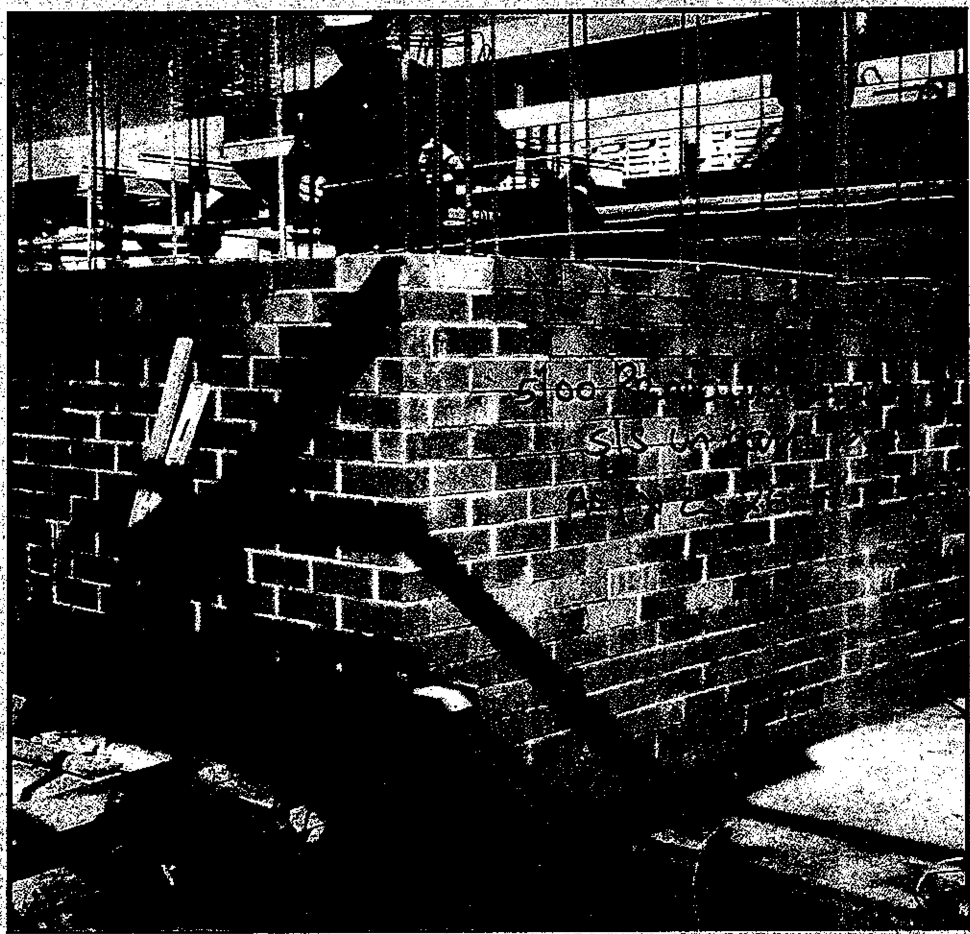
NZS 4210:1989 MASONRY CONSTRUCTION

Amendment No1&2
Appended

SANZ

NZS 4210:1989



SUPERSEDED

NEW ZEALAND STANDARD

SUPERSEDED

Code of practice for MASONRY CONSTRUCTION : MATERIALS AND WORKMANSHIP

UDC 693.2 : 624.012

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Standards Association of New Zealand

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RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS

		Clause reference herein
NZS 366:1963	Clay building bricks	2.1.3.1,
NZS 1900:----	Model building bylaw	
Chapter 1:1985	Preliminary	1.3.2, C1.3.2
Chapter 9:1985	Design and construction	1.1.1
NZS 3102:1983	Concrete masonry units	2.1.3.2, 2.1.3.5,
NZS 3103:1976	Sands for mortars and internal and external renderings	2.1.6.2,
NZS 3104:1983	Concrete production - High grade and special grade	2.3.2.1, 2.3.5.2
NZS 3105:1986	Concrete mixers (batch type and truck type)	2.3.5.1,
NZS 3109:1987	Concrete construction	C2.5.1.2, 2.6.1.3, 2.6.6.1, 2.20.2,
NZS 3112:----	Methods of test for concrete	
Part 1:1986	Tests relating to fresh concrete	2.3.2.1, 2.4.1.1, 2.C3
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NZS 3113:1979	Chemical admixtures for concrete	2.1.7.1
NZS 3117:1980	Pigments for portland cement, and portland cement products	2.2.2.2,
NZS 3121:1986	Water and aggregate for concrete	2.1.6.1, 2.1.6.2, 2.3.4.1,
NZS 3122:1974	Portland cement (ordinary, rapid hardening, and modified)	2.1.5.1, 2.1.9.2
NZS 3124:1987	Concrete construction for minor works	2.6.1.3
NZS 3402:1989	Steel bars for the reinforcement of concrete	2.1.4.2
NZS 3604:1984	Code of practice for light timber frame buildings not requiring specific design	2.4.2.1, 2.9.7.1, 2.10.3.2 C3.1.1, C3.C8.2
NZS 4229:1986	Concrete masonry buildings not requiring specific design	1.4.1, C1.4.1, 2.4.2.1, 2.6.1.2, 2.9.7.1, 2.10.3.2, C3.1.1
NZS 4230:----*	The design of masonry structures	1.4.1, C1.4.1, 2.9.6.1, 2.11.7, C2.9.7.1 C3.1.1

* Under revision

NZS 6507:----	Materials testing machines and force verification equipment	
Part 1:1986	The grading of the forces applied by materials testing machines	3.C4

OVERSEAS STANDARDS

AS1650:1981	Galvanized coatings	2.1.1.1, C2.1.1.1
AS 2163:1978	Graduated measuring cylinders	2.C2.1,
ASTM C67-86	Sampling and testing brick and structural clay tile	2.7.2.3,
ASTM C91-87a	Masonry cement	2.2.3.3, C2.2.3.3 2.4.1.1,
BS 604:1982	Graduated glass measuring cylinders	2.C2.1,
BS 890:1972	Building limes	2.1.5.2,
BS 970:----	Wrought steels for mechanical and allied engineering purposes	
Part 1:1983	General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels	2.1.1.1,
BS 5493:1977	Protective coating of iron and steel structures against corrosion	C2.1.1.1(a)

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

FOREWORD

While masonry is one of the oldest forms of building construction, it has undergone significant developments over recent years to meet the growing understanding of building behaviour in response to earthquake forces.

The unreinforced masonry of the Napier earthquake days has given way to today's standard requirements for the inclusion of reinforcing steel in masonry. Both the clay and concrete masonry manufacturing industries have responded to these requirements.

The masonry trade skills traditionally associated with laying of brick and block now embrace the placing of reinforcement and the grouting of that reinforcement within the masonry construction.

This Standard therefore places appropriate emphasis on the aspects of steelfixing and grouting. Investigation into the performance of grouts containing a gas-forming expansion agent has shown that the use of such grouts has a superior performance over the various other construction options available.

The Standard sets out the acceptable levels of workmanship and these form an important part of the examination for structural masons seeking registration under the New Zealand Masonry Trades Registration Scheme.

Wall tie performance has been shown to be a critical factor in determining the satisfactory performance of cavity masonry walls and veneer constructions under service conditions including earthquakes. The need for veneer wall ties to be able to cope with the lateral differential displacements between the veneer and supporting structural element under seismic load is recognized. Data has now become available to enable realistic movements required to be accommodated by wall ties to be evaluated.

It is believed that the requirements of this Standard will promote high quality procedures of masonry construction on a uniform basis throughout New Zealand.

NEW ZEALAND STANDARD

Code of practice for MASONRY CONSTRUCTION: MATERIALS AND WORKMANSHIP

PART 1 GENERAL

1.1 Scope

1.1.1
This Standard sets out requirements for the materials and workmanship to be used in the erection of masonry buildings and is cited as a means of compliance with the relevant requirements of NZS 1900:Chapter 9.

C1.1.1
This Standard does not specifically cover mortarless masonry nor the use of adhesives other than cement mortar between the masonry units. Such forms of masonry construction must be dealt with in terms of 2.1.2.

1.2 Interpretation

1.2.1
In this Standard the word "shall" indicates a requirement that is to be adopted in order to comply with the Standard, while the word "should" indicates a recommended practice.

1.2.2
Subject to 1.2.1, clauses prefixed by "C" and printed in italic type are intended as comments on the corresponding mandatory clauses.

1.2.3
The full titles of reference documents cited in this Standard are given in the list of Related Documents immediately preceding the Foreword.

1.3 Definitions

1.3.1
In this Standard, unless inconsistent with the context the following definitions apply:

BOND - RUNNING OR STRETCHER. The bond where the units of each course overlap the units of the preceding course by between 24 % and 75 % of the length of the units.

BOND - STACK. The bond where the units of each course do not overlap the units of the preceding course by the amount specified for running or stretcher bond.

CAVITY WALL. A wall built of 2 or more skins of masonry units arranged to provide a continuous air space between the skins.

> NOTE - This definition refers to 2 reinforced skins of masonry which are connected by ties to enable load sharing to take place between the skins. It does not refer to a masonry veneer attached to a masonry wall.
>
> Unreinforced masonry walls are not permitted, either of single or multiple skins, except for a masonry veneer.

CHARACTERISTIC STRENGTH. That axial strength which has a 95 % probability of being exceeded.

CHARACTERISTIC CYCLIC STRENGTH. That axial cyclic strength used in establishing ductility which has a 95 % probability of being exceeded.

CHARACTERISTIC STIFFFNESS. That axial stiffness which has a 95 % probability of being exceeded.

DUCTILE TIE. A wall tie, the ductility of which is equal to or greater than the minimum values specified in this Standard.

ELASTIC TIE. A wall tie which does not meet the ductility provisions of this Standard.

FACE LOAD. The load applied normal to the face of a wall that imposes either compression or tensile forces on the ties.

GROUT. The material used to fill cells, flues or cavities in masonry.

GROUT SPACE. Any space to be grouted or through which grout is intended to pass, and includes grouted cells and grouted cavities.

MASON. A person skilled in the construction of masonry.

MASONRY. Any construction in units of fired clay, concrete, or stone or other approved materials laid to a bond in, and joined together with, mortar.

MASONRY UNIT:

HOLLOW MASONRY UNIT. A masonry unit of which the net cross-sectional area in any plane parallel to the bearing surface is less than 75 % of its gross cross-sectional area measured in the same plane.

SOLID MASONRY UNIT. A masonry unit of which the net cross-sectional area in any plane parallel to the bearing surface is 75 % or more of its gross cross-sectional area measured in the same plane.

MORTAR. The material in which masonry units are bedded.

REGISTERED MASON. A mason who is accepted for registration by the New Zealand Masonry Trades Registration Board and is the holder of a current registration certificate.

REINFORCED CAVITY MASONRY. A construction of two or more skins of masonry with reinforcing steel in the completely grouted cavity between skins and complying with the requirements for reinforced masonry.

REINFORCED HOLLOW MASONRY. A construction of hollow masonry units having reinforcement in grouted cells and complying with the requirements for reinforced masonry.

REINFORCED MASONRY. Masonry in which reinforcing steel is so bonded that the materials act together in resisting forces.

SKIN or WYTHE. A continuous vertical tier of masonry one unit in thickness.

STRUCTURAL WALL. An element which is required to provide resistance to actions from forces imposed on a building.

VENEER. A single skin of non-loadbearing masonry which is attached to and laterally supported by its structural element.

WALL TIE. A tie, together with its fixings or anchorages, used to transfer face loads from a veneer to a structural wall, or between skins of a cavity wall, while being capable of accommodating differential in-plane horizontal and vertical deflections between the attached elements.

WYTHE see SKIN.

1.3.2

Unless inconsistent with the context, and subject to 1.3.1, terms defined in NZS 1900:Chapter 1 shall have the same meaning in this Standard.

C1.3.2

See in particular the definitions of "approved", "building", and "Engineer" in NZS 1900: Chapter 1.

1.4 Inspection

1.4.1

All masonry construction shall be inspected as required by NZS 4229 or NZS 4230 as appropriate from time to time by the supervisor with the object of establishing that the work in place is constructed generally in accordance with the intent of the drawings and specifications.

C1.4.1

Refer to the commentary clauses of NZS 4229 and NZS 4230 for recommendations regarding supervision.

1.5 Workmanship

1.5.1

The construction of masonry works deemed to comply with this Standard shall be carried out by competent, experienced tradesmen who shall be fully conversant with the detailed provisions of the Standard.

C1.5.1

The New Zealand Masonry Trades Registration Board provides a scheme which examines the competency of masons to comply with 1.5.1. Those masons, whose practical work and knowledge are found to be satisfactory, are registered by the Board. A registered mason may be assumed to have the skills and knowledge to be able to comply with the requirements of 1.5.1.

PART 2
MASONRY CONSTRUCTION

2.1
Materials

C2.1
No building code can specifically cover all materials, components and proprietary products. The use of those not so covered, therefore, must be subject to the discretion and informed judgement of the authority having jurisdiction, usually a territorial local authority issuing a building permit. The purpose of section 2.1, Materials, is to assist such authorities by stating in general terms the appropriate conditions under which approvals should be given. Clause 2.1.2.1(b) is principally intended to cover the introduction of new products or the use of established ones for new purposes. Clause 2.1.2.1(a) is intended to preserve the status quo for established products for which there is no need of additional test information and the like.

2.1.1
Corrosion resistant metal

2.1.1.1
Wall ties in ungrouted cavities, lintel bars, and any other metal components not completely embedded in concrete or grout and exposed to the weather or in any position where condensation or dampness will normally occur, shall be protected so as to have an acceptable resistance to corrosion. Material complying with (a) or (b) shall be accepted as complying with this clause.

(a) Mild steel hot dip galvanized as specified in AS 1650, subject to the special requirements of Part 3 with respect to wall ties, after forming to the final shape and dimensions, provided that in severely corrosive environments additional protection shall be considered

(b) Austenitic stainless steel of grades 302, 304, or 316 (in accordance with the ANSI/SAE or the British Standard designation system as specified in BS 970:Part 1) provided that grades 302 and 304 shall not be used in a marine atmosphere.

C2.1.1.1(a)
The minimum galvanized coating weights as specified in AS 1650 and the equivalent coating thicknesses are:

	Minimum coating weight	Minimum coating thickness
	g/m²	mm
Steel articles:		
5mm thick and over	*600*	*0.084*
Under 5mm but not less than 2mm	*450*	*0.063*
Under 2mm	*350*	*0.049*

BS 5493 provides guidance for the selection of various galvanized coating rates for different uses.

2.1.2
Other materials and proprietary products

2.1.2.1
Materials, components and proprietary products not specifically covered by this Standard may be used subject to the following conditions:

either

(a) They shall be shown, to the satisfaction of the Engineer, to have an established record of satisfactory performance in their intended use over a considerable time, or

(b) They shall satisfy all of the following conditions:

(i) The manufacturer has specifically designated them for the intended use;

(ii) The manufacturer has supplied to their users clearly presented and adequate technical information on their relevant properties, methods of installation and the like for the intended use;

(iii) The manufacturer has provided, to the satisfaction of the Engineer, relevant test information and assessments of their performance in the intended use issued by an approved authority.

C2.1.2.1
Some general performance requirements for particular uses are given in the appropriate clauses of this Standard.

2.1.3
Masonry units

2.1.3.1
Clay masonry units shall comply with NZS 366.

2.1.3.2
Concrete masonry units shall comply with NZS 3102.

2.1.3.3
Natural stone shall not be used unless it is approved as suitable for its intended use in accordance with 2.1.2.

C2.1.3.3
The properties of a proposed natural stone material should be carefully assessed for the use to which the stone is to be put. Consideration should be given to compressive and tensile strength, splitting properties, mortar bonding characteristics and weathering aspects such as porosity and abrasive and chemical durability.

While an established service record may exist, it is prudent to check that the quality of material being currently quarried meets a level of performance suitable for its intended use.

Stone from sedimentary geological formations almost always needs to be laid with its natural bedding plane horizontal.

The various considerations or limitations of use should form part of any approval issued in terms of this section.

The producer's recommendations relating to bond patterns, tie spacing, tie embedment and placing methods should be followed.

2.1.3.4
Masonry units shall not be re-used nor deemed to satisfy the requirements of this and related Standards unless accompanied by evidence of selection for grading, and testing in respect of crushing strengths, 28 day masonry-to-mortar bond strengths, and certification as to soundness and durability.

C2.1.3.4
Masonry buildings in New Zealand built prior to 1939 mainly used bricks for thick wall construction in which exterior work was frequently rendered for appearance and weatherproofing. Demolition bricks salvaged from these buildings will be a mixture of facings, back-up bricks and underfired plastering quality bricks. Manufactured well before the advent of New Zealand Standards, such bricks will very rarely be shown to comply with present day building codes.

2.1.3.5
When samples of concrete masonry units are taken for testing after delivery from the manufacturer the sample size and storage shall comply with NZS 3102 Appendix 2A. Tests shall be carried out in accordance with NZS 3102 with compressive strength conforming to section 7 of that Standard.

2.1.4
Reinforcement

2.1.4.1
All reinforcement other than ties, stirrups, spirals, joint reinforcement, welded wire fabric and wire strands or high strength alloy steel bars for prestressing tendons shall be deformed unless otherwise permitted by specific design.

2.1.4.2
Reinforcement shall comply with NZS 3402 unless otherwise permitted by specific design.

2.1.4.3
Prefabricated joint reinforcement, where used, shall be of corrosion-resistant metal complying with 2.1.1.

2.1.5
Cementitious materials

2.1.5.1
Portland cement shall comply with NZS 3122.

2.1.5.2
Building lime shall comply with BS 890.

2.1.6
Aggregate and water

2.1.6.1
Aggregate and water for grout shall comply with NZS 3121.

2.1.6.2
Sand for mortar shall comply with NZS 3103 and water for mortar shall comply with NZS 3121 provided that the mortar shall comply with 2.2.3.

2.1.7
Admixtures

2.1.7.1
Chemical admixtures, such as water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, water-reducing and accelerating admixtures, and air entraining admixtures shall comply with NZS 3113.

2.1.7.2
Expansive admixtures shall comply with 2.3.2.1(c).

2.1.8
Wall ties

2.1.8.1
All wall ties and their connections shall be of compatible corrosion-resistant material (see 2.1.1), and shall comply with the requirements of Part 3.

2.1.9
Storage and handling of materials

2.1.9.1
Aggregates shall be stored and handled in such a way as to prevent segregation or contamination by foreign materials. Aggregates of each specified size range shall be brought separately to the place of mixing and shall be stored in such a way as to prevent the materials intermixing. Washed sand shall be allowed to drain to a stable moisture content.

2.1.9.2
Cement shall be stored and handled in such a way as to protect it against deterioration or contamination, and to be capable of being inspected at all times. Any cement which does not comply with the requirements of NZS 3122 shall be removed from the site.

2.1.9.3
Masonry units shall be so stored and handled as to comply with 2.7.2 at the time of laying.

2.1.9.4
Approved ready-mixed mortar shall be so stored and handled as to comply with 2.2.3 at the time of use (see also 2.2.2.2(e)).

2.1.9.5
Reinforcement shall at the time of erection be undamaged and clean and free from all loose mill scale, dust and loose rust, and coatings such as paint, oil or anything which may reduce bond.

2.2
Mortar

2.2.1
Measurement of materials

2.2.1.1
Materials for mortar shall be accurately measured by weight or volume in suitably calibrated devices.

2.2.2
Composition and mixing

2.2.2.1
Mortar shall be composed of portland cement, sand and water and shall also contain hydrated lime or an admixture, or both unless it can be demonstrated that the performance requirements of this Standard can be achieved without lime or an admixture.

C2.2.2.1
The workability of mortars is significantly affected by sand grading and particle shape. For the majority of mortars it is likely that the use of an admixture or hydrated lime will be necessary to produce the desired workability. Admixture dosage should strictly follow the manufacturers instructions since significant loss of strength and bond can occur through over dosage.

Hydrated lime addition must not exceed the volume of cement (see 2.2.2.2(b).

Typical mix composition using hydrated lime are as follows:

Durability	Cement	Hydrated lime	Mortar
Very high	*1*	*0 - 0.25*	*3*
High	*1*	*0.5*	*4.5*
Medium	*1*	*1*	*6*

2.2.2.2
The following provisions shall apply:

(a) All materials shall be thoroughly mixed to an even consistency for a minimum time of 5 min in a mechanical batch mixer, provided that hand-mixing to an equivalent result may be permitted for quantities of mortar not exceeding 0.03 m^3;

(b) All lime other than dry hydrated lime shall be fully slaked. The volume of lime in a mix shall not exceed the volume of cement;

(c) The mixing and proportions of any admixture shall be in accordance with the manufacturer's instructions;

(d) If a batch of mortar which has been prepared for use has stiffened due to lapse of time, workability may be restored by the addition of water and thorough remixing, provided that the properties required by 2.2.3 shall not be impaired. Re-tempering water shall be added to a basin formed by the mortar and the mortar carefully worked into it. Re-tempering by dashing water over the mortar shall not be permitted;

(e) Any mortar not used within 1.5 hours after the addition of cement to the mix shall be discarded, provided that in cold weather (below 7 °C) this period may be extended to 2 hours, and provided that this requirement may be waived in the case of ready-mixed and retarded mortars if it can be established that such mortars meet the requirements of 2.2.3 and are satisfactory in all other respects;

(f) Where mortar is to be coloured, this shall be achieved by the use of approved coloured cement or by the addition of mineral oxide pigment conforming to NZS 3117. Dosages of mineral oxide shall not exceed 3 % by weight of cement unless it can be shown that greater concentrations do not have a detrimental effect on the mortar. In any case dosages in excess of 6 % by weight of cement shall not be used.

C2.2.2.2(f)
Dosages of some mineral oxide pigments in excess of 3 % may lead to unacceptable reductions in bond strength.

2.2.3
Properties

2.2.3.1
Compressive strength

2.2.3.1.1
The 28 day compressive strength of mortar when tested in accordance with Appendix 2.A shall be not less than 12.5 MPa.

2.2.3.1.2
A higher minimum compressive strength for mortar may be specified.

2.2.3.2
Bond strength

2.2.3.2.1
The 7 day masonry-to-mortar bond strength when tested in accordance with Appendix 2.B shall be not less than 200 kPa.

C2.2.3.2
The relevance of bond strength in the seismic resistance of reinforced structural masonry construction is limited, due to the presence of tensile reinforcement.

The bond strength value is more significant in the construction of unreinforced and lightly reinforced veneers. Apart from providing weather resistance and the structural connection mechanism to transfer the face loads of the veneer into the wall ties, mortar bond strength has an important effect on in-plane and out-of-plane flexural and shear strength of a brick veneer. Transverse strength tests of full scale walls indicate that bond between mortar and brick is the most important single factor affecting wall strength.

With the permitted use of unreinforced two storey veneers and mutli-storey reinforced veneers, mortar bond strengths become a significant factor in the overall performances of veneers.

The typical mortar bond values for masonry construction laid to the required workmanship standards are:

Clay brick masonry...................... 500 - 1000 kPa
Concrete brick masonry................. 400 - 900 kPa

2.2.3.3
Water retention

2.2.3.3.1
The flow after suction of mortar shall be not less than 60 % of the initial flow when tested in accordance with clause 23 of ASTM C91.

C2.2.3.3
Laboratories equipped for carrying out this test are very limited.

A simple site test can be carried out on clay or concrete bricks as follows:

(a) Mortar 2 bricks together to correct joint width, strike off mortar and wait 2 minutes.

(b) Lift the couplet by the top brick to a convenient height, usually waist height, turning the couplet over so that the lower brick becomes the top brick.

(c) The couplet is then lowered holding the new top brick.

(d) The couplet should not part during this test.

If after adjustment to the mortar mix or dampening of bricks, the test still cannot be performed, then the invoking of a full test to ASTM C91 may be required.

2.3
Grout

2.3.1
General

2.3.1.1
Grout shall be either fine grout complying with 2.3.3 or coarse grout complying with 2.3.4.

2.3.1.2
Only fine grout shall be used where any dimension of grout spaces is less than 60 mm.

2.3.2
Properties

2.3.2.1
Grout shall be mixed in such proportions that:

(a) It shall have a minimum compressive strength of 17.5 MPa when tested in accordance with Appendix 2.A and the test results are evaluated as required by NZS 3104

(b) It shall have a spread value within the range 450 mm to 530 mm for concrete masonry and 500 mm to 580 mm for clay masonry when tested in accordance with section 11 of NZS 3112:Part 1

(c) If using an expansive agent, the mix proportions shall be such as to give an increase in volume of between 2 % and 4 % before the initial setting of the grout, when tested in accordance with Appendix 2.C. Only expansive agents which enable expansion to be completed within 4 hours of dosage shall be used.

C2.3.2.1
Grout infill must have characteristics of flow which are considerably different from those for concrete. While the slump test is an appropriate test for measuring characteristics of concrete, it is technically inappropriate for grout.

For this reason, the spread test only is included as the method of determining the required properties of grout flow for various masonry applications.

C2.3.2.1(a)
Where grout is volume batched and site mixed, using the recommended prescribed mix below and also using materials for which no previous compression tests were taken, it is advisable at the start of the project to produce a test mix for sampling and compression testing in accordance with Appendix 2.A. The compressive strength at 28 days of this test mix must be at least 25 MPa. This higher strength value for the project test mix reflects a requirement to include a strength margin to allow for variations in the accuracy of producing the prescribed mix.

Grouts which can comply with the requirements of 2.3.2.1 are commonly produced by site mixing to the following volumetric proportions:

	Parts by volume		
	Cement	Concreting sand	Coarse aggregate 9-4.75 mm
Coarse grout	*3*	*8*	*4*
Fine grout	*2*	*7*	

Water is added in sufficient quantity to bring the grout within the specified range of spread.

C2.3.2.1(c)
The expansive agent is dosed at site immediately prior to placing but allowing sufficient time for mixing, to ensure that grout expansion takes place within the masonry cells or cavity and while the material is still fluid.

Expansive agents that cause expansion of the hardened concrete are not considered appropriate for fulfilling the requirements of section 2.12, High lift grouting with expansive admixture method.

2.3.3
Fine grout

2.3.3.1
Fine grout shall consist of portland cement, sand* and water, and may contain admixtures, except that the grouting of the small cores of knock-out-end clay bricks shall be by means of mortar used in laying the bricks, tamped into place.

2.3.4
Coarse grout

2.3.4.1
Coarse grout shall consist of portland cement, sand *, coarse aggregate and water, and may contain admixtures. The coarse aggregate shall have a nominal size range of 13.2 mm to 4.75 mm except that in special circumstances the maximum size may be up to 19.0 mm.

* NOTE - The sand referred to in 2.3.3.1 and 2.3.4.1 is sand complying with NZS 3121, not mortar sand.

2.3.5
Mixing of grout

2.3.5.1
At the site
Unless otherwise approved by the supervisor, the mixing of grout shall be done in a power-driven batch mixer complying with the provisions of NZS 3105, or other approved type which will ensure the thorough mixing of all materials to the degree of uniformity required by that Standard. The volume of the mixed material for each batch shall not exceed the manufacturer's maximum rated capacity of the mixer. The entire batch shall be discharged before re-charging. The mixing time shall be measured from the time when all the materials are in the mixer drum. The minimum time of mixing shall be 1.5 min for mixers having a capacity of 0.75 m^3 or less, and mixers of larger capacity shall have the time of mixing increased by 15 s for each additional 0.3 m^3 capacity or fraction thereof.

2.3.5.2
Off the site (ready mixed)
Grout supplied ready mixed from off the site shall comply with the relevant provisions of NZS 3104.

2.3.5.3
Maximum agitation period
Grout shall be placed within 1.5 hours, after the introduction of the mixing water to the cement and aggregates, or cement to the aggregates.

2.4
Testing

2.4.1
Building requiring specific design

2.4.1.1
Where masonry is the subject of specific design, the following tests on mortar and grout shall be conducted in accordance with the Standards, or Appendices to this Standard, noted below at frequencies specified by the specific design:

(a) Compressive strength of mortar .... Appendix 2.A

(b) Masonry-to-mortar bond strength .... Appendix 2.B

(c) Water retention of mortar .... ASTM C91

(d) Compressive strength of grout ... Appendix 2.A

(e) Spread of grout .... NZS 3112:Part1

(f) Expansion of grout (where an expansive agent is used) .... Appendix 2.C

2.4.2
Building not requiring specific design

2.4.2.1
For buildings not requiring specific design built in accordance with NZS 4229 and NZS 3604, the mason shall ensure that the following records are maintained:

(a) Proportions of mortar used, including admixtures,

(b) Supplier of grout and test certificates received or proportions of grout if site mixed,

(c) Results of daily check on the spread of the grout when in use,

(d) Use or not of an expansive agent.

In addition the mason, shall check the cleanliness of the sand supply.

C2.4.2.1
It is recommended that the mason, as a competent tradesman should have compressive strength tests of mortar carried out at regular intervals, particularly if the source of supply of sand is changed. In addition to being a check on the suitability of the mortar mix, such tests serve as a check on the cleanliness of the sand.

C2.4.2.1(d)
The reactivity of the expansive agent in the grout can be directly observed at the top of a grouted wall. Any adjustments in dosing rates for temperature conditions should be made in accordance with the manufacturer's instructions.

2.5
Initial preparation

2.5.1
Concrete base

2.5.1.1
Any discrepancies in the vertical alignment, other than those that can be corrected by a mortar bed not exceeding 20 mm thick at any point as provided by 2.7.1.3, and any discrepancies in the horizontal alignment of the supporting concrete base shall be corrected before masonry units are laid.

2.5.1.2
The base shall be clean and free from laitance, loose aggregate, and anything that would prevent the mortar from bonding to the base, provided that a damp-proof course may be permitted at the base of a veneer wall or where allowance has been made for this by specific design.

C2.5.1.2
Designers may require a properly prepared construction joint as specified for Type B in NZS 3109, except that it is recommended that the surface be broken to a depth of approximately 1.5 mm above and below the average level.

2.5.1.3
Units may overhang their support provided that allowance has been made for this in the design.

2.5.2
Starter bars

2.5.2.1
Starter bars shall be carefully set out to suit masonry modules and required locations within cells and cavities to the tolerances specified in 2.6.5.1. They shall be firmly tied in their correct position before concreting of the base is commenced.

C2.5.2.1
The correct location of starter bars is always important. For some applications, for instance retaining walls, misplacement of 10 mm in one direction may necessitate demolition and reconstruction of the foundations. Where starter bar misplacement exceeds the location tolerance, construction should only be permitted to proceed subject to the acceptance of this misplacement by the structural designer or, in the case of a building not subject to specific design, by a registered engineer. Particular attention should be paid to the location of starter bars at corners, intersections and openings in walls.

2.6 Reinforcing details

2.6.1 *General*

2.6.1.1
In buildings subject to specific design, reinforcement shall be as specified.

2.6.1.2
In buildings not requiring specific design, reinforcement shall be as required by NZS 4229.

2.6.1.3
All reinforcement shall be detailed, bent and placed in accordance with NZS 3109 or NZS 3124, except where modified in this Standard or by specific design. Details of standard bends are given in Appendix 2.D.

2.6.2 *Vertical reinforcement*

2.6.2.1
Vertical bars shall be fixed securely to starter bars unless required otherwise by specific design.

2.6.2.2
Vertical bars shall be securely held in position at the top of the wall, and at intervals not exceeding 1.2 m for 10 mm bars, 2.4 m for 12 mm bars, or 3.6 m for 16 mm or larger bars.

2.6.2.3
Long bars projecting above the top of the wall shall be further held to maintain the bars in their correct position, and shall be braced firmly against wind or other movement.

2.6.2.4
Unless required otherwise by specific design each vertical bar shall be positioned in the centre of its cell, or in the middle of the cavity in grouted-cavity construction.

2.6.3 *Horizontal reinforcement*

2.6.3.1
Horizontal bars required to be in grouted cells shall be at least 25 mm above or below a mortar joint and fully embedded in grout.

2.6.3.2
Each horizontal bar shall be positively held in position by tying the bar to the vertical reinforcement, by the use of specially designed units, by steel spacers or links, or by other approved methods.

2.6.3.3
Joint reinforcement shall be fully embedded in mortar and where applicable shall comply with the cover requirements.

2.6.4 Laps

2.6.4.1
Laps shall be not less than 40 diameters for grade 300 steel and 54 diameters for grade 430 steel.

C2.6.4.1
Laps at corners should be avoided because they may reduce the width of grout space (see 2.6.6).

2.6.4.2
Where there is more than one bar in a vertical grouted cell the laps shall be staggered to ensure that not more than one bar is lapping at any point unless a spiral enclosing all bars in each cell is used or unless required otherwise by specific design.

2.6.5 *Tolerances*

2.6.5.1
Unless otherwise approved, reinforcement shall be placed in the specified positions within the following tolerances subject to 2.6.6:

(a) Measured across the thickness of the wall: ±6 mm;

(b) Measured along the length of the wall: ±50 mm or one-quarter of the length of the grouted cell, whichever is the less;

(c) In columns and piers: ±6 mm.

2.6.6 *Cover*

2.6.6.1
Except as required by 2.6.6.2, the minimum cover to reinforcement of mortar, masonry and grout, treated as a homogeneous material, shall be as required by NZS 3109 for reinforced concrete.

2.6.6.2
All reinforcing bars shall be maintained at least 6 mm from masonry face-shells at all points except as provided by section 2.21, and this space shall be filled solid with grout.

2.7 Laying the units

2.7.1 *General*

2.7.1.1
All masonry units shall be laid in mortar in courses, true to line, plumb, and level to the tolerances specified.

C2.7.1.1
The corners should be laid first, levelled and aligned. The first course should be laid with great care as it will assist the mason in laying succeeding courses.

2.7.1.2
The units shall be set in soft plastic mortar to ensure proper embedment and bond.

2.7.1.3
The thickness of mortar joints shall be as follows:

(a) For structural masonry: 10 ±3 mm

(b) For masonry veneers: Not less than 7 mm nor greater than 20 mm, the chosen thickness being maintained throughout the wall concerned within a tolerance of ±3 mm

provided that the mortar bed beneath the bottom course may be of greater thickness in order to correct foundation discrepancies but shall not exceed 20 mm thick at any point.

C2.7.1.3
It should be noted that the recommended line and level tolerances for in situ *concrete work may lead to non-compliance of the mortar bed tolerance beneath the bottom course.*

Where the in situ *concrete surfaces on which masonry is to be laid vary such that the thickness of the mortar bed beneath the bottom course cannot be maintained within the tolerances given, remedial measures shall be taken. These may include cutting back the concrete surface (with possible reinstatement), or cutting the masonry units of the bottom course where necessary. Other options, including placing a high strength levelling screed (but not floor levelling compound), should be subject to specific design.*

Variations in surface levels need to be restricted between +6 mm and –10 mm to meet the objectives of 2.7.1.3.

2.7.1.4
Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, permissible deviations from established lines, grades and dimensions shall be determined by appropriate consideration of the tolerances listed in table 2.7.1.

2.7.1.5
Should a unit need to be moved after it has been bedded in place, it shall be lifted, cleaned, and relaid in fresh mortar.

2.7.1.6
Precautions shall be taken to prevent mortar from falling down cells and cavities.

Table 2.7.1
SUGGESTED TOLERANCES

Item	*Tolerances*
Deviation from the position shown on plan for a building more than one storey in height	15 mm
Deviation from vertical within a storey	10 mm per 3 m of height
Deviation from vertical in total height of building	20 mm
Relative displacement between load-bearing walls in adjacent storeys intended to be in vertical alignment	5 mm
Deviation from line in plan	
(i) In any length up to 10 m	5 mm
(ii) In any length over 10 m	10 mm total
Deviation of bed joint from horizontal	
(i) In any length up to 10 m	5 mm
(ii) In any length over 10 m	10 mm total
Average thickness of bed joint, cross joint, or perpend	±3 mm on thickness specified

2.7.1.7
Any mortar protruding more than 5 mm into cells or cavities shall be removed. No mortar protrusions shall be closer than 5 mm to reinforcing steel.

2.7.2
Condition of units

2.7.2.1
The masonry units shall comply with the requirements of 2.1.3 and, when placed in the structure shall be clean, sound and free of defects which could impair the strength, weather resistance or performance of the construction.

C2.7.2.1
When cutting of a unit is necessary it should be cut neatly and true to the shape required.

2.7.2.2
Concrete masonry units shall be air-dry prior to laying. In order that the units should not absorb too much moisture from the mortar, and thus impair the bond, some dampening of the unit surfaces shortly due to receive mortar is permitted during construction, but no free surface water shall be present at the time of placing the mortar.

2.7.2.3
Clay masonry units with a low initial rate of absorption shall be laid air-dry; clay masonry units with a higher initial rate of absorption shall be laid damp but with no surface moisture. An initial rate of absorption shall be deemed to be low when it does not exceed 30 g when tested in accordance with clause 9 of ASTM C67. Some discretion may be exercised in excessively damp or dry weather.

2.7.3
Hollow masonry units

2.7.3.1
Hollow masonry units shall have full mortar beds under face shells and shall have head joints filled to the same depth. In reinforced hollow masonry the cross-webs that adjoin cells containing reinforcing shall be fully bedded on mortar, provided that this requirement need not apply when all cells in a particular wall are to be grouted.

C2.7.3.1
In all-cells-filled masonry it is recommended that open end units be used so that the weakness introduced by adjacent cross-webs is avoided.

2.7.4
Solid masonry units

2.7.4.1
Solid masonry units shall have all joints completely filled with mortar.

2.7.4.2
Deep furrowing of bed joints shall not be permitted. However light furrowing or riffling the bed joint with the point of the trowel to produce solid bed joints is permitted.

2.7.5
Grout spaces

2.7.5.1
The minimum dimensions of a grouted cell or cavity in reinforced masonry construction shall be:

(a) 32 mm for low lift grouting with a maximum of 400 mm lift (refer to 2.14.1.1(b))

(b) 50 mm for low lift grouting with a maximum of 1200 mm lift (refer to 2.14.1.1(a))

(c) 65 mm for any of the high lift grouting methods (refer to sections 2.12, 2.13 and 2.15).

2.7.6
Bonding

2.7.6.1
Units shall be laid up in straight uniform courses with running bond, unless alternative patterns are specified.

C2.7.6.1
If stack bonding is used in load bearing grouted masonry adequate precautions should be made to hold the wall together during grouting to withstand grouting pressures. This applies also at intersections.

2.7.6.2
Units in intersections of all structural load bearing walls shall be lapped on successive courses unless equivalent mechanical anchorage is provided.

C2.7.6.2
Veneer is not regarded as load bearing masonry and need not be lapped in successive courses at corners and at re-entries. In veneer construction it is desirable to provide seismic control joints at corners and at re-entries to reduce damage to the veneer caused by the attached seismic resisting structure.

2.7.7
Mortar joints

2.7.7.1
Mortar joints that are intended to be smooth and weatherproof and that are not to be pointed shall be concave tooled to a depth not exceeding 6 mm and burnished after the initial stiffening has occurred.

2.7.7.2
Mortar joints that are to be pointed shall be raked out to a depth not exceeding 6 mm; deeper joints may be permitted only where allowance has been made for them in the structural design.

C2.7.7.2
The raking out of mortar joints can lead to moisture ingress and also to steel corrosion in reinforced masonry. It will also reduce the fire rating of a wall and the cover to ties.

2.7.7.3
Flashings shall not be incorporated unless detailed in the design.

2.7.8
Clean-out openings

C2.7.8
The positioning of clean-out openings (if any) is not specified in detail because this will depend on the needs of the particular job concerned. It will sometimes be possible to clean out grout spaces for low-lift grouting without the need for any clean-out openings, but clean-out openings will always be needed with high-lift grouting.

2.7.8.1
Where the low-lift grouting method is to be used, temporary clean-out openings shall be provided where necessary to ensure satisfactory cleaning-out (as required under section 2.8, Cleaning out) and inspection.

2.7.8.2
Where one of the high-lift grouting methods is to be used temporary clean-out openings shall be provided and shall be of adequate size and number to ensure satisfactory cleaning-out (as required under section 2.8) and inspection.

C2.7.8.2
In all-cells-filled reinforced hollow masonry it is strongly recommended that the first course be of open-end bond-beam units laid upside down to facilitate cleaning out. It is recommended that temporary cleanout openings be provided as follows:

(a) Reinforced cavity masonry:
Leave out every third unit in one skin;

(b) Reinforced hollow masonry: Openings at least 100 mm x 75 mm at every vertical reinforcing bar tied to a starter bar, but not further apart than 800 mm in any case.

Where clean-out openings have to be in fair face work, boxing to clean-outs should be set in so that grout is visible after grouting, followed by mortaring-in part or whole face shells on completion.

2.7.9
Weepholes

2.7.9.1
Weepholes in masonry veneers and in ungrouted hollow masonry walls shall be provided at the bottom of cavities and cells as necessary to drain moisture to the outside air.

2.8
Cleaning out

2.8.1
Grout spaces shall be cleaned out before grout is poured (see 2.5.1.2). Any drained cavities between veneers and supporting structural walls shall also be cleaned out.

2.8.2
Cleaning out shall include the removal of any mortar from ties and reinforcing bars, the removal of any mortar protruding into cells or cavities at joints, and the removal of all mortar droppings and other loose material.

C2.8.2
Loose material may be removed by hosing through the clean-out openings with a water jet at the end of each day's work, or alternatively a layer of sand not less than 25 mm thick can be provided at the bottom of the grout space and this sand together with other loose material removed by compressed air or other means through the clean-out openings.

2.8.3
Clean-out openings shall be closed after inspection and prior to grouting. This closing may be by boxing with timber at concealed surfaces or by mortaring-in face shells at visible surfaces. Clean-out boxing shall be braced, and supports shall be provided to closure units at ends of walls and at openings as required to resist grout pressure.

2.9
Veneer and cavity wall construction

2.9.1
General

2.9.1.1
In a wall consisting of a veneer and a structural element, or two skins of reinforced masonry which are separated by an ungrouted cavity or are in unbonded contact, the two components shall be connected together using wall ties as specified for the appropriate use in Part 3 following the placing and spacing requirements of this section.

2.9.1.2
Where a veneer and its supporting element are separated by an ungrouted cavity, the masonry units of the veneer shall have a minimum width of 70 mm.

2.9.1.3
Where a veneer and its supporting element are in contact, adequate provisions shall be made to prevent water from penetrating the structural wall.

2.9.2
Width of cavity

2.9.2.1
No ungrouted cavity, including any cavity between a veneer and its structural element, shall be less than 40 mm nor more that 75 mm wide unless special design consideration has been given.

2.9.3
Pipes and services

2.9.3.1
Pipes and services shall not be placed between a veneer and its structural element.

2.9.3.2
In cavities other than between a veneer and its structural element, any pipes and services shall be fastened to the inside skin and shall not bridge the cavity.

C2.9.3.2
Where pipes or other services are permitted in cavities, contact with the outside skin may form a bridge to allow the passage of moisture to the inside. In cavities to be grouted, additional considerations are proper filling and compaction of the grout around the obstruction, and the effect of the embedded service on the strength of the element.

2.9.4
Tie anchorage, cover and fixing

2.9.4.1
Wall tie anchorage in a skin of masonry shall be not less than the following:

For skins up to 100 mm thick	half the thickness
For skins over 100 mm thick	50 mm.

2.9.4.2
The minimum cover to ties from the weather face shall be:

25 mm for galvanized steel ties
15 mm for stainless steel ties
10 mm for plastics ties.

2.9.4.3
For timber frame buildings wall ties shall be positioned such that they have solid contact and direct fixing to the supporting stud.

C2.9.4.3
Face fixing through building paper represents the most common construction deemed to comply with 2.9.4.3.

When the studs are covered with a solid sheet material such as plywood, this may also be face fixed providing the fixings pass through the plywood to provide full anchorage in the supporting stud.

When the studs are covered with a soft sheet material such as open textured fibre board, polystyrene insulation etc, the soft sheet material would need to be cut locally and neatly to allow direct contact between stud and tie.

Any special soft sheet face fixed ties would need to demonstrate by test that their performance meets the appropriate specifications of Part 3 of this Standard.

2.9.5
Placing of ties

2.9.5.1
Wall ties as specified herein shall be placed within 5° of a right angle to the plane of the masonry in accordance with the manufacturer's recommendations, which shall comply with the provisions of 3.5.4.

2.9.6
Spacing of ties

2.9.6.1
Wall ties for running bond masonry shall be spaced generally as follows:

(a) Unreinforced veneers, supported by:

Timber walls	*Reinforced concrete or reinforced masonry walls*
600 mm horizontal x 350 mm vertical, maximum; or 450 mm horizontal x 450 mm vertical, maximum,	600 mm horizontal x 400 mm vertical maximum, or equivalent area,

provided that the vertical spacing shall not exceed 5 courses high;

(b) Reinforced veneers: Refer to NZS 4230;

(c) Reinforced cavity walls: As for veneered walls provided that for grouted-cavity masonry, ties need to be provided only where necessary to resist hydrostatic grout pressures.

C2.9.6.1(c)
The ability of the wall ties to resist grout pressure depends not only on the strength of the tie, but also on the embedment in the mortar and the strength of the mortar at the time of grouting.

2.9.6.2
At unsupported edges and at all openings through veneered walls or grouted or non-grouted cavity walls, wall ties spaced as required by 2.9.6.1 shall be provided at not more than 300 mm or 2 courses, whichever is the smaller, from the top, bottom and ends or sides of the openings.

2.9.6.3
At the bottom of veneered walls, wall ties spaced as required by 2.9.6.1 shall be provided at not more than 300 mm above the concrete or masonry base.

2.9.6.4
For walls consisting of two or more skins of reinforced hollow masonry separated by a non-grouted cavity, the spacing of wall ties shall not be greater than that required for veneered walls unless permitted by specific design.

2.9.6.5
The positions of wall ties for stack bonded masonry shall be the subject of specific design.

C2.9.6
Wall ties for reinforced cavity masonry should not be staggered but aligned vertically so as to allow the passage of a rod or vibrator.

2.9.7
Tie categories and classifications required

2.9.7.1
Wall ties attaching masonry veneers not exceeding a mass of 220 kg/m² to non-specific design buildings detailed to NZS 3604 or NZS 4229 may be of medium duty (MD) as specified in Part 3 except in seismic zone A for veneers of mass exceeding 180 kg/m² where ties shall be either:

(a) Heavy duty (HD) spaced in accordance with clause 2.9.6.1 or

(b) Medium duty (MD) with spacing reduced to

  (i) 600 mm x 300 mm or 450 mm x 350 mm for timber walls

  (ii) 500 mm x 400 mm or equivalent area for reinforced concrete or masonry.

Only stiff veneer ties shall be used in these applications, unless seismic separation joints are provided in the veneer (see 2.10.3.2).

This Code does not cover the provision for veneers attached to single storey timber framed buildings supported on perimeter braced pile foundation systems.

C2.9.7.1
Single storey brick veneer clad timber framed buildings which are supported by a reinforced concrete or masonry foundation wall at floor level, to which veneers are attached with stiff wall ties, have proved to be effective in limiting the lateral deflections of the structure, thereby reducing seismic damage to the veneer at corners and openings.

The perimeter braced pile foundation system requires specific design limiting the deflection of the lateral bracing system of flexible braced pile foundation structures and the single storey timber frame to the limits of the flexible ties. Design information for this type of structure is covered in NZS 4230.

2.9.7.2
Tie classifications for all other veneer applications shall be determined by specific design.

2.10 Methods of controlling wall movements

2.10.1
General

2.10.1.1
Wall movements including the effects of temperature, the shrinkage of concrete masonry units and the expansion of clay masonry units shall be controlled either by the use of adequate reinforcement or by control joints.

C2.10.1.1
Concrete masonry units are likely to shrink in service while some clay masonry units can expand. The amounts will depend on the condition of the masonry as constructed and upon the service conditions of the building.

Typical figures for expansion (+ ve) and contraction (- ve) are as follows:

Thermal expansion

Concrete masonry	*0.01 mm/m/°C*
Clay masonry	*0.006 mm/m/°C*

Reversible moisture movement

Ordinary concrete masonry	*-0.1 to -0.4 mm/m*
Lightweight concrete masonry	*-0.2 to -0.6 mm/m*
Clay masonry	*+0.2 to -0.1 mm/m*

Irreversible expansion of clay masonry varies widely, depending on new materials and production methods, but can be up to 1 mm/m at age 1 year. Experience to date with New Zealand made bricks has shown no problems in typical usage, but care should be exercised with unusual wall configurations or bricks from other sources. In these cases figures based on experimental data should be sought for the particular units to be used.

2.10.2
Vertical control joints

2.10.2.1
Buildings not subject to specific design
For reinforced hollow concrete masonry and grouted concrete masonry cavity walls that have not been the subject of specific design, control joints shall be provided at not more than 8 m spacing and where

required located:

(a) At major changes in wall height,

(b) At changes in wall thickness other that at piers,

(c) At control joints in the foundations, roof and floors,

(d) At chases and recesses for services,

(e) Near wall intersections,

(f) Near return angles in L, T and U shaped structures,

(g) At one or both sides of wall openings.

C2.10.2.1
In reinforced masonry there is a requirement for trimming reinforcement around each opening. The relevance or practicality of providing control joints at these positions needs special attention (see 2.10.5).

2.10.2.2
Concrete masonry veneer construction
In unreinforced concrete masonry veneer, provisions in addition to those outlined in 2.10.2.1 for vertical control joints shall be made at each side of an opening or window exceeding 1.8 m in width. Alternatively, specified in-joint reinforcement, local to the position where shrinkage cracking is to be controlled, shall be provided.

C2.10.2.2
A shrinkage joint in masonry veneer may take the form of a raked continuous vertical joint. Clay masonry veneer tends to expand in service and no shrinkage controls are required. Some consideration for accommodating long term movement may be required where fired clay masonry units are used and which are known to be subject to irreversible moisture expansion effects.

2.10.2.3
The width of a vertical control joint shall be as follows:

(a) For shrinkage movement the sides of the joint may be initially in an unbonded contact state

(b) For expansive movement the sides of the joint shall be separated by a distance determined by specific design and the joint shall be filled with a compressible joint filler.

C2.10.2.3
The control joint design depends on the structural transfer of loads, if any, required by specific design.

2.10.3
Separation joints

2.10.3.1
Panel blockwork contained within a structural frame and the associated separation joints shall be subject to specific design.

2.10.3.2
Veneer construction, other than that deemed to comply with the limitations of NZS 3604 and NZS 4229, together with associated separation joints to allow the veneer to accommodate differential movements of the structural elements under seismic load, shall be subject to specific design.

C2.10.3.2
Where the supporting structural element is significantly more flexible under racking load than the veneer, significant damage to the veneer can occur particularly at internal and external corners. The displacement can be either reduced by using a stiffer supporting wall or by providing appropriate separation details. The acceptable levels of seismic damage to a cladding such as veneer is not clearly defined. In Coalinga, USA, which experienced an earthquake of force 6.5 on the Richter scale, veneer with poor fixings collapsed but veneer with correctly installed ties survived undamaged despite the absence of special separation details. Veneer damage at Edgecumbe in 1987 revealed primarily a problem in inadequate tie provision and fixing. The adoption of full corner and window separation details is seen as a logical engineering step towards limiting damage in veneers. Typical examples of separation details that may form part of a specific design specification are contained in Appendix 2.E. Veneer construction in these cases are likely to make use of the special flexible ties whose performance is set out in Part 3 of this Standard.

2.10.4
Weatherproofing

2.10.4.1
Control and separation joints in external walls shall be waterproof.

C2.10.4.1
Care should be taken to select filler and caulking materials that meet the anticipated movements of the joint and will withstand weather conditions.

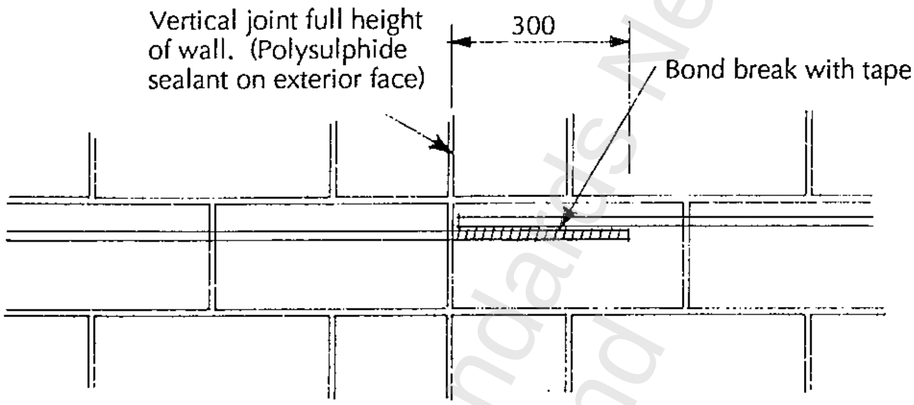
2.10.5
Bond beams

2.10.5.1
Where for structural purposes, reinforcement passes through the position of a control joint, the reinforcement shall be treated so as to prevent bond of the grout to the bar for a distance of:

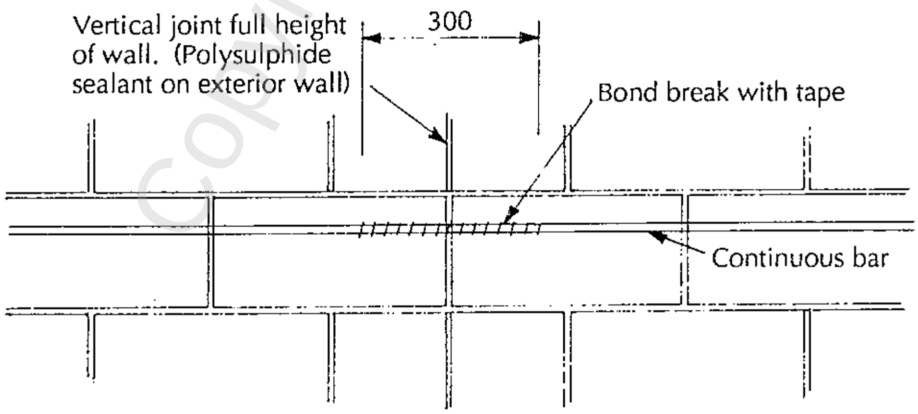
(a) 150 mm on either side of a control joint within a single wall,

(b) 300 mm on one side of a control joint between two walls.

C2.10.5.1
The debonding of the reinforcement is to provide for shrinkage movement to be taken up by an induced crack. The wall section at such a position may be reduced by the raking out of the vertical joint between the masonry units at the intended control joint position. Control joints which have performed well in practice are shown in fig.2.10.1.



(a) Control joint separating two walls



(b) Control joint within single wall

Fig. 2.10.1
TYPICAL CONTROL JOINT

2.11
Grouting of cells and cavities general

2.11.1
Grouting shall not commence until the mortar joints have attained sufficient strength to resist blow-outs and grout spaces have been cleaned out.

2.11.2
The height of individual lifts in any pour shall be limited so as to prevent blow-outs.

2.11.3
Grout shall completely fill all cells and cavities containing reinforcement and such other cells required by design or other considerations.

2.11.4
Cells that are not to be filled shall be covered to prevent the entry of grout, provided that this shall be done in such a manner that the mortar bond between courses is not impaired.

2.11.5
Grout in each lift shall be thoroughly compacted in order to fill all voids and ensure bond between grout and masonry or construction joints.

2.11.6
The tops of grouted walls shall be protected in order to prevent too rapid drying during hot or drying weather or winds.

2.11.7
Any of the following grouting methods shall be used with:

(a) Design grade C masonry as defined in NZS 4230:

(i) High lift grouting with expansive admixture as defined in 2.12

(ii) High lift grouting with reduced compaction as defined in 2.15

(iii) Low lift grouting as defined in 2.14.

(b) Design grades A or B masonry as defined in NZS 4230:

(i) High lift grouting with expansive admixture as defined in 2.12

(ii) High lift grouting without expansive admixture as defined in 2.13

(iii) Low lift grouting as defined in 2.14.

C2.11.7
High lift grouting using an expansive admixture relying upon the action of aluminium powder to form a gas generated expansion of the grout has been found to provide significantly superior results in both supervised and unsupervised masonry work. The expansive action avoids the re-consolidation actions required of ALL other high lift grout methods.

Requirements of the expansive grout are detailed in 2.1.7 and 2.3.2.1.

The extent of the gas generation is affected by temperature and expansions become smaller as the temperature is reduced. In temperatures below 5 °C some supplementary re-consolidation of the grout may be required.

The grading of the different methods illustrates their structural performance and designers should note that high lift grouting with reduced compaction is NOT considered compatible with specific masonry design criteria. Where possible non-specific design specifications should call for high lift grouting with expansive admixture.

2.12
The high lift grouting with expansive admixture method

2.12.1
General

2.12.1.1
Grouting using an expansive admixture is carried out as a semi-continuous operation without horizontal construction joints for pours up to a maximum of 3.6 m with consolidation provided as the pour height proceeds with recompaction.

2.12.2
Procedure

2.12.2.1
An expansive admixture shall be dosed in accordance with the manufacturer's instructions and suitably mixed immediately prior to placing in the masonry.

2.12.2.2
The placing and consolidation shall be as follows:

(a) Place grout into cells to be grouted in a semi-continuous operation allowing for consolidation as the work proceeds up to a maximum height of 3.6 m;

(b) After filling and waiting for expansion to take place, the wall tops shall be locally recompacted by trowelling. Alternatively a weighted or fixed restraining board shall be placed on top of the wall immediately after grouting and left in place for at least 4 hours.

2.12.2.3
Consolidation shall be carried out by mechanical vibration or rodding with a solid bar or rod of minimum dimension 16 mm.

2.13
The high lift grouting without expansive admixture method

2.13.1
General

2.13.1.1
The high lift grouting without expansive admixture method means grouting a pour not exceeding 3.6 m high as a semi-continuous operation without intermediate horizontal construction joints. Grouting is done in a series of lifts, each not exceeding 1.2 m high. Compaction is by consolidation followed by reconsolidation.

2.13.2
Procedure

2.13.2.1
The placing and consolidation shall be as follows:

(a) Grout the first lift to a height not exceeding 1.2 m;

(b) Consolidate the first lift by mechanical vibration;

(c) Wait for the first lift to settle, which generally shall not be less than 15 min nor more than 60 min;

(d) Grout the second lift;

(e) Consolidate the second lift and simultaneously re-consolidate the first lift by mechanical vibration;

(f) Repeat this sequence of operations of grouting, consolidation and waiting as necessary until the end of the waiting period for the final lift of the pour;

(g) Reconsolidate the final lift and top off as necessary.

2.13.2.2
Consolidation and reconsolidation in this method shall be by the use of a mechanical vibrator.

2.14
The low lift grouting method

2.14.1
General

2.14.1.1
The low lift grouting method means grouting in increments between horizontal construction joints conforming to 2.16. The spacing of construction joints shall not exceed:

(a) 1200 mm where no dimension of the grout space is less than 50 mm

(b) 400 mm where any dimension of the grout space is less than 50 mm.

2.14.2
Procedure

2.14.2.1
The procedure shall be as follows:

(a) Lay units to the height of the first lift;

(b) Grout the first lift;

(c) Consolidate the first lift so as to fill all voids;

(d) Prepare the construction joint;

(e) Repeat this sequence of operations until the final lift is completed, grouted and consolidated.

2.14.2.2
Grout shall be consolidated by rodding or mechanical vibration.

2.15
The high lift grouting method with reduced compaction

2.15.1
General

2.15.1.1
The high lift grouting method with reduced compaction means grouting in a continuous single pour to a maximum height of 2.4 m, with thorough vibration during the placement of the grout.

2.15.2
Procedure

2.15.2.1
The procedure shall be as follows:

(a) Grout with continuous vibration to a maximum height of 2.4 m;

(b) Wait for a period of 15 to 60 min and then re-vibrate and top up the wall with grout as required.

2.16
Construction joints

2.16.1
Horizontal construction joints shall preferably be formed at the top of the uppermost masonry units. In no case shall they be formed more than 20 mm below the top.

2.16.2
Horizontal construction joints in grout shall be formed by thoroughly cleaning the surface of the hardened grout and removing all laitance and loose and foreign matter.

2.17
Bracing during construction

2.17.1
Temporary bracing shall be provided to masonry where necessary to resist lateral loads during construction.

C2.17.1
Unfilled blockwork 190 mm thick, 1m high becomes unstable when subjected to a wind gust of velocity above about 25 m/s, while a similar wall 2.4 m high becomes unstable at a gust velocity above about 17 m/s. Thinner walls become unstable at lower gust velocities.

2.18
Cold weather construction

2.18.1
When masonry construction is carried out at an air temperature below 4 °C the following precautions shall be taken:

(a) Water used for mixing mortar shall be heated,

(b) Masonry shall be protected for not less than 24 h after laying by covers, blankets, heated enclosures, or the like to ensure that the mortar can gain strength without freezing or harmful effects from cold winds, and

(c) No frozen materials nor materials containing ice shall be used.

2.19
Hot weather construction

2.19.1
When masonry construction is carried out at an air temperature above 27 °C or where there is a drying wind at lower temperatures the following precautions shall be taken:

(a) Masonry units may be lightly dampened before laying (see 2.7.2),

(b) Mortar shall be kept moist and shall not be spread on the wall so far ahead of the units being placed as to cause loss of plasticity,

(c) The mortar shall be prevented from drying so rapidly that it cannot cure properly. This may be done by applying a very light fog spray several times during the first 24 hours after laying or by other protective measures over the same period,

(d) Grout shall be protected from too rapid drying as required by 2.11.6.

C2.19.1
Premature drying of joints and grout can occur in a combination of situations relating to relative humidity, wind speed and concrete temperature.

Typically with a RH of 50 %, concrete temperature of 20 °C, wind speeds in excess of 20 km/h will result in premature drying requiring the precautions outlined to be implemented. At RH of 80 % the critical wind speed is 40 km/h.

2.20
Chases, recesses, sleeves, conduits or other pipes

2.20.1
Chases and recesses in masonry shall be constructed only as permitted by specific design.

2.20.2
The requirements of NZS 3109 for sleeves, conduits, and other pipes embedded in concrete shall apply also to masonry except that reinforcement perpendicular to sleeves, conduits and pipes shall be not less than 0.1 % of the area of the masonry cross-section.

2.21
Weather protection

2.21.1
General

2.21.1.1
Single skin masonry walls, other than unreinforced veneers, which are exposed to weather or groundwater, shall comply with the requirements of either 2.21.2 or 2.21.3.

2.21.1.2
Cavity masonry walls reinforced in the outer skin, and reinforced veneers, shall also comply with the requirements of either 2.21.2 or 2.21.3 if they contain reinforcing or other steel, which does not comply with the requirements for corrosion resistant metal given in 2.1.1.

C2.21.1.2
Well compacted concrete blocks formed with dense concrete and good aggregate can be manufactured so as to be relatively impervious and to comply with the requirements of permeability tests. Weatherproof walls can be constructed using such blocks, but the ability of the wall to remain weatherproof depends on both sound detailing and proper construction practices.

Concrete block manufacture in some parts of the country concentrates on lightweight blocks often made with pumice aggregate and these blocks are not intended to form an impervious weatherproof wall without the addition of a weatherproof coating.

The effect of shrinkage cracks should be considered on coatings and this may affect the choice of the coating or the amount of reinforcing used to control shrinkage.

2.21.2
Weatherproofing methods

2.21.2.1
Walls which are required to be weatherproof shall either:

(a) Be made weatherproof by means of a suitable weatherproofing system, properly detailed and applied, or

(b) Shall be constructed of masonry units which are shown to comply with the requirements of a suitable permeability test and either:

(i) The mortar joints, including bed joints and perpendicular ends shall not permit the passage of moisture, or

(ii) The mortar joints, although not impervious, shall not form a continuous bridge across the skin, and the passage of moisture through the wall shall be prevented by drained cavities or a continuous layer of grout which is not pierced by permeable material or voids or cavities.

C2.21.2.1(a)
For further guidance on weatherproof coatings, refer to the "Masonry Manual" published by the New Zealand Concrete Masonry Association, or the Building Research Association of New Zealand, Research report No. R44: Jansen M.L. and Parris W.F, "Water uptake behaviour of uncoated and coated concrete blocks".

2.21.3
Walls not required to be weatherproof

2.21.3.1
Walls which are exposed to the weather, but which are not required to be weatherproof, and walls which are exposed to groundwater, but which are not required to be waterproof, may be constructed so as not to be impervious, provided the cover requirement of 2.6.6.2 is modified such that all reinforcing bars are maintained at least 15 mm or 1.5 times the maximum aggregate size, whichever is greater, from masonry face shells at all points.

APPENDIX 2.A
COMPRESSIVE STRENGTH TEST FOR MORTAR AND GROUT

2.A1
Scope

2.A1.1
This Appendix sets out the method of test for the determination of the 28 day compressive strength of mortar and grout.

2.A2
Sampling of mortar and grout

C2.A2
Two methods of sampling mortar (2.A2.1 and 2.A2.2) and of moulding grout (2.A3.2 and 2.A3.3) are given for flexibility. The use of freshly mixed samples to be compacted directly into non-absorbent moulds gives easily operated tests which may be more effective for control purposes. The alternative sampling for mortar taken from the mortar bed and moulding of grout into absorbent moulds are more difficult tests but will give compressive strengths more related to the strength in the masonry.

2.A2.1
Except as provided in 2.A2.2 the sample shall be of freshly mixed material.

2.A2.2
Mortar may be taken from a mortar bed which has been spread on the masonry for a period of 1 min and then remixed by hand for 30 s.

2.A2.3
The sample shall be taken from at least 3 widely distributed locations in the batch and sufficient shall be taken for a total of at least 3 test specimens.

2.A3
Moulding and compaction of test specimens

2.A3.1
Each test, whether for mortar or grout, shall consist of a minimum of 3 specimens.

2.A3.2
Except as provided in 2.A3.3 and 2.A3.4 test specimens of mortar and grout shall be moulded and compacted in cylindrical moulds conforming to section 3 of NZS 3112:Part 2.

2.A3.3
Test specimens of grout may be moulded and compacted in square section moulds formed of masonry units of the same type and condition as those being used in the structure and lined with absorbent paper.

2.A3.4
The minimum lateral dimension of test specimens shall be not less than 4 times the nominal maximum aggregate size or 50 mm whichever is the greater. The length of test specimens, whether capped or uncapped, shall be not less than 1.90 and not greater than 2.10 times the minimum lateral dimension.

2.A4
Curing, capping and testing of specimens

2.A4.1
Curing of specimens shall be in accordance with clause 3.5.1 or 3.5.2 of section 3 of NZS 3112:Part 2.

2.A4.2
Where necessary, capping of specimens shall be in accordance with section 4 of NZS 3112:Part 2.

2.A4.3
Testing of specimens shall be carried out at an age of 28 days after mixing of the mortar or grout in accordance with section 6 of NZS 3112:Part 2.

APPENDIX 2.B
MASONRY-TO-MORTAR BOND STRENGTH TEST

2.B1
Scope

2.B1.1
This Appendix sets out test procedures for the determination of the 7 day masonry-to-mortar bond strength.

2.B2
Test procedures

2.B2.1
Each test shall consist of a minimum of 6 specimens.

2.B2.2
Masonry-to-mortar bond tests shall be conducted by any of the procedures set out in 2.B3, 2.B4 and 2.B5.

2.B3
Bending of masonry couplets

2.B3.1
The couplets shall be constructed and cured as groups of 3 stack bonded piers 2 units high in accordance with 2.B4.2 and 2.B4.3. The couplets shall be tested as shown in fig.2.B1. The test force shall be increased steadily by suitable increments without shock until bond failure occurs, when bond stress shall be calculated as:

Bond stress

$$= \frac{eP_t}{Z} - \frac{P_t + 9.8\,M_m + 9.8\,M_b}{A} \times 10^{-3}\ \text{kPa}$$

where

A is as given by 2.B6.1

Z is as given by 2.B6.1

e is as shown in fig. 2.B1 (m)

P_t is the test force at failure (N) where the test force is applied by placing a mass of M_t kg on the test beam, ($P_t = 9.8\,M_t$)

M_m is the mass of the top masonry unit (kg)

M_b is the mass of the test beam (kg)

Results shall be reported to the nearest 5 kPa.

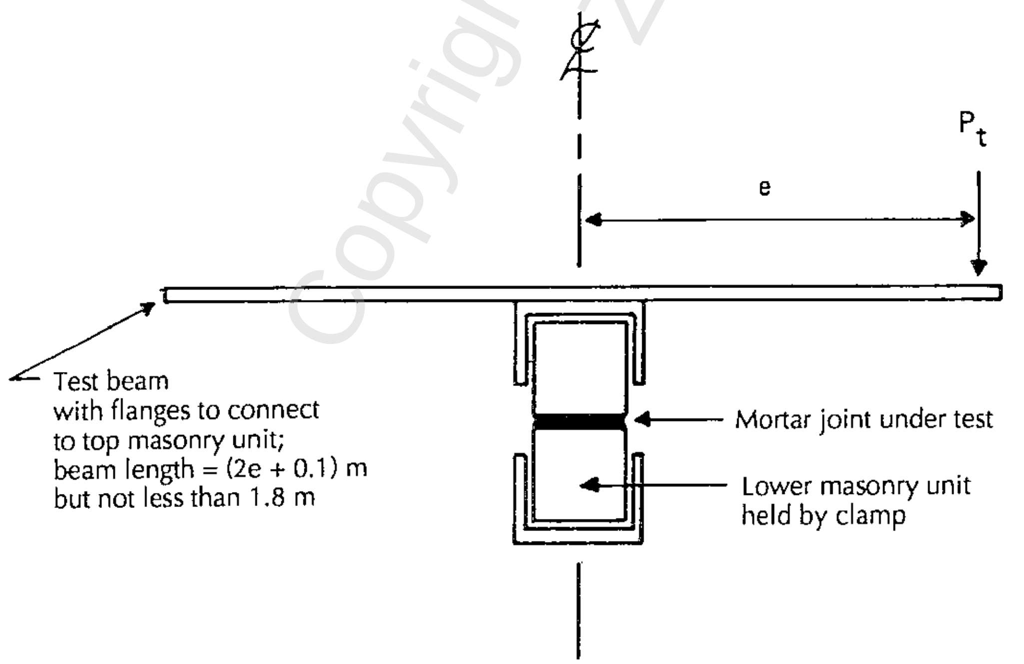


Fig. 2.B1
ARRANGEMENT FOR BENDING TEST OF MASONRY COUPLET FOR DETERMINATION OF BOND STRENGTH

2.B4
Bending of masonry piers

2.B4.1
General

2.B4.1.1
This test method shall apply only to units not exceeding 100 mm in height.

2.B4.1.2
Bond strength between masonry units and mortar shall be determined by means of bending tests carried out on piers tested as beams supported at the two ends and centrally loaded (see fig. 2.B2).

2.B4.2
Construction of piers

2.B4.2.1
The beams shall be constructed by one of the masons employed on the job as groups of three stack-bonded piers 9 units high.

2.B4.2.2
The piers shall be constructed as follows:

(a) Set out three masonry units on a firm, flat surface with a single vapour-proof sheet laid over it large enough to wrap around the group of piers on completion.

(b) Place a mortar bed on all three units from, as nearly as possible a single trowel-full of mortar.

(c) Wait 30 s before placing three units on the mortar bed, to produce three stack-bonded couplets. Cut off surplus mortar but do not strike off or tool the joints.

(d) Two min after placing the first mortar bed, place a second bed.

(e) Repeat steps (c) and (d) until the piers are the height specified in 2.B4.2.1.

(f) On completion of the laying cut down the perpends with a wire without disturbing the piers. Wrap the three piers in the vapour-proof sheet and leave undisturbed until the testing date.

2.B4.3
Curing time of piers

2.B4.3.1
Testing shall be carried out 7 days after making the piers, except that when chemically retarded mortar has been used to construct the piers, the unexpired period for which the mortar was retarded shall be added to the normal 7 days curing period. The age at test shall also be extended by the full amount of any time during which the air temperature remains below 4 °C plus half the amount of any time during which the air temperature is between 4 °C and 10 °C.

2.B4.4
Testing of beams

2.B4.4.1
Testing shall be carried out using the following procedure:

(a) Determine the mass of each pier to the nearest 1kg and record (M_1).

(b) Lay a pier on its side so that the stretcher faces of the units are uppermost.

(c) Support the pier on masonry units symmetrically placed at each end to form a beam with a clear span 50 mm less than the overall length as shown in fig. 2.B2(b).

(d) Load the beam by placing additional masonry units (or other suitable weights) carefully and without shock on the centre three units until the beam breaks. Determine the mass of the applied load to the nearest 1kg and record (M_2).

2.B4.5
Calculations

2.B4.5.1
Calculate the bond stress from the formula:

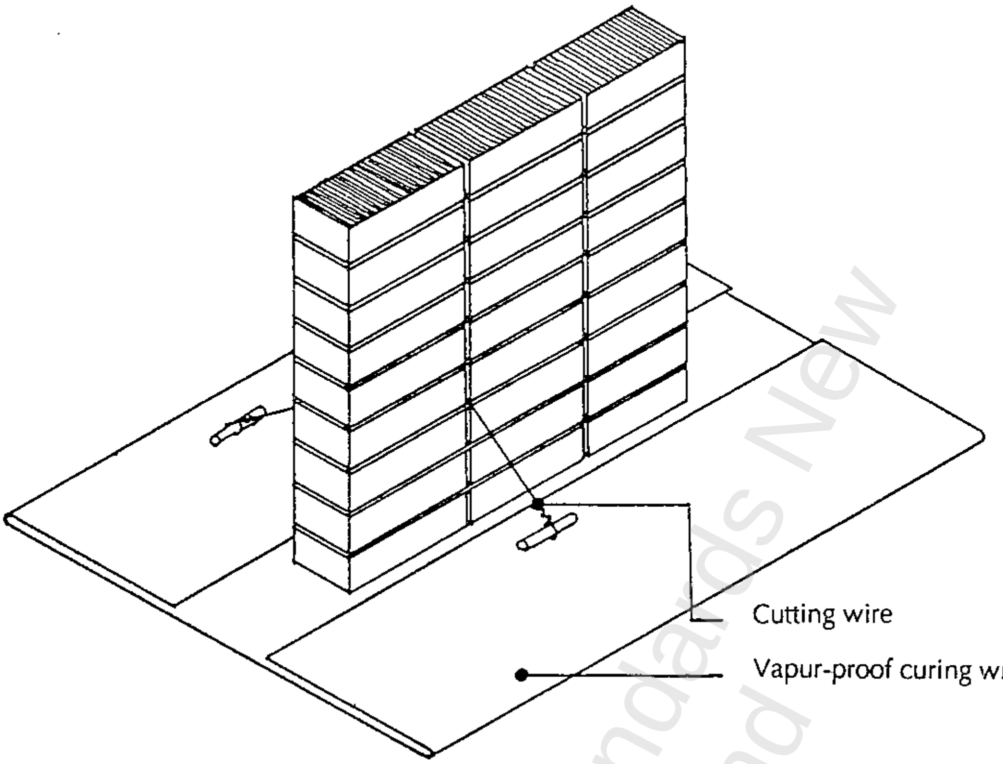
Bond stress

$$= \frac{1}{Z}\left[1.225\ M_1 \times \frac{(L-50)^2}{L} + 2.042\ M_2 \times (L-50)\right] \times 10^{-6} \ldots \text{kPa}$$

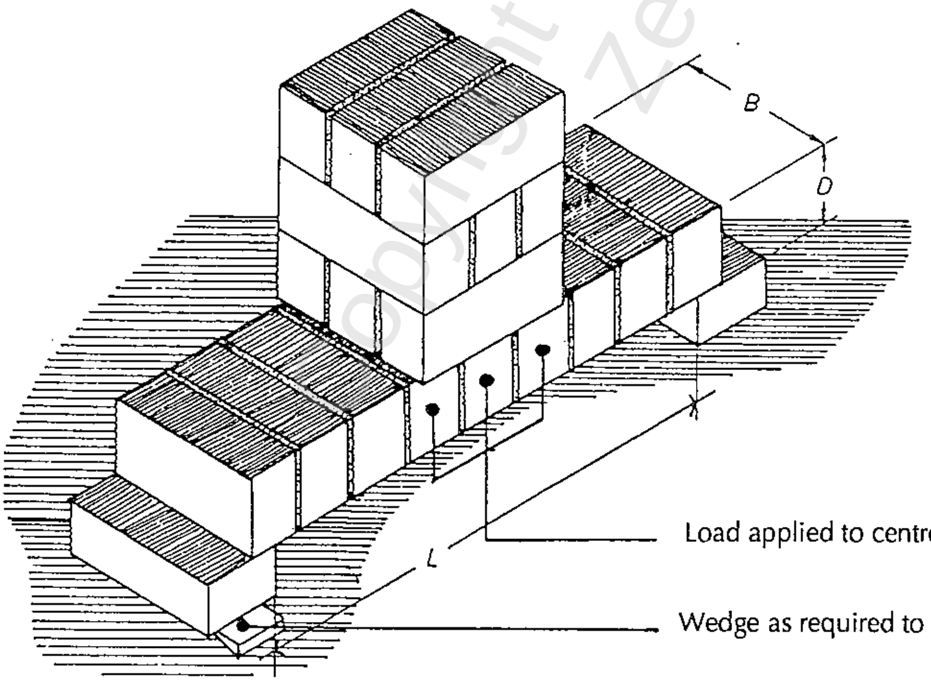
where
M_1 = Mass of beam (kg)
M_2 = Mass of applied load (kg)
L = Overall length of beam (mm)
Z = Section modulus of the beam, calculated as in 2.B6 (m^3)

2.B4.6
Reporting of results

2.B4.6.1
Report the six individual results and the average of the six results to the nearest 5 kPa.



(a) Making the piers in groups of three



(b) Testing the piers

Fig. 2.B2
BENDING TEST OF MASONRY PIERS FOR DETERMINATION OF BOND STRENGTH

2.B5
Other methods

2.B5.1
Any other approved test method may be used, provided that:

(a) The method shall take into account the following:

(i) The mass of the masonry units under test,

(ii) The mass of any test equipment used,

(iii) Eccentricity of loading or induced moments;

(b) Shear stress induced in the mortar shall not exceed 30 % of the bond stress

(c) Compressive stress induced in the mortar shall not exceed 130 % of the bond stress.

2.B6
Calculation of area and section modulus

2.B6.1
In determining bond stress by any of the methods of test listed in this Appendix, the area (A) and section modulus (Z) shall be taken as:

(a) For solid masonry units:

$$A = bd \times 10^{-6} \quad (m^2)$$

$$Z = (bd^2/6) \times 10^{-9} \quad (m^3)$$

where

b = length of masonry unit (mm)

d = width of masonry unit on which mortar bed is to be laid (mm)

(b) For hollow masonry units:

$$A = (d_1 + 5 - d_2)\, b \times 10^{-6} \quad (m^2)$$

$$Z = \frac{2I \times 10^{-9}}{d_1} \quad (m^3)$$

where

b = length of masonry unit (mm)

d_1 = width of masonry unit (mm)

d_2 = width of cell at widest point (mm)

$$I = \frac{b}{12}\left[d_1^3 - (d_2-5)^3 \right] \quad (mm^4)$$

(The expression (d_2-5) allows for the narrowing of the cell and the effect of mortar squeezing on to the web.)

APPENDIX 2.C
TEST FOR EXPANSION OF GROUT

2.C1
Scope

2.C1.1
This Appendix sets out the method of test for the determination of the expansion by volume of a grout containing an expansive admixture by monitoring the rise in surface level of a sample of the grout in a measuring cylinder.

2.C2
Apparatus

2.C2.1
The following apparatus is required for the test:

(a) A 2000 ml graduated glass measuring cylinder conforming to BS 604 or AS 2163;

(b) A vibration free level surface;

(c) A timing device readable and accurate to 1 min;

(d) A scoop small enough to fit inside the measuring cylinder.

2.C3
Procedure

Use the following test procedure:

(a) Obtain a representative sample of grout by one of the methods set out in section 3 of NZS 3112:Part 1 within 10 min of the addition of the expansive admixture to the grout.

C2.C3
(a) This test should be performed immediately after the grout has been sampled. Hence a sample which has already been subjected to the spread test is not acceptable.

(b) Using the scoop, fill the measuring cylinder to 1600 ± 20 ml with grout. Level the surface and stand the measuring cylinder on the vibration free surface.

(c) Start the timing device and record the grout level to the nearest 10 ml.

(d) Record the level of grout solids at regular intervals (no more than 15 min) until no further change can be observed.

C2.C3(d)
Often a grout containing an expansive admixture will form more bleed water than the same grout without an expansive admixture. The extra bleed water is forced out by the formation of hydrogen gas. It should be noted that the level of the grout solids should be recorded, not the surface level of the bleed water.

2.C4
Other test methods

2.C4.1
Alternative methods which contain the lateral movement of the grout within a cylinder of constant cross-section and use direct vertical measurement of movement may be used subject to:

(a) The degree of linear expansion shall be readable to within 0.5 % of the vertical height of the grout sample.

(b) The diameter of the cylindrical container shall neither be less than 30 mm nor less than 5 times the maximum aggregate size contained in the grout.

(c) The test procedures shall follow that of 2.C3 except that a rigid cylinder of constant section can be substituted for a measuring cylinder in 2.C3(b).

(d) Calculations using linear height measurements instead of volume as in 2.C5.1 before and after expansion shall be used to determine the percentage increase in volume.

(e) The reported results shall be in accordance with 2.C6.1.

C2.C4.1
For site testing, the method of 2.C3 is often inappropriate and a disposable cylindrical container method can be used. Typically a rigid plastic waste drainage pipe 50 mm in diameter, bottom capped with a height of grout sample 300 mm should show a height movement of not less than 6 mm nor more than 12 mm with an accuracy of measurement being to 1.5 mm i.e. the range of acceptable performance : 2 % - 4 % expansion.

2.C5
Calculations

2.C5.1
Calculate the expansion of grout solids, Δ after time, t as a percentage of the initial volume from the formula:

$$\Delta = \frac{(V_t - V_i)}{V_i} \times 100$$

where
V_t = grout volume after time, t (ml).
V_i = initial grout volume (ml).

2.C6
Report

2.C6.1
Report the expansion of grout solids to the nearest 1 % and the time until expansion ceases to the nearest 15 min.

C2.C6.1
A graph of grout solid volume change against time is often useful and may be included in the report.

APPENDIX 2.D
HOOKS AND BENDS FOR REINFORCING BARS

2.D1
Details of the standard hook and bend for main reinforcing bars and for stirrups and ties are given in fig. 2.D1.

2.D2
The minimum diameters of bends for main reinforcing bars measured on the inside of the bar shall be as given by table 2.D1.

2.D3
The diameters of bends for stirrups and ties measured on the inside of the bar shall be equal to the diameter of the enclosed bar except that it shall be not less than the appropriate value given in table 2.D2 where d_b is the stirrup or tie bar diameter.

Table 2.D1
MINIMUM DIAMETERS OF BENDS FOR DEFORMED BAR

Steel grade *	*Bar diameter (mm)* d_b	*Minimum diameter of bend*
300 or 430	6-20	$5d_b$
	24-28	$6d_b$

Table 2.D2
MINIMUM DIAMETERS OF BENDS FOR STIRRUPS AND TIES

Steel grade *	*Bar diameter (mm)* d_b	*Minimum diameter of bend*	
		Plain bars	Deformed bars
300 or 430	6-20	$2d_b$	$4d_b$

* The steel grades given in the tables are the lower characteristic yield strengths of steel specified in NZS 3402 which, at the time of publication of this Standard, has not yet been published. Until such time as NZS 3402 is published, or the grades of steel specified therein become available, bars shall be bent to the minimum diameters specified in NZS 3109.

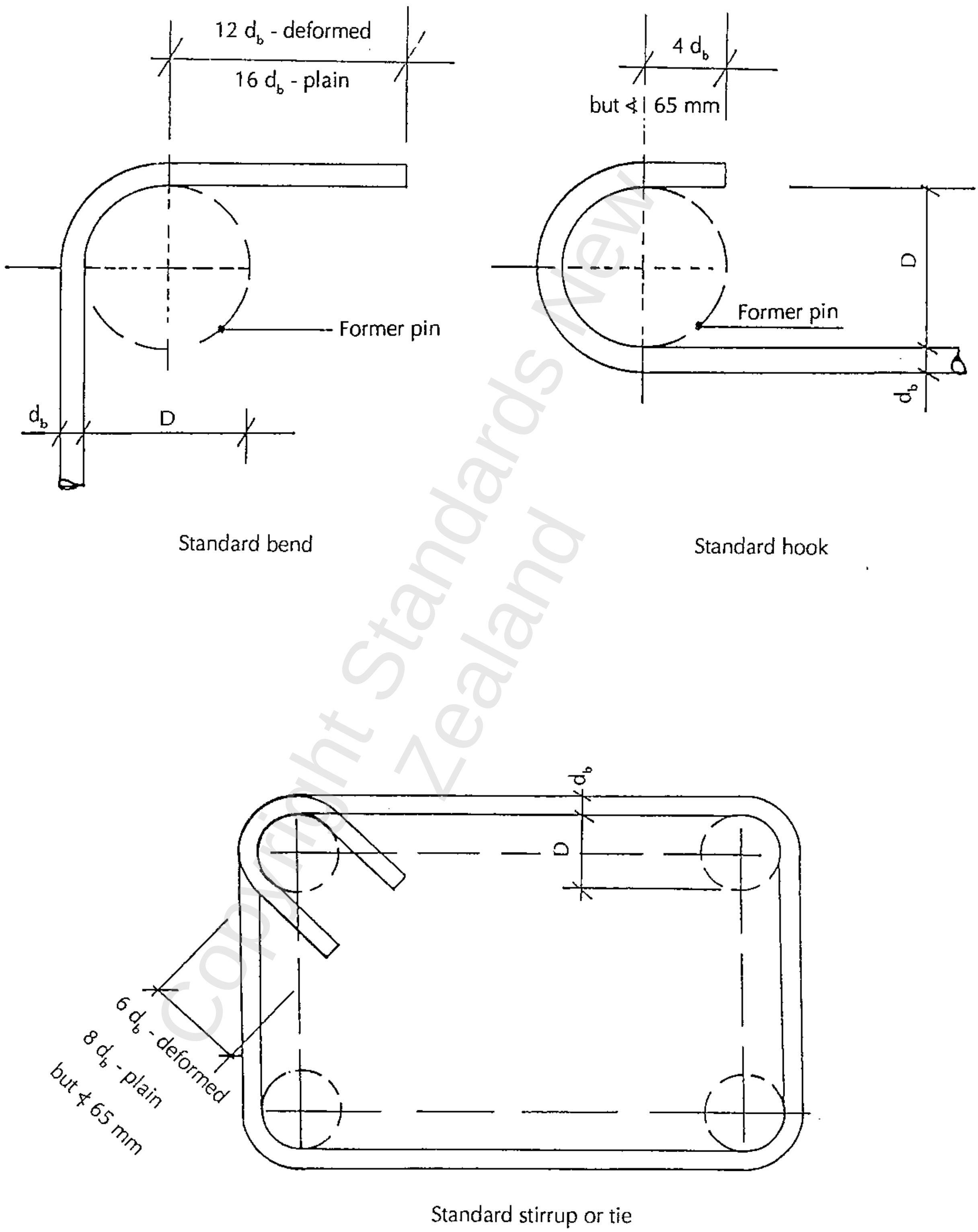


Fig 2.D1
STANDARD BEND, HOOK AND STIRRUP OR TIE

APPENDIX 2.E
VENEER SEPARATION JOINTS

2.E1
Scope

2.E1.1
This Appendix discusses the need for separation joints in construction consisting of a masonry veneer supported by a flexible structure.

2.E2
General

2.E2.1
Fig. 2.E1 illustrates in an exaggerated way the differential deflections that may occur during a cycle of seismic loading. The flexible structure, while carrying the face loading from the veneer, is likely to have a significantly higher displacement in the plane of the wall during an earthquake.

2.E2.2
At various positions the differential deflections will show up in different ways requiring special details. Generally details at windows and doorways involve modifications to window and door joinery. These are of limited direct interest to the mason. The wall perimeter deflected form does however require special details that have a direct influence on the masonry veneer construction.

2.E3
Typical details

2.E3.1
Wall head
Fig. 2.E1 illustrates that the flexible structural frame will shorten in height. Any oversailing roof or floor structure originally supported by the structural frame could transfer its loading into the non-load bearing masonry veneer unless sufficient clearance is provided during construction. This detail is also important to cater for general building movements such as shrinkage of the timber frame and expansion of clay masonry. A typical detail is shown in fig. 2.E2 illustrating the separation detail.

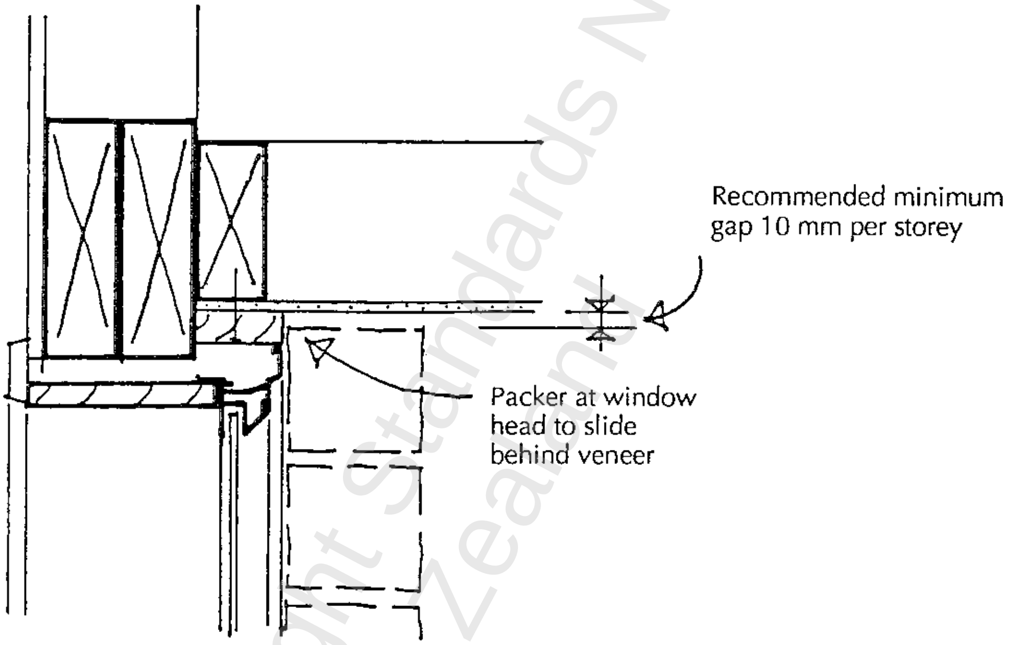
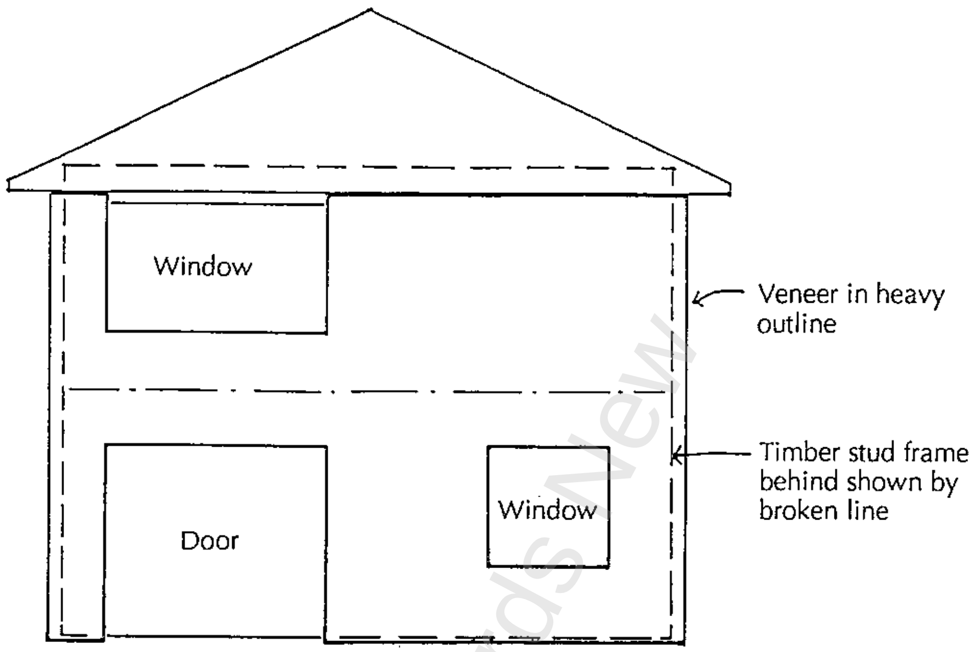
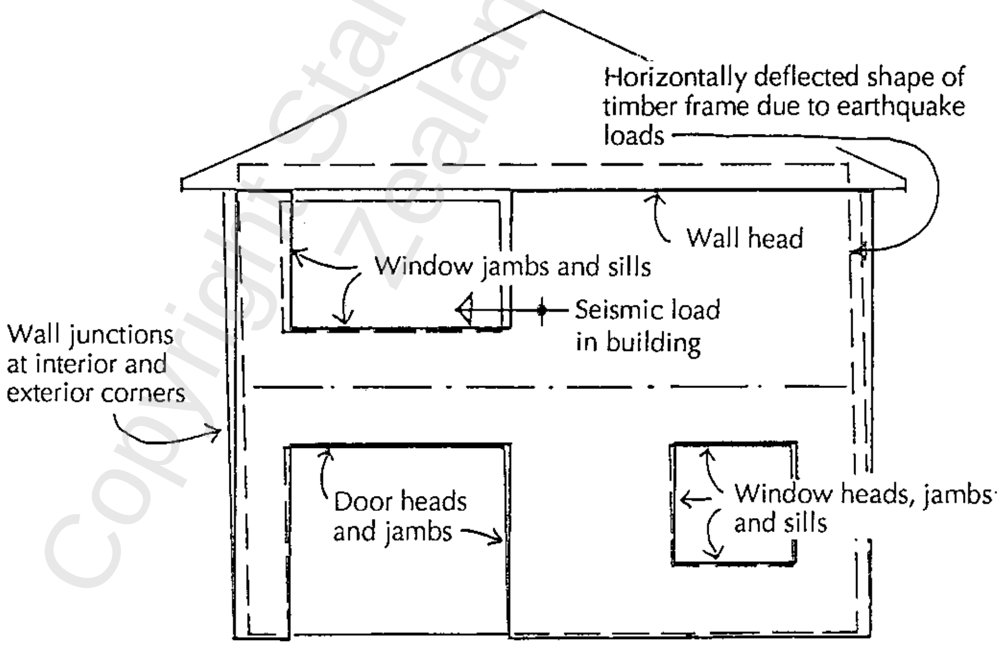


Fig. 2.E2
TYPICAL SEPARATION DETAIL AT WINDOW HEAD



ELEVATION OF VENEER WITH STUD FRAME BEHIND



STUD FRAME DEFLECTED UNDER SEISMIC LOADING FROM VENEER (TOTAL MOVEMENT EXAGGERATED FOR CLARITY) SHOWING THE POSITIONS WHERE SEPARATION DETAILS WILL BE REQUIRED.

NOTE - Window, door and wall heads and window sills require separation details to allow for vertical differential movement between the timber framing and the veneer.

Fig. 2.E1
DIFFERENTIAL IN-PLANE DEFLECTIONS BETWEEN TIMBER FRAME AND VENEER

2.E3.2
Corners and wall junctions

2.E3.2.1
Reference to fig. 2.E1 will illustrate the dilemma of a traditional bonded veneer corner. The movement of the structural frame will cause severe corner damage to the veneer. This damage has been seen in many of the recent earthquakes both in New Zealand and overseas.

2.E3.2.2
Essentially the details figsures 2.E3 and 2.E4 show the departure from the traditional bonded corners. The size of the separation joint required depends upon the stiffness concerned for the structural frame and may vary for each specifically designed project. The wider the separation joint used the greater becomes the need for special weatherproofing details.

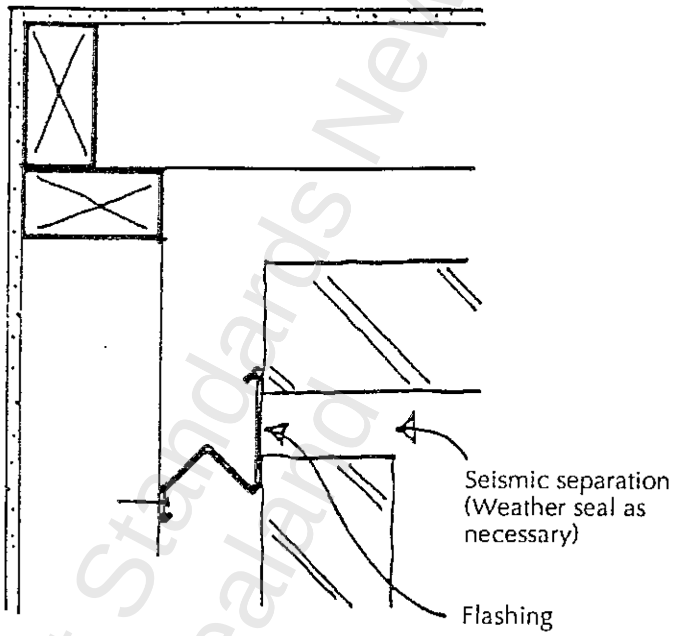


Fig. 2.E3
TYPICAL SEPARATION DETAIL AT INTERNAL CORNER

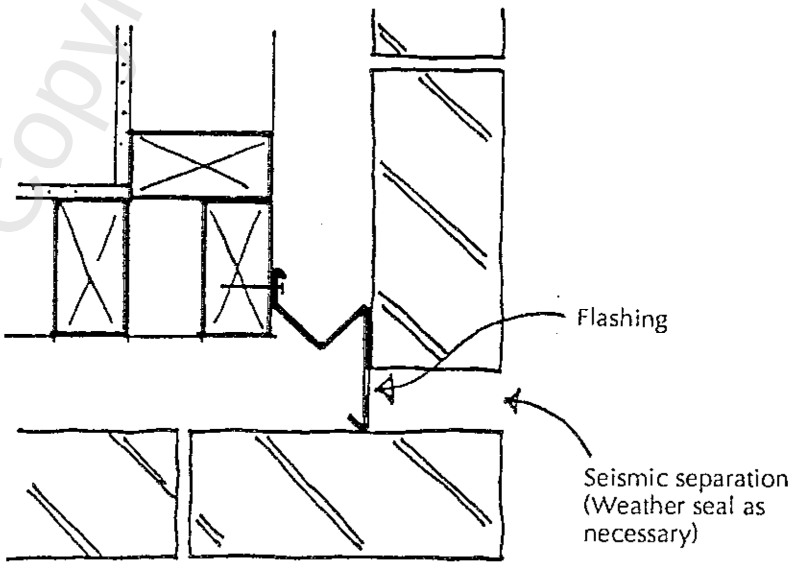


Fig. 2.E4
TYPICAL SEPARATION DETAIL AT EXTERNAL CORNER

2.E3.3
Window and door openings

2.E3.3.1
Reference to fig. 2.E1 illustrates the need to permit the window or door frame to slide unhindered into the veneer cavity in flexible structures during earthquakes. Figures 2.E5 and 2.E6 show typical details of how this can be accomplished.

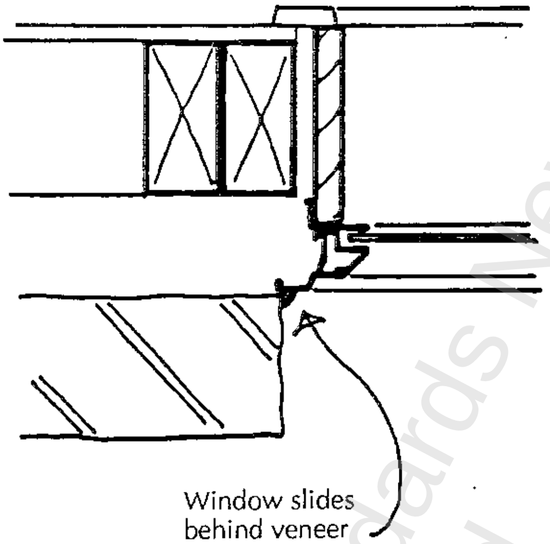


Fig. 2.E5
TYPICAL SEPARATION DETAIL AT WINDOW JAMB

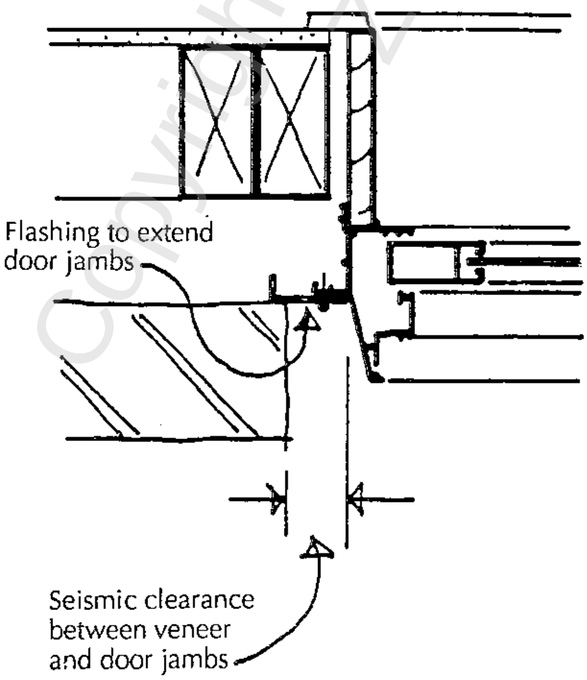


Fig. 2.E6
TYPICAL SEPARATION DETAIL AT SLIDING DOOR JAMB

PART 3
WALL TIE PERFORMANCE REQUIREMENTS

3.1
Scope

3.1.1
This Part specifies the requirements for wall ties used for tying together -

(a) Masonry veneer walls of brick or block to flexible structural frame elements, such as timber, steel studs or wall girts

(b) Masonry veneer walls of brick or block to reinforced concrete or reinforced masonry structural walls, and

(c) The skins of cavity brick and/or cavity block walls which are part of a loadbearing structural wall.

C3.1.1
This part principally specifies performance requirements for wall ties and, to a lesser extent, the design and manufacture of wall ties. Building construction requirements for ties are covered in 2.9.7.

Uses of wall ties are also covered by NZS 4229, NZS 4230 and NZS 3604.

Ties for grouted cavity walls are not covered by this Part and should be specifically designed for each application.

3.2
Category and classification

3.2.1
End use categories

3.2.1.1
There are three end use categories of wall ties as follows:

(a) Stiff veneer ties, which together with their fixings, shall be capable of transferring face loads between a single skin masonry veneer and a structural wall while being able to restrain differential in-plane horizontal deflections and accommodate differential vertical deflections between the attached elements

(b) Flexible veneer ties, which together with their fixings, shall be capable of transferring face loads between the veneer and the structural wall, while not transmitting shear or bending loads across the cavity when accommodating differential in-plane horizontal and vertical deflections between the attached elements.

A flexible tie, in its unstressed condition, shall be constructed so as to not reduce or increase by more than 2 mm the cavity width when accommodating differential in-plane horizontal and vertical deflection between the attached elements

(c) Cavity ties, which are wall ties designed to tie together two skins of masonry which are separated by an ungrouted cavity.

C3.2.1.1(c)
Cavity walls can be designed so that the two separated skins of masonry act together as a unit under face loading. To achieve this, cavity wall ties need to be stiff and strong when subjected to axial loads, but to be still able to accommodate small differential in-plane movements between the skins, such as due to shrinkage or other moisture movements.

3.2.2
Classification
Wall ties shall be classified as either elastic or ductile ties, in accordance with the ductility provisions as required in this Part. Ties shall be further classified into service classifications as follows:

(a) Medium Duty (MD)

(b) Heavy Duty (HD)

(c) Extra Heavy Duty (EH)

C3.2.2
The minimum strength, stiffness and ductility requirements for each category and classification of tie are given in 3.5. Note that significant shear and bending forces can be induced in stiff veneer ties if they are subjected to differential in-plane horizontal deflections.

3.3
Materials

3.3.1
Wall ties and fixings shall be of corrosion resistant material complying with the requirements of 2.1.1.1, except that where galvanized protection is used, they shall have a minimum coating weight of 460 g/m² and a minimum coating thickness of 0.064 mm for all thicknesses of steel 5 mm or less. In addition, where galvanizing is used, the galvanizing shall be done after forming the ties to their final shape.

C3.3.1
The specification for corrosion resistance of wall ties and fixings should consider the design life of the structure, as well as the prevailing environmental conditions and potential development of electrochemical reactions.

Based on experience in the United Kingdom (Ref. 3.1) the expected rate of loss of protective zinc coatings for hot-dip galvanized steel wall ties in New Zealand is between 10-20 g/m²/yr for most normal environments, depending on aspects such as design features, exposure to driving rain, workmanship, etc. Satisfactory corrosion protection of wall ties with a zinc coating of 460 g/m² may therefore be expected up to a maximum of about 46 years. The life beyond this point is related to the deterioration in cross-sectional area of the steel tie until a critical performance stress level is reached.

Highly corrosive environments are found near the sea and in some industrial areas. The building designer and/or Local Authority should give consideration to special environmental effects and a more durable coating or material, e.g., stainless steel, may need to be selected.

Polypropylene and similar materials are not suitable for ductile ties.

3.3.2
Ties shall be manufactured in such a way that damage to any corrosion protection during construction shall be minimized.

3.3.3
Fasteners for veneer wall ties shall be specified by the manufacturer and shall be supplied packaged with the ties.

3.4
Dimensions within bed joint

3.4.1
That part of a wall tie which provides anchorage into the mortar bed joint in masonry shall have an overall thickness of the anchorage section, including any crimping or bending, not exceeding 5 mm, unless the thickness of the joint for which the tie has been tested is specified on the labelling.

3.5
Performance requirements

3.5.1
The minimum strength, stiffness and ductility of veneer ties, when axially loaded in accordance with Appendix 3.C, shall not be less than the applicable values given in table 3.5.1 for each particular service classification of duty.

Stiff veneer ties are required to perform a similar function except that they are required to restrain horizontal differential in-plane movements between the veneer and the structural wall (see 3.5.2).

C3.5.1
Flexible veneer ties are required to provide stability to a single skin masonry veneer against face loads, while at the same time accommodating horizontal and vertical differential in-plane movements between the veneer and the structural wall.

3.5.2
In addition to the requirements of 3.5.1, stiff veneer ties shall, when tested in accordance with Appendix 3.C, have a minimum horizontal in-plane characteristic stiffness of not less than 500 N per mm and a minimum horizontal in-plane characteristic cyclic strength of not less than 900 N.

3.5.3
The minimum strength and stiffness of cavity wall ties, when axially loaded in accordance with Appendix 3.C, shall not be less than the applicable values given in table 3.5.2 for each particular service classification of duty.

3.5.4
The design of both veneer and cavity ties shall be such as to prevent transfer of water along the length of the ties. Selected samples of ties shall be tested in accordance with Appendix 3.B and shall be deemed to comply with the requirements of this clause only if the blotting paper shows no signs of dampness and remains dry for the duration of the tests.

Table 3.5.1
VENEER TIES (FLEXIBLE AND STIFF)
MINIMUM STRENGTH, STIFFNESS AND DUCTILITY UNDER AXIAL LOADING

Classification	*Min. characteristic stiffness N/mm*	*Elastic tie*	*Ductile tie*		
		Min. characteristic strength	*Min. characteristic cyclic strength*	*Min. deflection at ultimate yield*	*Min. ductility*
Medium duty	240	1400	700	9	2
Heavy duty	360	2000	1000	9	2
Extra-heavy duty	480	3000	1500	9	2

Table 3.5.2
CAVITY WALL TIES
MINIMUM STRENGTH, STIFFNESS AND DUCTILITY UNDER AXIAL LOADING

Classification	*Min. characteristic stiffness, N/mm*	*Min. characteristic strength (N)*
Medium duty	1000	720
Heavy duty	2500	1800
Extra-heavy duty	5000	3600

3.5.5
Flexible ties must be made so that no component of a tie can disengage in service, including during earthquakes.

3.6 Manufacturing requirements

3.6.1
In the interests of ease of handling and construction safety, ties shall be made without sharp points or corners that could injure site workers.

3.6.2
Each finished wall tie shall be free from fractures and surface cracks. Wall ties made of galvanized steel shall have an unbroken galvanized coating throughout.

3.6.3
The tolerance between moving parts of flexible wall ties, in the direction of the face loads, shall be such as to not allow more than ±1mm before the stiffness of the tie comes into effect.

C3.6.3
Flexible ties, by their very nature, may be made up of a number of moving parts. Manufacturing tolerances are required for assembly purposes. While such slackness will modify the area of the hysteresis loops, the tolerance limits are small compared with the minimum ultimate deflections specified. Several investigations have shown that slackness of this magnitude within the F.D. hysteresis loop is unlikely to affect the response, (Ref. 3.2) and such manufacturing tolerances are therefore acceptable.

3.7 MARKING

3.7.1
Each wall tie shall be colour-coded with a readily visible spot, stripe or similar mark, as follows:

(a) Medium duty ties - no colour mark

(b) Heavy duty ties - red

(c) Extra-heavy duty ties - blue.

3.7.2
Each ductile veneer tie shall additionally be stamped with an upper case letter "D".

3.7.3
The following information shall be marked on each package of wall ties or on a label securely attached thereto:

(a) The name or registered trade name or mark and address of manufacturer

(b) The materials used in manufacture, including fasteners and corrosion protection

(c) Elastic or ductile tie

(d) Category - cavity or veneer tie

(e) Service classification of duty

(f) Maximum and minimum cavity width, in millimetres

(g) Fastening requirements

(h) State compliance with NZS 4210.

C3.7.3
An illustration of a label meeting these minimum labelling requirements is given in Appendix 3.A.

3.8 Assessment of compliance with this Standard

3.8.1
Wall ties shall be assessed for strength and stiffness compliance with this Part, in accordance with the schedule given in table 3.8.1. Methods of compliance deemed to satisfy this Standard may be a SANZ Certification Mark, a BRANZ Appraisal Certificate, or a TELARC Registered Laboratory report on a sampling from manufacturer's lot up to a maximum size of 100 000 units of any one category and classification.

3.8.2
Where the physical properties of a given category and service classification of wall ties are to be tested for compliance with this Standard, wall ties shall be sampled at random from that lot and the test results shall apply to that lot.

3.8.3
Where a lot is to be tested in accordance with both Appendix 3.B and Appendix 3.C, the same samples may be used, first for Appendix 3.B tests, and subsequently, with the addition of other samples as required, for Appendix 3.C tests.

Samples tested in tension shall not be further tested in compression or vice versa.

3.8.4
The manufacturer shall, on request, furnish the purchaser or his representative with a copy of the test certificate or report as required under 3.8.1.

Table 3.8.1
SCHEDULE FOR ASSESSMENT OF COMPLIANCE

Characteristic	*Specification*	*Test method*	*No. of specimens in the test sample*
Resistance to water transfer	Clause 3.5.4	Appendix 3.B	5
Strength	Clause 3.5.1, 3.5.2, 3.5.3	Appendix 3.C	6
Stiffness	Clause 3.5.1, 3.5.2, 3.5.3	Appendix 3.C	6
Stiff ties - ductility and cyclic strength	Clause 3.5.1, 3.5.2	Appendix 3.C	6
Flexible ties - ductility and cyclic strength	Clause 3.5.1	Appendix 3.C	12
Corrosion resistance	Clause 3.3.1	-	-

APPENDIX 3.A
MINIMUM LABELLING REQUIREMENTS

3.A1
An example of labelling showing the recommended size of label and required minimum information for wall tie packages is shown below.

Name of manufacturer:	Smiths Steelworks Ltd - HAMILTON
Material:	Steel
Corrosion protection:	Hot dipped galvanized
Elastic or ductile:	Ductile
Flexible or stiff tie:	Flexible
Category of wall tie:	Veneer
Service classification of ties:	MEDIUM DUTY
Maximum cavity width:	60 mm
Minimum cavity width:	40 mm
Fastening requirements:	Type .... Length .... Diameter .... Number of Fasteners ....
If used, SANZ or BRANZ Certificate Number	Complies with NZS 4210

75 mm minimum

100 mm minimum

APPENDIX 3.B
METHOD OF TEST FOR RESISTANCE TO WATER TRANSFER

3.B1
Scope
This Appendix describes the method for the determination of resistance to water transfer across wall ties.

3.B2
Principle

3.B2.1
Ties are cleaned and placed into a testing rig in which the outer end of the ties are clamped between metal jaws.

3.B2.2
The inner end of the ties shall be fastened to a part of a structural member in accordance with the manufacturer's installation recommendations. The part of the structural member shall be capable of being moved horizontally or vertically in the test rig.

3.B2.3
The inner ends of the ties are positioned to simulate both favourable and unfavourable conditions of service. The jaws of the test rig are subjected to a controlled flow of water to simulate free water flowing down the inside face of the external skin of a cavity wall or masonry veneer wall. The ties are observed to see whether water is transferred by them across the wall cavity.

3.B3
APPARATUS
The following apparatus is required:

(a) A testing apparatus of the type illustrated in fig. 3.B1, or equivalent

(b) A supply of clean tap water to which may be added a wetting agent

COMMENT: 'Teepol' is a suitable wetting agent.

(c) Blotting paper sufficient to wrap the specimens.

3.B4
Samples
A test sample shall consist of not less than five specimens, taken in accordance with 3.8.2.

3.B5
Preparation of test specimens
Specimens shall be wiped clean of any grease, loose rust or dirt or foreign matter.

3.B6
Procedure
The procedure for each specimen when using an apparatus of the type illustrated in fig. 3.B1 shall be as follows:

(a) Install the tie horizontally with any designated top face uppermost, into the testing apparatus with the metal jaws firmly clamped over it and the clamped section of the tie projecting the minimum designed in-service cavity width inside, and at right angles to, the face of the jaws

(b) Wrap a piece of blotting paper, 20 mm wide, around the exposed end of the tie with its furthest point at a distance from the jaws of the apparatus, equal to the design cavity width. Secure with sticky tape so that at least 3 mm length of blotting paper is exposed towards the jaws.

C3.B6(b)
The transfer of water across the tie into the building should be prevented by a water shedding device at least 20mm from the face of the wall.

(c) Fill the header tank with water so that it continuously overflows without interruption. Ensure that a continuous film of water runs across the distribution plate of the test rig

(d) Adjust the rate of flow to approximately 50 mL/s per metre of distribution width. Continue this flow for not less than 1 min

(e) At the conclusion of the test period, remove the blotting paper and examine for signs of dampness. Use fresh paper for subsequent tests

(f) Repeat steps (a) to (e) for each tie, except that the end with the blotting paper is lowered vertically as follows:

- (i) Cavity ties .... 10 mm
- (ii) Veneer ties for use with timber frame construction .... 20 mm
- (iii) Veneer ties for use with metal frame construction .... 5 mm
- (iv) Ties of special design (refer comment) .... Nil.

C3.B6(f)(iv): *Ties of special design are those designed so that differential movement between the outer skin of masonry and the inner skin or supporting structure does not result in the ties being forced out of the horizontal.*

(g) For ties without a designated top face, turn over the tie and repeat steps (a) to (f).

3.B7
Reporting of results
Report the following information:

(a) Identification of the lot of wall ties tested, including:

(i) Manufacturer

(ii) Materials

(iii) Elastic or ductile

(iv) Flexible or stiff

(v) Category of ties

(vi) Service classification of duty

(vii) Maximum and minimum cavity width; and

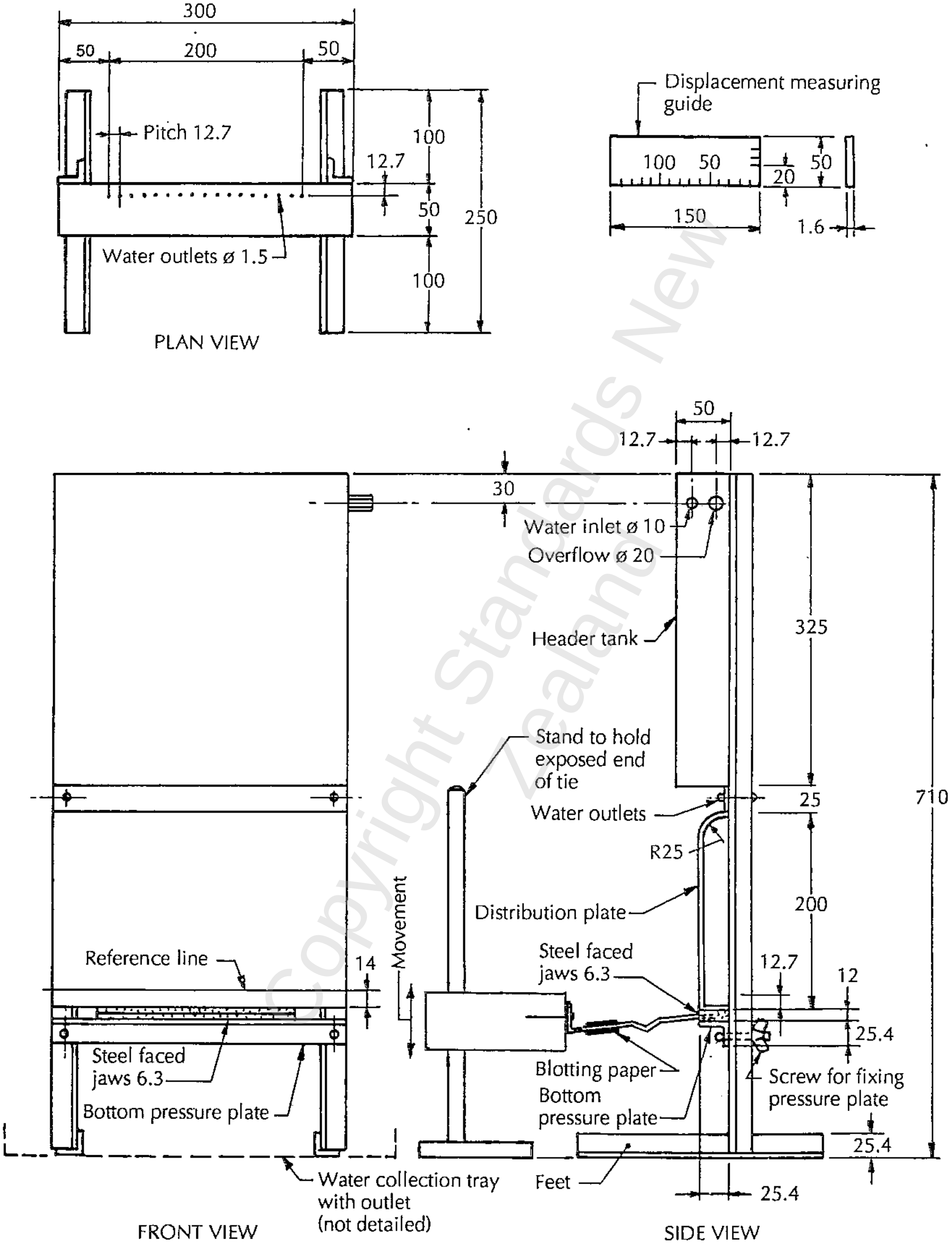
(viii) Source of the lot

(b) Name of testing authority and location of test

(c) Date of test

(d) Any variations from standard testing procedures

(e) Comments, if relevant.



Dimensions in millimetres

Fig. 3.B1
TEST APPARATUS FOR RESISTANCE TO WATER TRANSFER TEST

APPENDIX 3.C
METHOD FOR DETERMINATION OF CHARACTERISTIC STRENGTH AND CHARACTERISTIC STIFFNESS UNDER FACE LOADING AND IN-PLANE LOADING

3.C1
Scope

This Appendix describes the method for the determination of the characteristic stiffness and characteristic strength or ductility and characteristic cyclic strength of a lot of wall ties.

3.C2
Principle

Cavity ties are set at each end into a mortar-bonded couplet of masonry units of bricks or blocks. Veneer ties are set at one end into a mortar-bonded couplet of bricks, and attached at the other end to a piece of structural member. The specimens are held in a testing machine and a force is applied until the ties fail.

3.C3
Materials

The materials required are as follows:

(a) Minimum width of masonry units shall be 70 mm

(b) Mortar - of proportions cement: 1, lime: 1, sand: 4 parts by volume and otherwise complying with 2.2, to be used not less than 15 min nor more than 30 min after mixing

(c) Timber - 100 mm x 50 mm kiln-dried radiata pine

(d) Vapour-proof sheet - sufficient to wrap specimens

(e) Structural stud frame elements - for masonry veneer ties only, short lengths of kiln-dried radiata pine, with 7 mm ply packing, metal stud or other relevant structural member.

3.C4
Apparatus

The following apparatus is required:

(a) A testing machine which complies, as regards accuracy, with the requirements for grade 2.0 of NZS 6507:Part 1. The machine shall be capable of:

   (i) Holding firmly each stack-bonded couplet or member described in 3.C6

   (ii) Displacing them relative to each other, without twist, tilt or rotation, by the amounts specified in table 3.C1; and

   (iii) Applying either tension or compression force along the (undisplaced) axis of the tie.

(b) Fasteners - in accordance with 3.3.3.

3.C5
Samples

Samples shall be taken in accordance with 3.8.1.

3.C6
Manufacture of test specimens

3.C6.1
Form of specimens

Specimens shall be built to the maximum cavity width prescribed by the manufacturer.

The form of specimen shall be as follows:

(a) For cavity ties - a pair of stack-bonded couplets

(b) For veneer ties - a stack-bonded couplet linked by one wall tie to a short piece of structural member and in addition, stack-bond couplets for mortar to brick bond tests shall be constructed in accordance with Appendix 2.B.

3.C6.2
Construction

3.C6.2.1
Cavity tie specimens shall be constructed as follows:

(a) Place a timber batten, cut with its horizontal width equal to the designated cavity, and vertical dimensions of 50 mm, on a vapour- proof sheet on a horizontal surface.

(b) Set out 12 masonry units along each side of the timber batten so that each masonry unit is separated from adjacent units in the same line by a perpend gap approximately 25-30 mm wide. Where concrete blocks or large bricks are to be tested, two rows of six masonry units may be used along each side of timber battens.

(c) Place ties on top of the masonry units of each pair of couplets, with an embedment of 50 % of the width of the masonry units ±5 mm, in a position such that they are in the middle of the masonry units, at right angles to the inside faces of the masonry units and fully covered by mortar.

(d) Place a bed of mortar on six masonry units using a normal bricklaying action and using a single trowelful of mortar for each couplet.

(e) After not less than 1 minute nor more than 4 minutes from the commencement of spreading of the mortar bed, place the second course of masonry units, ensuring a uniform 10 mm joint thickness. Strike off any excess mortar, including perpend joints, taking care not to disturb the tie.

(f) Repeat steps (a) to (e) as required until the total number to be tested has been made (see 3.C10).

(g) Wrap the specimens in the vapour-proof sheet and leave them undisturbed.

3.C6.2.2
Veneer tie specimens shall be constructed as follows:

(a) Fix the ties in accordance with the manufacturer's instructions to short lengths of timber or short lengths of the relevant metal stud or structural member. Place a piece of 7 mm construction grade plywood between the tie and the timber stud.

(b) Set out 12 bricks along a straight line upon a vapour-proof sheet on a horizontal surface, with the heads of the bricks separated by about 25-30 mm.

(c) Place one tie on top of each brick, with a minimum embedment of 35 mm from the cavity, in a position such that they are in the middle of the bricks, at right angles to the inside faces of the bricks and fully covered by mortar.

(d) Place a bed or mortar on six bricks using a normal bricklaying action and using a single trowelful of mortar for each couplet.

(e) After not less than 1 minute nor more than 4 minutes from the commencement of spreading of the mortar bed, place the second course of bricks, ensuring a uniform 100 mm joint thickness. Strike off any excess mortar, including perpend joints, taking care not to disturb the tie.

(f) Repeat steps (a) to (e) as required until the total number of specimens to be tested has been made (see 3.C10).

(g) Wrap the specimens in the vapour-proof sheet and leave them undisturbed.

3.C7
Preparation and sampling of specimens

3.C7.1
Age at testing
The specimens shall be tested on the 28th day after manufacture.

3.C7.2
Selection of specimens
The specimens shall be randomly divided into two equal groups, one of which shall be tested in compression and the other in tension. For ductility and cyclic strength tests, one group shall be tested starting the first load cycle in compression and the other in tension.

3.C7.3
Setting up for testing
Each pair of couplets, or couplet and timber or other member, shall be firmly held by the machine in the relative positions they would occupy if no displacement occurred.

3.C7.4
The couplets, or couplet and timber or other members, shall then be displaced horizontally and vertically simultaneously, relative to each other by an amount dependent on the type of tie being tested, in accordance with table 3.C1. The timber or other members shall be moved downwards relative to the veneer.

3.C7.5
Prior to arriving at the test position in 3.C7.4, stiff wall ties to be tested for axial strength and stiffness shall be first subjected to eight load reversals of lateral displacement between the horizontal limits in 3.C11(f). Readings of the force versus displacement, as set out in 3.C11(c) shall be recorded during each cycle of loading of the ties.

C3.C7.5
Lateral displacements of stiff wall ties are possible during an earthquake and must still be able to resist the specified face loads. The hysteresis loops should be recorded for engineering appraisal of the lateral strength properties of the stiff tie and may be an important consideration in the design of the veneer structure and are required for the application of stiff wall ties to the building type covered by 2.9.7.

3.C7.6
The method adopted to achieve this displacement shall not be such as to prevent disruption of the bed joint. The couplets, or couplet and timber or other member, shall be restrained from any relative twisting, tilting or rotation.

Table 3.C1
DISPLACEMENT OF ENDS OF WALL TIES FOR TESTING

Category and application of tie	*Displacement, mm*	
Type of tie	*Vertical*	*Horizontal from central position*
Stiff veneer ties	10	10
Flexible veneer ties	20	40
Cavity wall ties	10	10

Comment to table 3.C1
Wall ties may be subject to vertical (and horizontal) shear stresses resulting from differential movement of different masonry skin materials, or masonry skin and the structural stud frame material in the plane of the wall or by seismic induced differential displacements in the veneer construction. The displacement used in the tests is intended to equate with most severe in-service conditions in the application of a tie to a range of building constructions and height of veneer, permitted by current building codes.

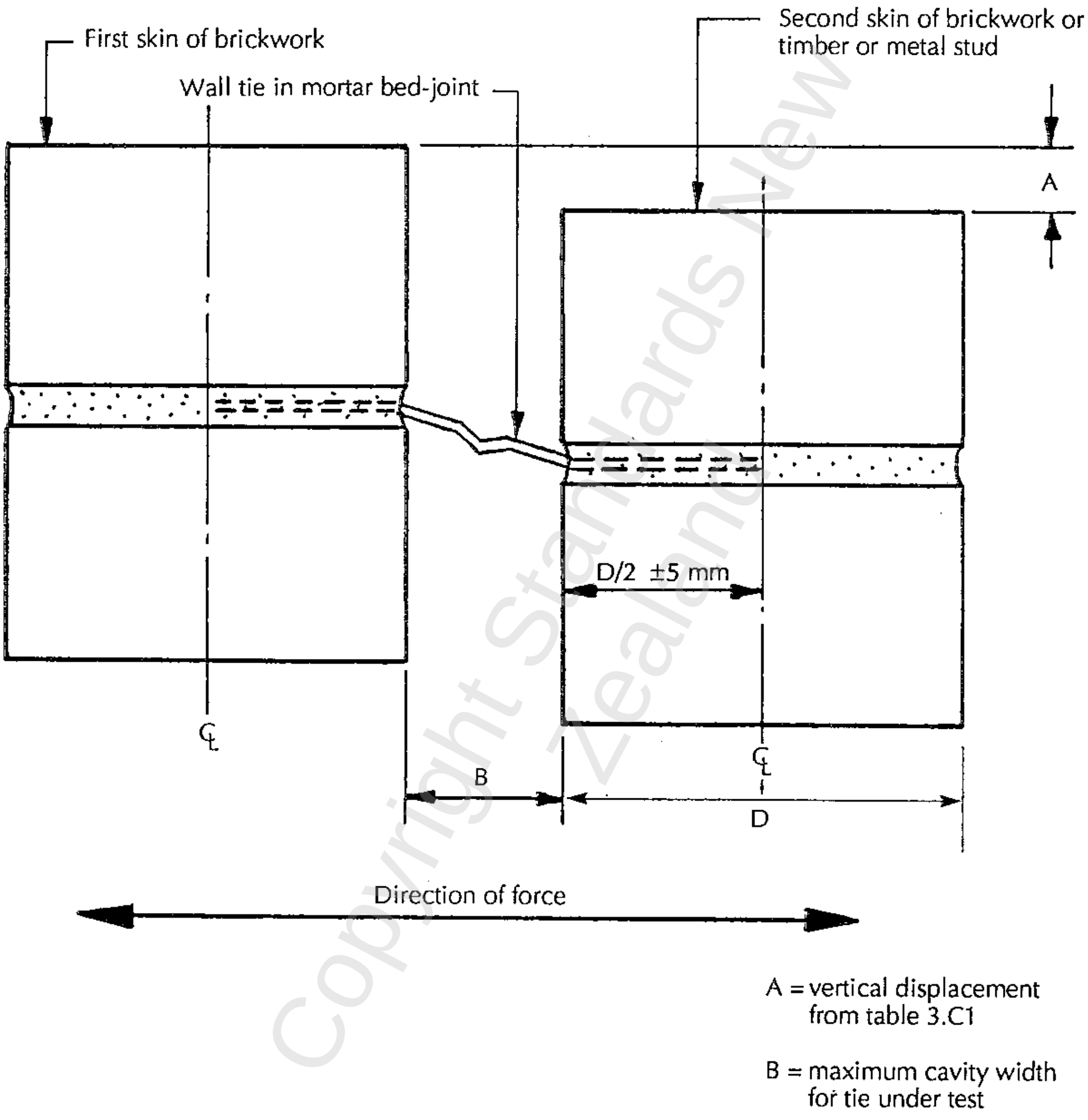


Fig. 3.C1
VERTICAL DISPLACEMENT OF WALL TIES UNDER TEST CONDITIONS

NOTE - Simultaneous horizontal displacement also applies.

3.C8
Procedure for stiffness and monotonic strength test

3.C8.1
The procedure for determining the axial stiffness and strength of all tie types shall be as follows:

(a) Ensure that the specimen is securely held in the displaced position (see 3.C7.4).

(b) Subject the tie to either tension or compression force along the axis (normal to the inside face of the couplet).

(c) Increase the force steadily, until a maximum is reached.

(d) Take readings of force versus displacement, either by a continuous graphical method, or by readings at sufficiently regular intervals to provide the information required by 3.C9.2. Record the force at 1.0 mm deflection, also the maximum force and the deflection at that load and details of failure mode.

(e) Repeat the test items (b) to (d) with another tie in the relative position before displacement had occurred (see 3.C7.3).

C3.C8.1
Flexible ties should have a horizontal displacement capacity in the plane of the veneer of not less than the code deflections for the building to which the veneer is attached. The horizontal limit in table 3.C1 represents typical values for single-storey timber buildings on a braced timber subfloor construction, suitably stiffened two-storey timber and steel stud-framed buildings, and single and multi-storey commercial and industrial buildings supporting veneers in increments of up to 10 m in height.

The vertical displacement limits for stiff veneer ties in table 3.C1 relate to single storey timber framed structures supported on concrete foundation walls to floor level.

3.C8.2
The procedure for determining horizontal stiffness of stiff ties in the horizontal plane of the veneer shall be as follows:

(a) Ensure that the specimen is securely held in the zero displaced position.

(b) Subject the tie to either tension or compression forces along the horizontal axis of the veneer at right angles to the axis of the tie.

(c) Increase the force steadily, until a maximum is reached.

(d) Take readings of force versus displacement, either by a continuous graphical method, or by readings at sufficiently regular intervals to provide the information required by 3.C9.2. Record the force at 1.00 mm deflection, also the maximum force and deflection at that load and details of failure mode.

C3.C8.2
Stiff ties should have a horizontal stiffness and ductile displacement capacity to ensure that they are capable of transferring face loads between a single skin of masonry and the structural wall while being able to restrain horizontal deflections between the attached elements.

The bracing effect of the unreinforced veneers through the structural stiff face-fixed flat strap metal ties attaching single storey veneers to timber structures, which are supported on reinforced masonry or concrete foundation walls at floor level to the provisions of NZS 3604, have been observed to perform satisfactorily in recent earthquakes.

3.C9
Determination of stiffness properties and monotonic strength of individual ties

3.C9.1
Strength
The strength of each tie, X, in kilonewtons, shall be taken as the maximum force resisted in the test.

3.C9.2
Stiffness
The stiffness of each cavity tie, Y, in kilonewtons per millimetre, shall be calculated from the following formula;

$$Y = \frac{\text{Force increment}}{\text{Deflection increment}}$$

where the force increment and deflection increment are determined as follows:

(a) Plot a graph of the best-fitting curve of force, in kilonewtons, versus deflection, in millimetres

(b) Mark off the portion of the curve or the force that caused 1.0 mm deflection, from zero load as applicable (see fig. 3.C2)

(c) Determine the force increment over the marked portion of the curve, as the increase in force between the lower and upper marks.

3.C10
Calculation of characteristic values

NOTE - The characteristic value is that value above which 95 % of results can be expected to lie. Any number of test results may be used with the appropriate formula but it should be noted that the greater the number of test results the more accurate and favourable the characteristic value is likely to be.

3.C10.1
Characteristic strength
The characteristic strength of the lot of wall ties shall be calculated upon a statistical analysis of 6 or more individual test results, in both compression and tension using the following formula:

$$X_c = \bar{X} - 1.65\, S_{(x)}$$

where

X_c = characteristic strength in either compression or tension, kN

$\bar{X}$ = average strength of n results where n > 6, kN

$S_{(x)}$ = unbiased standard deviation of X

3.C10.2
Characteristic stiffness
The characteristic stiffness, Y_c of the lot of wall ties tested shall be calculated upon a statistical analysis of 6 or more individual test results, in both compression and tension using the following formula:

$$Y_c = \bar{Y} - 1.65S_{(Y)}$$

where

Y_c = characteristic stiffness in either compression or tension, kN/mm

$\bar{Y}$ = average stiffness of n results where n > 6, kN/mm

$S_{(Y)}$ = unbiased standard deviation of Y

3.C11
Procedure for ductility and cyclic strength tests for axial and in-plane loads for veneer ties

3.C11.1
The procedure shall be as follows:

(a) For axial loads ensure that the specimen is securely held in the displaced position (see 3.C7.3, 3.C7.4, 3.C7.5 and 3.C7.6.

(b) For in-plane loads in stiff veneer ties, ensure that the applied load is horizontal to the end of the tie in the plane of the wall in accordance with the provision of 3.C7.6.

(c) Take readings of force versus displacement, either by a continuous graphical method or by readings at sufficiently regular intervals to provide hysteresis loops for the information required in paragraphs (d) and (e) or in paragraph (f) for the following load cycles:

(d) For axial loads subject the tie to two reversals of force to a displacement of ±1.0 mm in excess of the tolerance permitted in 3.6.3, then

(e) Subject the tie to eight load reversals of force to a displacement of not less than ±9 mm inclusive of the tolerance permitted in 3.6.3.

(f) For horizontal loads in the plane of the veneer, subject the stiff ties to eight load reversals of a force to a displacement of not less than ±10 mm. Take readings of force versus displacement as required in (c) above.

(g) Test half of each lot starting the first cycle in compression and the balance of the lot starting the first cycle in tension.

(h) In the case of flexible veneer ties repeat (b) above for ties in their positions if no horizontal or vertical displacement had occurred to the supporting structure.

3.C12
Calculation of ductility and cyclic strength

3.C12.1
Ductility
The ductility of each tie in tension or compression on the first cycle at ultimate yield shall be calculated from the following formula:

$$\text{Ductility} = \frac{\text{Deflection capacity}}{\text{Deflection at first yield}}$$

where the representative deflections are to be determined as follows:

(a) The deflection at first yield shall be found graphically by extrapolating a straight line from the displacement at zero load through the displacement point at first yield on the first cycle of load or at 1.0 mm displacement, to the force corresponding to the deflection at ultimate strength (see fig. 3.C2).

(b) The deflection capacity shall be the deflection at which cyclic strength is reached in accordance with 3.C12.2 provided that the ultimate yield deflection is not less than that required by 3.6.4 (see fig. 3.C2).

3.C12.2
Cyclic strength
The cyclic strength of a tie, when subjected to eight load reversals, at constant displacement being not less than that required by 3.5.1, shall be the minimum axial force in the tie in tension or compression on the first cycle of loading, provided the loss of

strength in the tie on the fourth cycle is not more than 30 % of the strength on the first cycle (see fig. 3.C2).

Where the loss of strength on the fourth cycle is more than 30 % of the strength on the first cycle of loading, the tie shall be rated as an elastic tie.

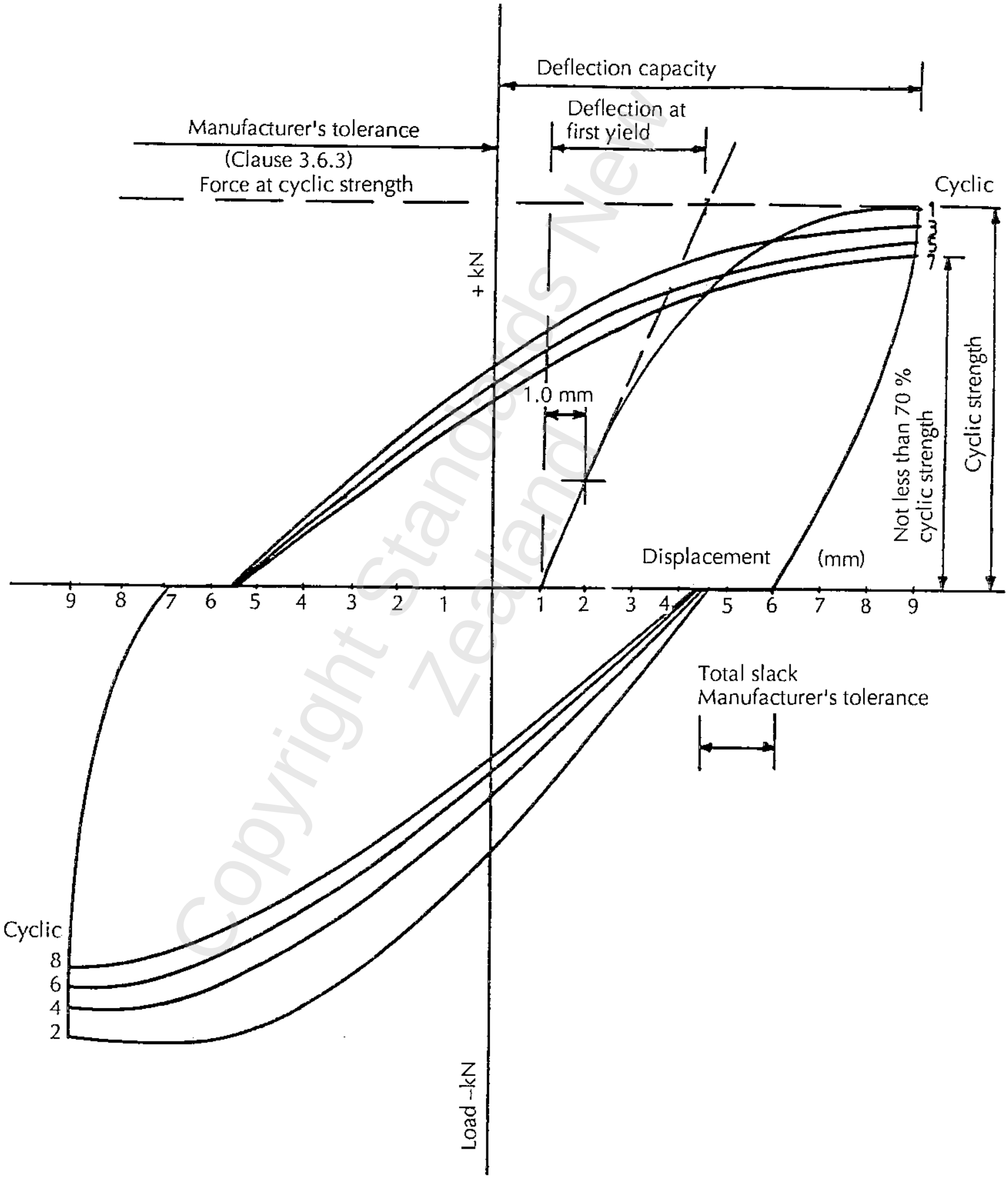


Fig. 3.C2
EXAMPLE OF AXIAL DUCTILITY AND CYCLIC STRENGTH FOR DUCTILE VENEER TIES
(cavity ties similar except tolerances not applicable)

3.C13
Minimum ductility
The minimum ductility of the lot of veneer ties tested shall be not less than that specified in table 3.1.

3.C14
Characteristic cyclic strength
The characteristic cyclic strength, C_s of the lot of wall ties tested for ductility shall be calculated upon a statistical analysis of six or more individual test results, in both tension and compression, using the following formula:

$$C_s = \bar{C} - 1.65\ S_{(c)}$$

where

$\bar{C}$ = average cyclic strength in tension and compression of n results where $n > 6$, kN

$S_{(c)}$ = unbiased standard devitation of C

3.C15
Reporting of results
The following information shall be reported:

(a) Identification of the lot of wall ties tested, including -

(i) Manufacturer

(ii) Materials used in manufacture including fasteners

(iii) Elastic or ductile tie

(iv) Category of ties - cavity or veneer tie

(v) Service classification of duty

(vi) Maximum and minimum cavity width; and

(vii) Source of the lot

(b) Name of testing authority and location of test

(c) Date of test

(d) For each tie -

(i) Strength in compression or tension, as applicable

(ii) Stiffness

(iii) Ductility

(e) For the lot -

(i) Characteristic strength in compression

(ii) Characteristic strength in tension

(iii) Characteristic stiffness in compression

(iv) Characteristic stiffness in tension

(v) Minimum ductility and ultimate strength in compression

(vi) Characteristic ductility and ultimate strength in tension

(vii) Where applicable, characteristic of load displacement in-plane deflection of stiff wall ties

(f) Bond strength characteristics of couplets, in accordance with NZS 4210

(g) Any variations from standard testing procedure

(h) Comments, if relevant.

REFERENCES

(3.1) MOORE, J F A. The performance of Cavity Wall Ties. Building Research Establishment current paper CP 3/81, Garston, England, BRE, 1981.

(3.2) STEWART, W. Timber Design Society Newsletter No. 10, May 1985.

ADDITIONAL REFERENCES

LAPISH E B and ALLEN D. Variability of Tie Loads in Brick Masonry Veneer Construction. 4th Canadian Masonry Symposium, Fredricton, New Brunswick, Canada, June 1986.

McGINLEY W M, LONGWORTH J, WARARUKU J, HATZINIKOLAS M. Masonry Veneer and Steel Stud Curtain Walls. 4th Canadian Masonry Symposium, Fredricton, New Brunswick, Canada, June 1986.

NORRIS, C H, HANSEN R J, HOLLEY M J, BIGGS J M, NAMYET S, NIMAMI J K. Structural Design for Dynamic Loads. McGraw-Hill Book Co Inc.

DEAN J A, STEWART W G, CARR A J. The Seismic Behaviour of Plywood Sheathed Walls. NZ Journal of Timber Construction, Vol. 2 No. 3, September 1986.

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NOTES

COMMITTEE REPRESENTATION

This Standard was prepared under the direction of the Building and Civil Engineering Divisional Committee (30/-) for the Standards Council, established under the Standards Act 1988.

The Masonry Construction Committee (42/7) was responsible for the preparation of the Standard and consisted of representatives of the following organizations:

New Zealand Ceramic Industries Association
New Zealand Concrete Masonry Association
New Zealand Institute of Architects
New Zealand Masonry Trades Employers Federation
Works and Development Services Corporation

In addition, for the development of Part 3, representatives of Building Research Association of New Zealand and a wall tie manufacturer joined the committee, and Mr EB Lapish was co-opted.

STANDARDS ASSOCIATION OF NEW ZEALAND
6TH FLOOR, WELLINGTON TRADE CENTRE, 181-187 VICTORIA STREET, WELLINGTON 1.
(Private Bag, Wellington) Telex: NZ 3850 Telephone: (04)842-108
Fax: (04)843-938

	AMENDMENTS
Date of issue	*Description*

APPROVED TO NEW ZEALAND STANDARD

THE NEW ZEALAND STANDARD CERTIFICATION MARK SCHEME

The 'S' Mark appearing on a product, container or label is an assurance that the goods are manufactured under a system of supervision, control, and testing (including periodical inspection at the manufacturer's works by SANZ Certification Officers) designed to ensure compliance of the commodity, process, or practice with the relevant New Zealand Standard. The New Zealand Standard Certification Mark, registered as a certification trade mark under the Trade Marks Act 1953, may be used only in terms of a licence issued by SANZ, and must be accompanied by the licence number and the NZS number.

Used correctly in conjunction with advertising the 'S' Mark can provide a strong assurance of product quality for a manufacturer when selling his goods and thus becomes a powerful marketing tool.

Manufacturers may obtain particulars of the conditions of licensing from the Director, Standards Association of New Zealand, Private Bag, Wellington.

Declared on 23 June1989 by the Standards Council to be a standard specification pursuant to the provisions of section 10 of the Standards Act 1988.

First published: August 1989

The following SANZ references relate to this Standard:

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Draft for comment No. DZ 4210
CPT ref: KMcl 4
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NEW ZEALAND STANDARD

NZS 4210:1989

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Code of practice for
MASONRY CONSTRUCTION:
MATERIALS AND WORKMANSHIP

AMENDMENT No. 2

May 1993

SUPERSEDED

EXPLANATORY NOTE - Amendment No. 2 clarifies the testing requirements for wall ties. It does not make changes to the technical content of the Standard.

APPROVAL

Amendment No. 2 was approved on 29 April 1993 by the Standards Council to be an amendment to NZS 4210:1989 pursuant to the provisions of section 10 of the Standards Act 1988.

(Amendment No. 2, May 1993)

3.5.1
Delete the clause and **substitute:**

"The minimum strength, stiffness and ductility of flexible and stiff veneer ties, when axially loaded in accordance with Appendix 3.C, shall not be less than the applicable values given in table 3.5.1 for each particular service classification of duty.

"Stiff veneer ties are required to perform a similar function to flexible ties except that they are required to restrain horizontal differential in-plane movements between the veneer and the structural wall (see 3.5.2)."

(Amendment No. 2, May 1993)

Table 3.5.1
In the headings to the third and fourth columns, **add** the unit "N".

In the heading to the fifth column, **add** the unit "mm".

(Amendment No. 2, May 1993)

Table 3.8.1
Delete the table and **substitute** the table given on page 2 of this amendment.

(Amendment No. 2, May 1993)

APPENDIX 3.C
3.C6.2.2
In line 4 of item (e), **delete** "100 mm" and **substitute** "10 mm".

(Amendment No. 2, May 1993)

3.C8.1
Re-number the clause "3.C8.2".

In item (e), **add** at the beginning of the sentence: "For flexible ties,"

(Amendment No. 2, May 1993)

C3.C8.1
Re-number the commentary clause "C3.C8.2".

(Amendment No. 2, May 1993)

3.C8.2
Re-number the clause "3.C8.1".

(Amendment No. 2, May 1993)

C3.C8.2
Re-number the commentary clause "C3.C8.1".

Delete the first line and **substitute:**

"Stiff ties should have a horizontal in-plane stiffness and an axial ...".

(Amendment No. 2, May 1993)

Table 3.8.1
SCHEDULE FOR ASSESSMENT OF COMPLIANCE

Characteristic	*Specification*	*Test method*	*Minimum no. of specimens in test sample*	
			Stiff ties	*Flexible ties*
Resistance to water transfer	Clause 3.5.4	Appendix 3.B	5	5
Horizontal in-plane stiffness of stiff veneer ties	Clause 3.5.2	Appendix 3.C	6	–
Horizontal in-plane ductility and cyclic strength of stiff veneer ties*	Clause 3.5.2	Appendix 3.C	6	–
Axial stiffness and strength in tension	Clauses 3.5.1, 3.5.3	Appendix 3.C	6	12†
Axial stiffness and strength in compression	Clauses 3.5.1, 3.5.3	Appendix 3.C	6	12†
Axial ductility and cyclic strength	Clauses 3.5.1, 3.5.3	Appendix 3.C	6	12†
Corrosion resistance	Clause 3.3.1	–	–	–

* Stiff veneer ties tested for horizontal in-plane ductility and cyclic strength shall be used subsequently for the axial stiffness and strength test.

†Flexible ties require 6 samples each to be tested in both the displaced and the undisplaced positions.

(Amendment No. 2, May 1993)

3.C9.2
Delete the first line and **substitute:**

"The stiffness of any wall tie, Y, in kilonewtons per ...".

(Amendment No. 2, May 1993)

3.C10.1
In line 9, **delete** "n>6" and **substitute** "n≥ 6.

(Amendment No. 2, May 1993)

3.C10.2
In line 10, **delete** "n>6" and **substitute** "n≥ 6".

(Amendment No. 2, May 1993)

3.C11.1
In item (h), **delete** the first line and **substitute** "In the case of flexible veneer ties repeat (d) and (e) ....."

(Amendment No. 2, May 1993)

3.C14
In line 9, **delete** "n>6" and **substitute** "n≥ 6".

(Amendment No. 2, May 1993)

3.C15
Delete items (d) and (e) and **substitute** the following:

"(d) For each type of tie, flexible or stiff –

(i) Horizontal in-plane stiffness and strength (stiff veneer ties only)

(ii) Horizontal in-plane ductility and cyclic strength (stiff veneer ties only)

(iii) Axial stiffness and strength in tension of wall ties

(iv) Axial stiffness and strength in compression of wall ties

(v) Axial ductility and cyclic strength of wall ties

(e) For the lot of each type of tie, flexible or stiff–

(i) Horizontal in-plane characteristic stiffness and strength (stiff veneer ties only)

(ii) Characteristic horizontal in-plane ductility and cyclic strength (stiff veneer ties only)."

(iii) Characteristic axial stiffness and strength in tension of wall ties

(iv) Characteristic axial stiffness and strength in compression of wall ties

(v) Characteristic axial ductility and cyclic strength of wall ties

(Amendment No. 2, May 1993)

NEW ZEALAND STANDARD

NZS 4210:1989

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Code of practice for
MASONRY CONSTRUCTION:
MATERIALS AND WORKMANSHIP

AMENDMENT No. 1

July 1992

EXPLANATORY NOTE – This Amendment applies when this Standard is used as an Acceptable Solution that is referenced in Approved Document B1 Structure – General, to the New Zealand Building Code. The Amendment need not apply when this Standard is used under the Model Building Bylaw system which remains in operation until 31 December 1992.

To ensure receiving advice of the next amendment to NZS 4210:1989 please complete and return the amendment request form.

APPROVAL

Amendment No. 1 was approved in July 1992 by the Standards Council to be an amendment to NZS 4210:1989 pursuant to the provisions of section 10 of the Standards Act 1988.

(Amendment No. 1, July 1992)

1.3.2
Delete the clause.

(Amendment No. 1, July 1992)

C1.3.2
Delete the commentary clause.

(Amendment No. 1, July 1992)

2.1.2.1
In items (a) and (b) (iii), **delete** the words "to the satisfaction of the Engineer".

(Amendment No. 1, July 1992)

2.3.5.1
In line 2 **delete** the words "Unless otherwise approved by the supervisor".

(Amendment No. 1, July 1992)

2.6.3.2
In line 4 **delete** the words "or by other approved methods".

(Amendment No. 1, July 1992)

2.6.5.1
In line 1 **delete** the words "Unless otherwise approved".

(Amendment No. 1, July 1992)

STANDARDS NEW ZEALAND
WELLINGTON TRADE CENTRE, 181-187 VICTORIA STREET
WELLINGTON 1

REQUEST FOR ADVICE OF NEXT AMENDMENT

Please fill in the request for the next amendment to this New Zealand Standard and mail to Standards New Zealand, Private Bag, Wellington.

If this request slip has not been returned SNZ has no record that you wish to be advised of future amendments to this Standard.

To confirm that the next amendment has been requested, enter details of despatch:

REQUEST FOR NEXT AMENDMENT

NZS 4210:1989
Amendment No. 2

If more than one copy is required state quantity here . . . COPIES - please type or print clearly.

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Code of practice for
MASONRY CONSTRUCTION:
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AMENDMENT No. 2

May 1993

EXPLANATORY NOTE - Amendment No. 2 clarifies the testing requirements for wall ties. It does not make changes to the technical content of the Standard.

APPROVAL

Amendment No. 2 was approved on 29 April 1993 by the Standards Council to be an amendment to NZS 4210:1989 pursuant to the provisions of section 10 of the Standards Act 1988.

(Amendment No. 2, May 1993)

3.5.1
Delete the clause and **substitute:**

"The minimum strength, stiffness and ductility of flexible and stiff veneer ties, when axially loaded in accordance with Appendix 3.C, shall not be less than the applicable values given in table 3.5.1 for each particular service classification of duty.

"Stiff veneer ties are required to perform a similar function to flexible ties except that they are required to restrain horizontal differential in-plane movements between the veneer and the structural wall (see 3.5.2)."

(Amendment No. 2, May 1993)

Table 3.5.1
In the headings to the third and fourth columns, **add** the unit "N".

In the heading to the fifth column, **add** the unit "mm".

(Amendment No. 2, May 1993)

Table 3.8.1
Delete the table and **substitute** the table given on page 2 of this amendment.

(Amendment No. 2, May 1993)

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3.C6.2.2
In line 4 of item (e), **delete** "100 mm" and **substitute** "10 mm".

(Amendment No. 2, May 1993)

3.C8.1
Re-number the clause "**3.C8.2**".

In item (e), **add** at the beginning of the sentence: "For flexible ties,"

(Amendment No. 2, May 1993)

C3.C8.1
Re-number the commentary clause "**C3.C8.2**".

(Amendment No. 2, May 1993)

3.C8.2
Re-number the clause "**3.C8.1**".

(Amendment No. 2, May 1993)

C3.C8.2
Re-number the commentary clause "**C3.C8.1**".

Delete the first line and **substitute**:

"Stiff ties should have a horizontal in-plane stiffness and an axial ...".

(Amendment No. 2, May 1993)

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Axial stiffness and strength in tension	Clauses 3.5.1 3.5.3	Appendix 3.C	6	12†
Axial stiffness and strength in compression	Clauses 3.5.1 3.5.3	Appendix 3.C	6	12†
Axial ductility and cyclic strength	Clauses 3.5.1 3.5.3	Appendix 3.C	6	12†
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† Flexible ties require 6 samples each to be tested in both the displaced and the undisplaced positions.

(Amendment No. 2, May 1993)

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Delete the first line and **substitute:**

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(Amendment No. 2, May 1993)

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In line 9, **delete** "n>6" and **substitute** "n≥ 6.

(Amendment No. 2, May 1993)

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(Amendment No. 2, May 1993)

3.C11.1
In item (h), **delete** the first line and **substitute** "In the case of flexible veneer ties repeat (d) and (e) ....."

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(Amendment No. 2, May 1993)

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(e) For the lot of each type of tie, flexible or stiff–

(i) Horizontal in-plane characteristic stiffness and strength (stiff veneer ties only)

(ii) Characteristic horizontal in-plane ductility and cyclic strength (stiff veneer ties only)."

(iii) Characteristic axial stiffness and strength in tension of wall ties

(iv) Characteristic axial stiffness and strength in compression of wall ties

(v) Characteristic axial ductility and cyclic strength of wall ties

(Amendment No. 2, May 1993)