

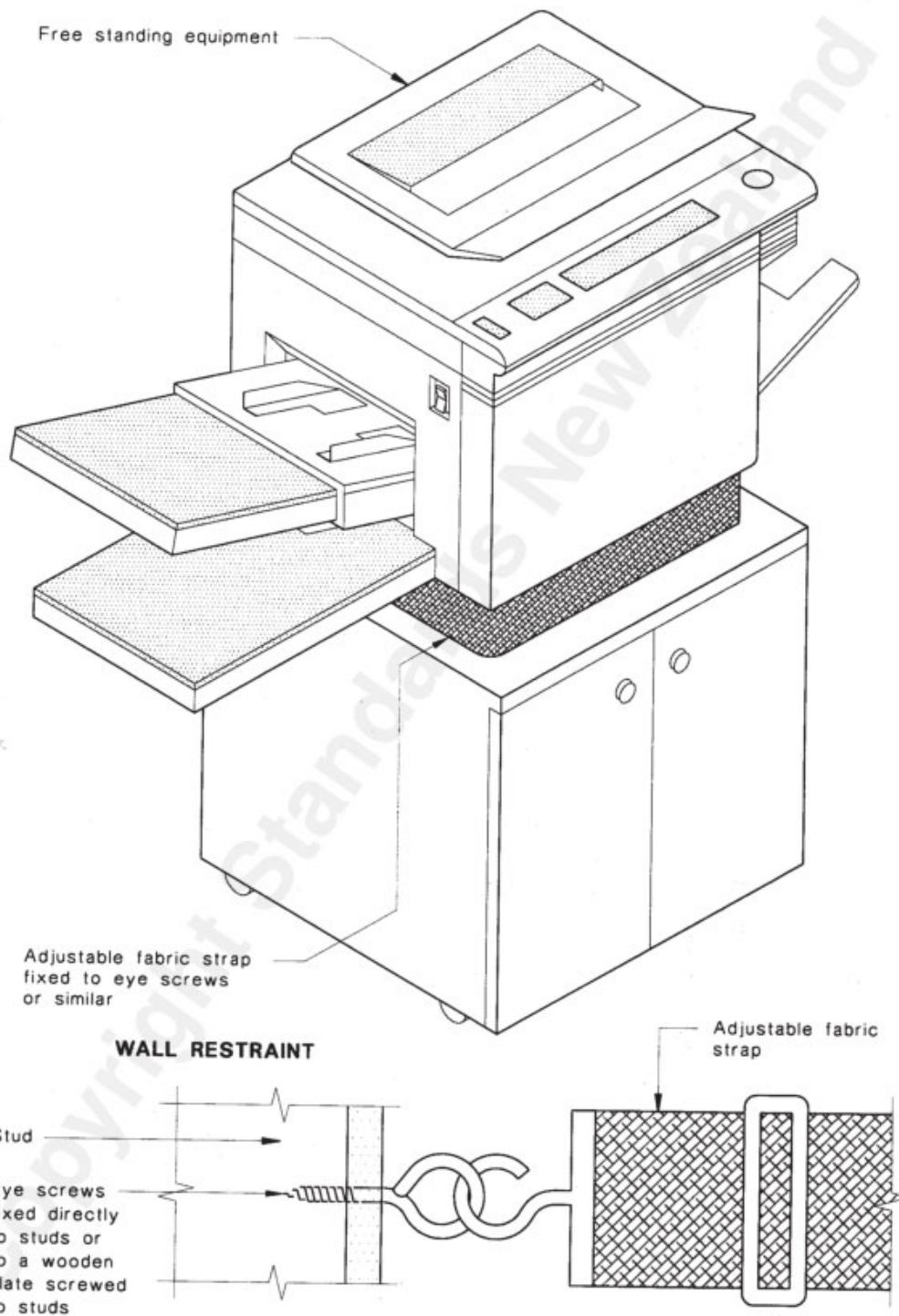
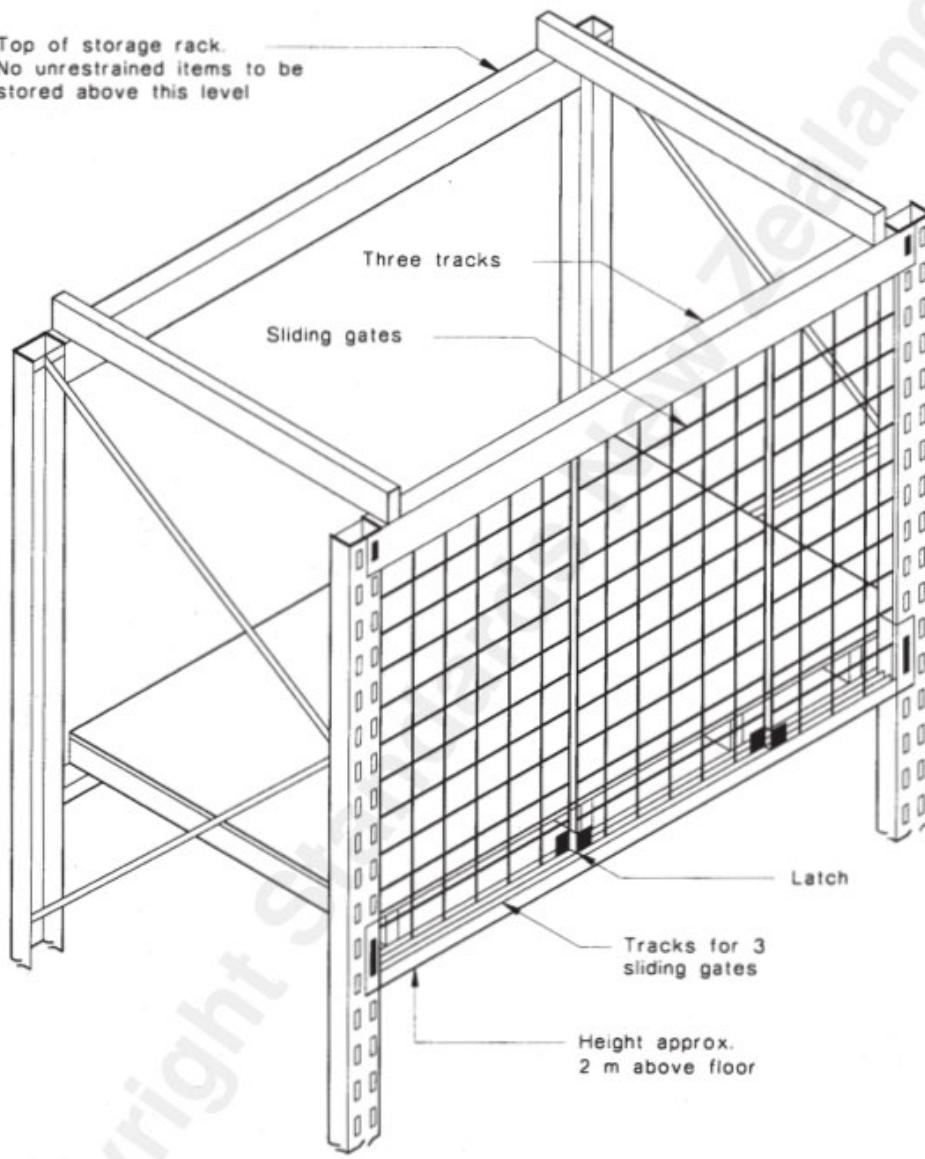


Figure 6.13 – Suggested seismic restraint of free standing equipment (continued)



NOTE —

- (1) This restraint system can be used for supermarket shelving above 1.8 m – 2.0 m height.
- (2) Storage racks to be designed to NZS 4203.
- (3) Details of sliding gates to suit the storage operation.

Figure 6.14 – Suggested seismic restraint of items in storage racks

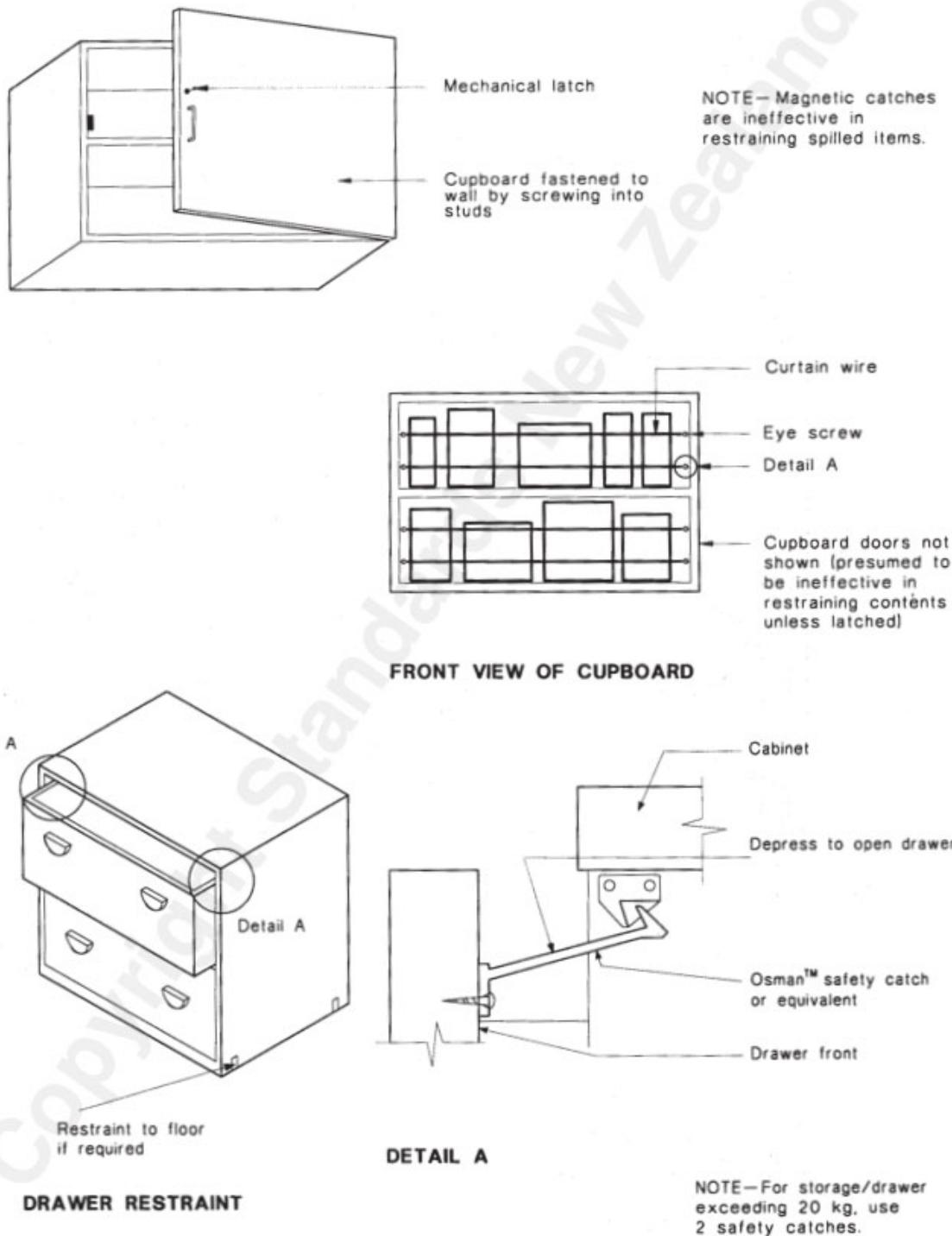
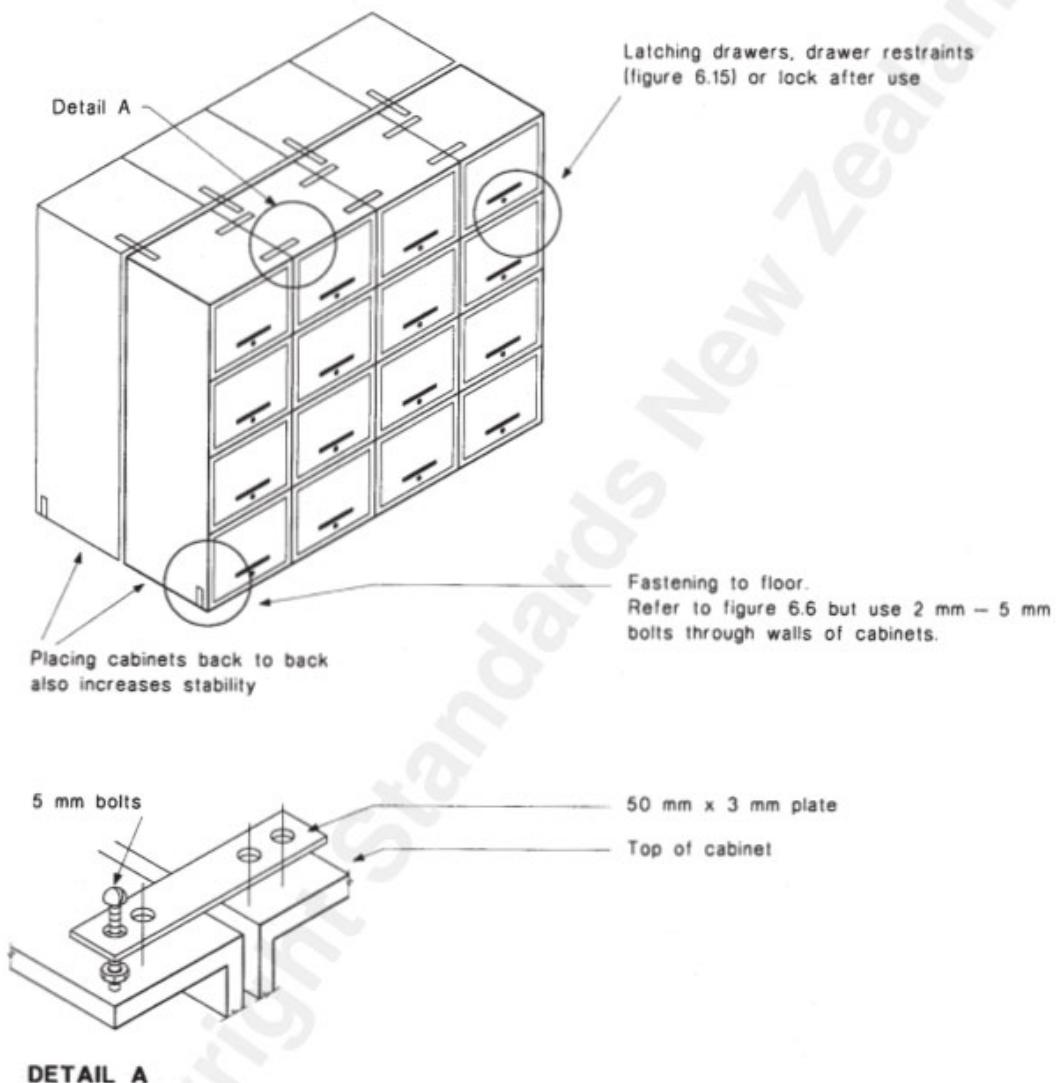
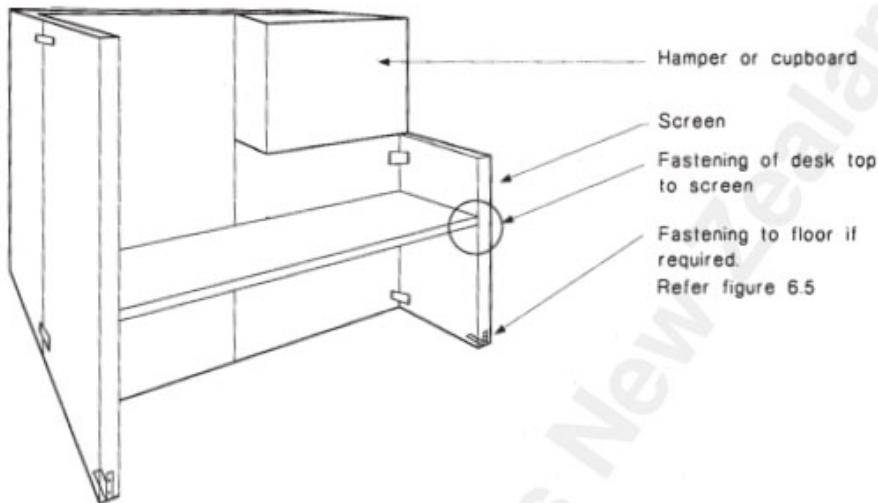


Figure 6.15 – Suggested seismic restraint of items in cupboards and drawers

**NOTE –**

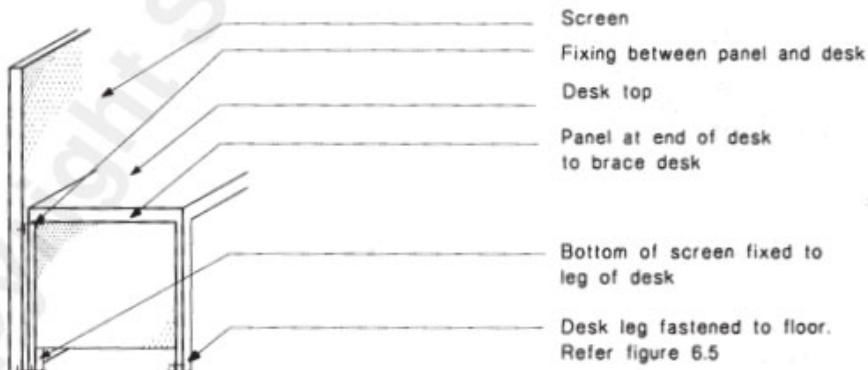
- (1) Bolting cabinets together increases stability.
- (2) Bolting may be done through cabinet walls.
- (3) For single row of cabinets restrain tops to wall (if possible) and bottom of cabinets to floor.

Figure 6.16 – Suggested seismic restraint of filing cabinets



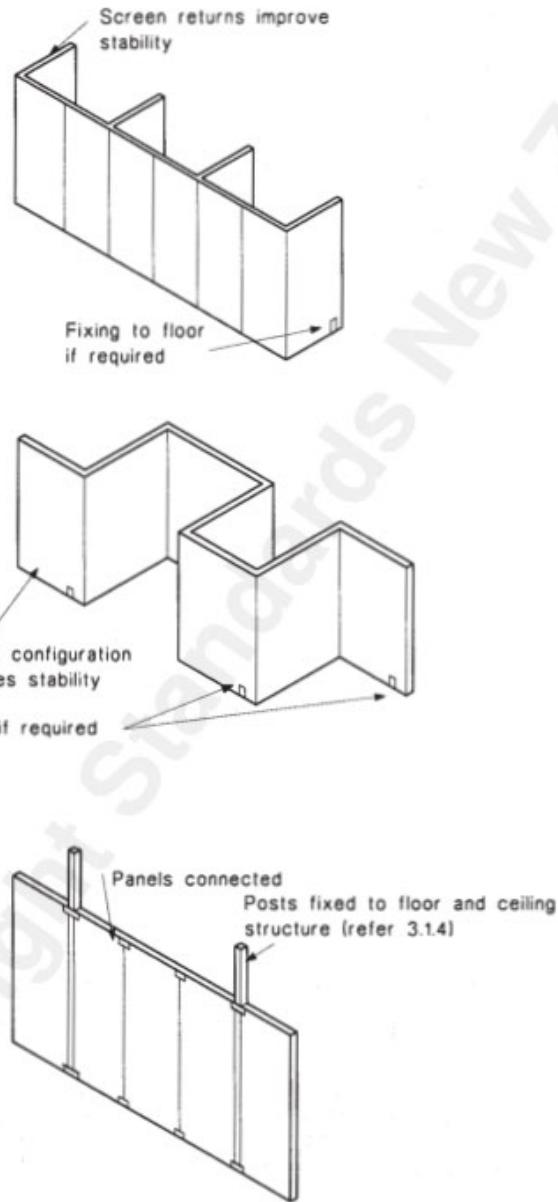
WORK STATION

NOTE —All screens and desk to be positively connected together so unit as a whole maintains its integrity during shaking.



DESK PROVIDING RESTRAINT TO SCREEN

Figure 6.17 – Suggested seismic restraint of office screens



OTHER METHODS OF RESTRAINT FOR SCREENS

Figure 6.17 – Suggested seismic restraint of office screens (continued)

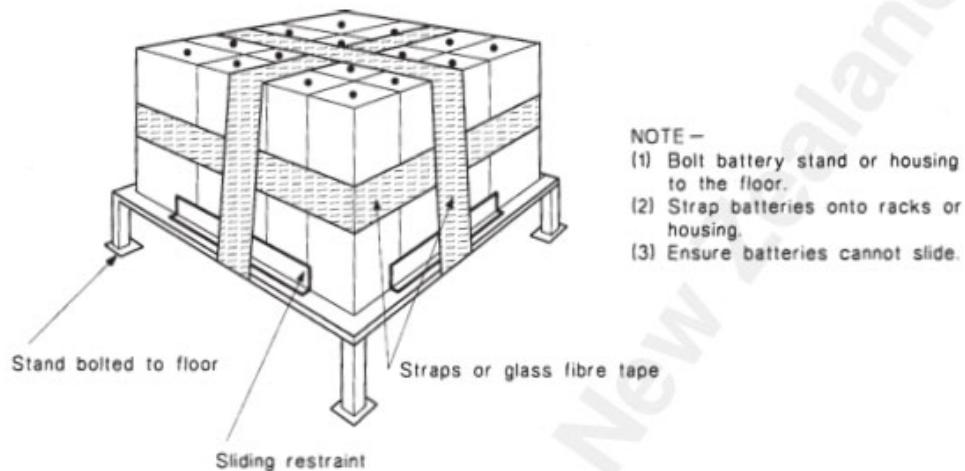


Figure 6.18 – Suggested seismic restraint of emergency power battery racks

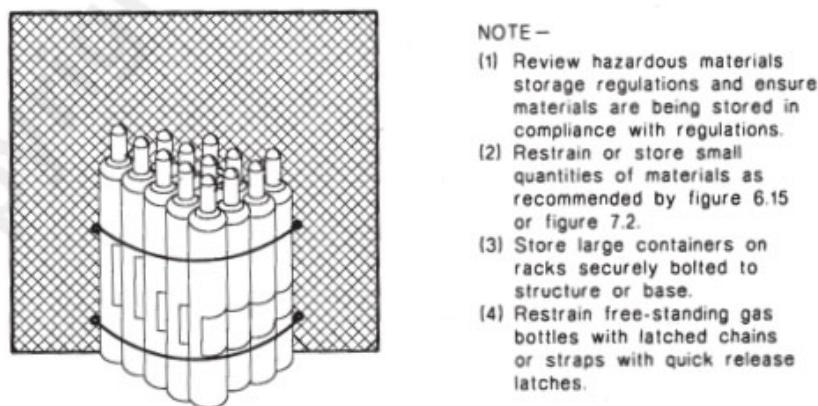
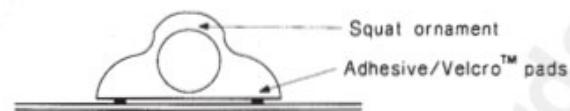
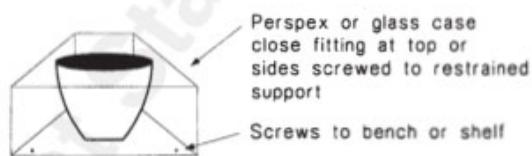
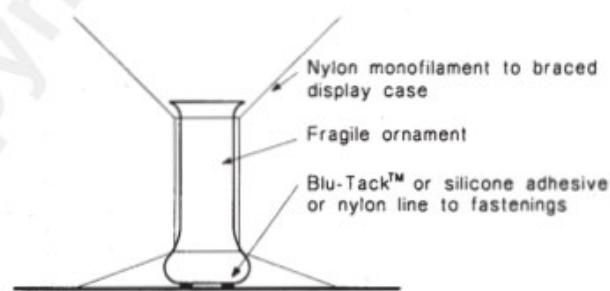


Figure 6.19 – Suggested seismic restraint of hazardous materials

**BASE OF ORNAMENT****RESTRAINT USING BLU-TACK™****RESTRAINT USING VELCRO™**

NOTE—

- (1) Blu-Tack™ only suitable for ornaments weighing less than 1 kg.
- (2) The squatter the ornament the stronger the restraint.
- (3) After installation and every 4 months check the adhesion by pressing against the top gently.

**RESTRAINT BY TRANSPARENT CONTAINER****Figure 7.1 – Suggested seismic restraint of ornaments on benches or shelves**

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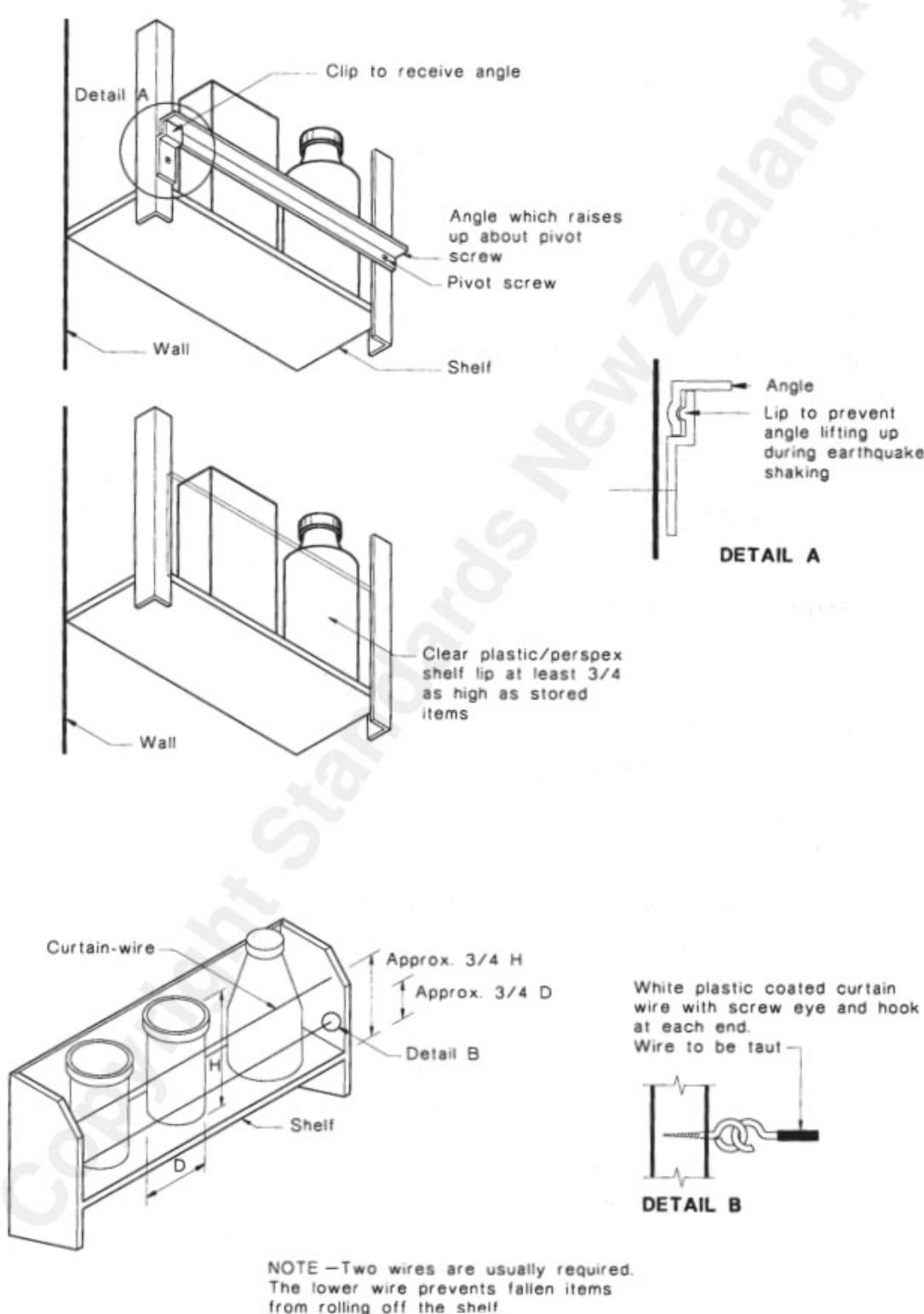
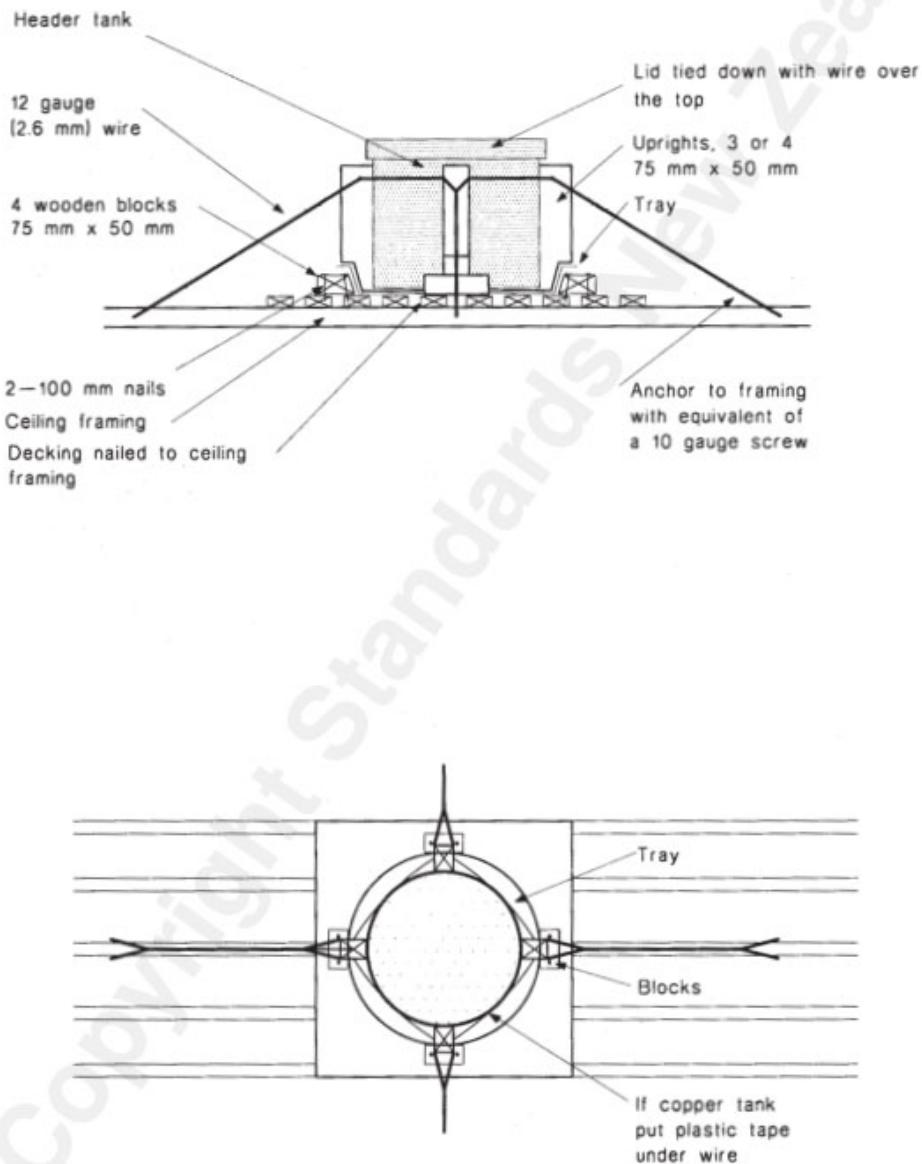


Figure 7.2 – Suggested seismic restraints for fragile items in cupboards or on shelves



Adapted from publication by Cooney R.

Figure 7.3 – Suggested seismic restraints for domestic water header tank

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Figure B1 – Probability that MMVII intensity earthquake is exceeded in a 25 year period

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