NZS 3112.2:1986
New Zealand Standard

METHODS OF TEST FOR CONCRETE

Part 2
TESTS RELATING TO THE DETERMINATION OF STRENGTH OF CONCRETE

Amendment no1 incorporated
Amendment No2
Appended

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COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the Concrete Industry Sectional Committee (31/-) for the Standards Council, established under the Standards Act 1965.

The Concrete Testing Committee (2/2/5) was responsible for the preparation of the Standard and consisted of representatives of the following organizations:

Aggregates Association of New Zealand
Department of Scientific and Industrial Research
Ministry of Works and Development
New Zealand Portland Cement Association
New Zealand Ready Mixed Concrete Association

Amendment No. 1 was prepared under the direction of the Building and Civil Engineering Divisional Committee (30/-) for the Standards Council, established under the Standards Act 1965.

The Concrete Testing Committee (31/18) was responsible for the preparation of the Amendment and consisted of representatives of the following organizations:

Aggregates Association of New Zealand
Department of Scientific and Industrial Research
Ministry of Works and Development
New Zealand Concrete Research Association
New Zealand Ready Mixed Concrete Association

STANDARDS ASSOCIATION OF NEW ZEALAND
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(Private Bag, Wellington), Telex: NZ 3850, Telephone: (04)842-108.

AMENDMENTS

No	*Date of issue*	*Description*	*Entered by, and date*
1	May 1986	Major changes in moulding and curing of test cylinders, strength tests and statistical analyses have been made as the result of comments received from users	Incorporated in this edition.

CONTENTS PAGE

REQUEST FOR NEXT AMENDMENT

If this address label has not been returned SANZ has no record that you wish to receive future amendments to this standard.

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NOTES

RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS		Clause reference herein
NZS 1021:1965	Methods for the load verification of testing machines.	6.2
NZS 3109:1980	Concrete construction	Foreword
NZS 3121:1980	Water and aggregate for concrete	2.1

FOREWORD TO NZS 3112 : Part 2 : 1980

NZS 3112: Part 2 is one of four separate volumes covering methods of test for concrete.

Part 2 is a revision of Secton B of NZS 3112:1974. Sections A and C of NZS 3112:1974 are revised in Parts 1 and 3 respectively of the udpated standard.

Part 2 contains methods of test relating to the strength of concrete. A number of errors and omissions have been rectified and minor changes made to clarify the test procedures.

The method for determining the compressive strengths of cores has been considerably modified. The procedures for obtaining and preparing core samples have been extended and emphasis is placed on recording information required to evaluate the result of the compression test.

The statistical analysis of strength test results has been simplified and the section dealing with compliance with specified requirements has been deleted. Compliance is described in NZS 3109.

FOREWORD TO 1986 EDITION

NZS 3112 : Part 2 : 1986 is a new edition of NZS 3112 : Part 2 : 1980 incorporating Amendment No. 1 and is published concurrently with new editions of Parts 1, 3 and 4 of the Standard.

The test numbers remain the same as in the 1980 edition and no tests have been added or deleted.

Changes resulting from comments received from users of the Standard have been made. Major changes include:

Moulding of test cylinders. Dimensions of moulds are no longer given, but emphasis is now placed on dimensions and tolerances of the test cylinders.

Curing of test cylinders. The permissible range of initial curing temperatures for cylinders made in the field has been increased to 10 °C to 26 °C.

Strength tests. The requirements for the testing machine have been modified to ensure that, where the machine is used in the lower fifth of its scale reading, the accuracy of such readings will be similar to that achieved within the remainder of the scale. The machine operating procedure as a test nears its conclusion has been modified.

Statistical analysis. The formula for "Best estimate" overall production standard deviation has been expressed in a form that obviates an anomaly that has previously occurred when the mean strength, rounded to the nearest 0.5 MPa, has been used and negative values of a d^2 obtained.

NOTES

NEW ZEALAND STANDARD

METHODS OF TEST FOR CONCRETE

Part 2
Tests relating to the determination of strength of concrete

1
SCOPE AND INTERPRETATION

1.1
Scope

1.1.1
This Standard establishes requirements for methods of test relating to the determination of strength of concrete.

1.2
Interpretation

1.2.1
In this Standard, the imperative mood or the word "shall" indicates an operation or a requirement that is to be adopted in order to comply with the Standard. The world "should" indicates a recommended practice.

1.2.2
Cross references to other clauses or to clause subdivisions within this Standard quote the number only, for example: "Capping materials shall comply with the requirements of 4.4.1 or 4.4.2."

1.3
References

1.3.1
The full titles of reference documents cited in this Standard are given in the list of Related Documents immediately preceding the Foreword.

2 DEFINITIONS

2.1
For the purposes of this Standard the following definitions shall apply:

ACCURACY. Agreement of the measurements with the true value of the magnitude of the quantity measured.

AGGREGATE. An assemblage of naturally occurring, processed or manufactured inorganic particles, used for making concrete.

CONCRETE. A mixture consisting predominantly of cement, water and aggregate.

CURING. The process by which the moisture content and temperature of concrete are appropriately maintained to facilitate cement hydration.

NOMINAL MAXIMUM AGGREGATE SIZE. The sieve size, in the sieve series listed in table 1 of NZS 3121 next coarser than the size above which more than 15 % of the total coarse aggregate is retained.

SEGREGATION. Localized concentrations of the respective components of a mixture, resulting in non-uniform distribution in the mixture.

3 MOULDING AND CURING CONCRETE TEST CYLINDERS

3.1 Scope

3.1.1
This method specifies the procedures for moulding and curing concrete cylinders for compressive and tensile strength tests. The procedures cover compaction by hand and by vibration, and curing under both laboratory and field conditions. In the latter case a distinction is made between the curing methods for specimens required for quality control and acceptance tests, and those for field control tests.

3.2 Specimen size

3.2.1
The concrete test specimens shall be cylindrical with a nominal length equal to twice the nominal diameter. The diameter of the cylinder shall be not less than four times the nominal maximum aggregate size in the concrete and in no case shall its nominal diameter be less than 100 mm.

3.3 Apparatus

3.3.1

The following apparatus is required:

(a) *Moulds*, made of heavy gauge seamless metal tubing or of metal castings capable of being opened longitudinally to facilitate removal of the specimen without damage and fitted with efficient closing devices that will ensure accurate alignment and tight closure of the joints in service. Rigid machined metal base and top plates to be provided. The least lateral dimension of the top plates to be not less than the external diameter of the mould.

Effective means to be provided for tightly fastening the base plates and, where required, the top plates to the moulds without distortion of the plates.

When assembled, the moulds to be right circular cylinders and suitable for the production of concrete specimens complying with the requirements of 6.3. Before use, coat the moulds thinly with a release agent and ensure they are substantially watertight during use as judged by their ability to hold water poured into them.

(b) *Tamping rod.* A round straight steel rod approximately 16 mm in diameter and approximately 600 mm long, with one end rounded to a hemispherical tip.

3.4 Procedure

3.4.1

Compact the concrete in the moulds using one of the following procedures in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance:

(a) *Hand compaction.* Set the moulds on a rigid horizontal surface and place the concrete in the mould in three layers of approximately equal volume. In placing each scoopful of concrete move the scoop around the top edge of the mould to ensure a symmetrical distribution of the concrete within the mould. Rod each layer with at least 25 strokes of the tamping rod, distributing the srokes uniformly over the cross-section. Rod the first layer throughout its depth. Rod subsequent layers so that the strokes penetrate into, but not through, the immediate underlying layer. Tap the sides of the mould to close any voids left by the rod after each layer has been compacted. Ensure that compaction of the last layer leaves the mould overfull.

(b) *Compaction by vibrating table.* Attach the moulds rigidly to the vibrating table and fill with concrete in three approximately equal layers. Apply vibration to each layer for a period sufficient to ensure complete compaction without significant segregation. Usually sufficient vibration has been applied as soon as the surface has become relatively smooth. During vibration of the last layer make small additions of concrete, as required, to keep each mould overfull.

3.4.2
Immediately after compaction, by rodding or vibration, use one of the following procedures:

(a) *Hardened vertically.* Strike off the surplus concrete with a trowel to produce a flat even surface that is level with the edge of the mould and that has no depressions or projections larger than 1 mm.

(b) *Hardened horizontally.* Work the top plates down on to the concrete with a sliding and rotary motion until they fit snugly against the top of the moulds. Then securely fasten the top plates to the moulds without distorting the plates. Immediately lay the moulds on their sides with their axes horizontal and maintain in this position until the specimens are removed from the moulds.

3.5 Curing

3.5.1
Specimens made in the laboratory

Immediately after moulding the specimens place the moulds in an enclosure maintained at 21 ±2 °C and allow to remain undisturbed until the specimens are removed from the moulds. For vertically hardened specimens, cover the moulds with the top plates within 1 h of casting. Remove the specimens from the moulds not earlier than 16 h nor later than 50 h after moulding and store at a temperature of 21 ±2 °C under moist conditions such that free water is maintained on the surface of the specimens at all times.

3.5.2
Specimens made in the field for 28 day control and acceptance tests

3.5.2.1
Immediately after moulding the specimens, store the moulds in a suitable enclosure such that the temperature in the immediate vicinity of the specimens remains within the range 10 to 26 °C. For vertically hardened specimens, cover the moulds with the top plates within 1 h of casting. Leave undisturbed for at least 16 h. After this initial curing the specimens shall be either:

(a) Forwarded to the testing laboratory in their moulds so that they reach the laboratory not more than 80 h after moulding, or
(b) Removed from their moulds and immediately forwarded to the testing laboratory, or
(c) Removed from their moulds and stored on site under moist conditions such that free water is maintained on the surface of the specimens at all times and the temperature remains within the range 10 to 26 °C until forwarded to the testing laboratory so that they reach the laboratory not more than 80 h after moulding, or
(d) Removed from their moulds not later than 80 h after moulding and stored on site at 21 ±2°C under moist conditions such that free water is maintained on the surface of the specimens at all times until they are forwarded to the testing laboratory.

3.5.2.2
During transit to the testing laboratory, pack the specimens in damp sand or sawdust, or use other suitable means to prevent loss of moisture from them. Place the specimens in a suitable container to protect them from extremes of temperature and to ensure that they are not damaged in any way. Transit time from the site to the testing laboratory should be minimized but in no case shall it be greater than 64 h.

3.5.2.3
On receipt at the laboratory, store all specimens at 21 ±2 °C under moist conditions such that free water is maintained on the surface of the specimens at all times.

3.5.3
Specimens for field control tests

3.5.3.1
Curing at ambient temperatures

Immediately after moulding the specimens, store the moulds in a suitable enclosure such that the temperature in the immediate vicinity of the specimens remains within the range 10 to 26°C. For vertically hardened specimens, cover the moulds with the top plates within 1 h of casting. Leave undisturbed until the specimens are removed from the moulds. Remove specimens from the moulds not earlier than 16 h nor later than 80 h after moulding. Immediately after removal from the moulds, seal the specimens in plastic bags, and place these close to that point in the structure where the concrete from which the sample was taken has been placed. Protect the specimens from damage in any way and from direct sunlight. Transfer the specimens to the testing laboratory not more than 24 h prior to testing, protecting them from loss or gain of moisture, from extremes of temperature and from damage.

3.5.3.2
Accelerated curing

Where the specimens represent concrete that is to be subjected to accelerated curing, for example, low-pressure steam curing, place the moulded specimens in such a location that they are subjected to conditions of temperature and humidity not varying by more than ± 5 °C and ± 10 % relative humidity from the conditions to which the concrete they represent is subjected.

Immediately after curing transfer the specimens to the testing laboratory, protecting them from loss or gain of moisture, from extremes of temperature and from damage, until they are tested.

3.5.3.3
Determination of stressing time for prestressed concrete

Immediately after moulding the specimens store the moulds in such a location that they are subjected to conditions of temperature and humidity not varying by more than ± 5 °C and ± 10% relative humidity from the conditions to which the concrete they represent is subjected.
At an appropriate time transfer the specimens to the testing laboratory, protecting them from loss or gain of moisture, extremes of temperature and from damage until they are tested.

4 CAPPING CYLINDRICAL CONCRETE SPECIMENS

4.1 Scope

4.1.1
This method specifies procedures for capping hardened concrete cylinders and drilled cores with high-strength gypsum plasters or sulphur-based materials.

4.2 Requirements

4.2.1
Capping materials shall comply with the requirements of 4.4.1 or 4.4.2. A capped surface shall be plane within a tolerance of 0.05 mm and shall not depart from perpendicularity to the axis by more than 0.5°.

4.3 Apparatus

4.3.1
The following equipment is required:

(a) *Capping plates.* Either glass plates at least 6 mm thick or ground metal plates to form high-strength gypsum plaster caps. Similar metal plates to form caps of sulphur compound. In all cases the plates to be at least 20 mm greater in diameter than the concrete cylinder, and the surface against which the cap is formed is not to depart from a plane by more than 0.05 mm. If a recessed metal plate is used the thickness of metal beneath the recess to be at least 12 mm and the recess to be not deeper than 12 mm.

(b) *Alignment jigs.* Suitable alignment jigs for use with capping plates to ensure that caps do not depart from perpendicularity to the axis of the specimen by more than 0.5°.

(c) *Melting pots for sulphur-based materials.* Pots used for melting sulphur-based materials to be electrically heated and fitted with automatic temperature controls. They should be lined with a material which is non-reactive with molten sulphur.

4.4 Capping materials

4.4.1
High-strength gypsum plaster

Neat high-strength gypsum plaster when tested in three nominally 100 mm by 50 mm cylindrical specimens shall develop a minimum average strength of at least 20 MPa when subjected to the same environment for the same length of time as capped specimens. Mixtures for test shall be mixed by the same method and with the same water content as used in preparing the capping material. The cylinders are to be moulded in two approximately equal layers, each layer being rodded with a spatula to remove air bubbles. The cylinder moulds are to be overfilled and the surplus removed by working it off with a glass or steel plate. The surface so formed must be within 0.05 mm of plane.

NOTE –
(1) Use of minimum quantity of mixing water and vigorous mixing will assist the development of sufficient strength at an age of 1 to 2 h.

(2) Low strength moulding plasters, commonly called plaster of paris, or mixtures of plaster and portland cement, are not suitable for capping.

4.4.2
Sulphur-based materials

These materials are composed of sulphur with or without inert fillers. To be suitable for capping the materials shall be capable of developing a strength of at least 35 MPa in 2 h when specimens are tested as nominally 25 mm by 25 mm cylinders. The end surfaces of the cylinders must be plane within 0.05 mm.

NOTE – Surplus sulphur based material may be reused, but the melting pot should be frequently emptied and recharged with fresh material. Loss of strength and fluidity occur if the sulphur mixture is contaminated with oil or debris or if sulphur is lost by volatilization.

4.5 Capping procedures

4.5.1
Prepare caps in the following manner:

(a) Clean the ends of the specimen to remove deposits of any material that might interfere with the bond of the cap. Ensure that the ends of the specimens to be capped with sulphur mixture are sufficiently dry at the time of capping to preclude the formation of steam or foam pockets in or under the caps. Pre-drying of the ends with compressed air is generally satisfactory.

(b) Make caps as thin as is practicable, and never more than 4 mm thick. Coat the capping plates with a thin layer of mineral oil to facilitate release.

(c) Form caps of high strength gypsum plaster by placing sufficient paste on the capping plate, and pressing the cylinder end into it, using the alignment jig to locate the cylinder.

(d) Form sulphur-based material caps by pouring sufficient material, melted at 130 to 145 °C, into the prewarmed capping plate, and sliding the cylinder gently down the alignment jig into it.

(e) Release capped cylinders from flat capping plates with a sliding motion. With recessed plates, tap the plate gently to effect release. If, on inspection, a cap is found to be defective due to cracking, loss of bond, or non-compliance with 4.2, remove it and recap the cylinder.

NOTE — Concrete test specimens capped with suitable sulphur-based materials may be subjected to determination of compressive strength immediately following the process of capping.

(f) Do not immerse specimens with gypsum plaster caps in water but make provision to prevent loss of moisture from the specimens before they are tested. If the specimens are stored in a moist room, protect the plaster caps against water dripping on their surfaces.

5 MOULDING AND CURING CONCRETE BEAMS FOR FLEXURE TESTS

5.1 Scope

5.1.1
This method specifies procedures for moulding and curing concrete beams for flexural strength tests. The procedures cover compaction by hand and by vibration, and curing under both laboratory and field conditions. In the latter case a distinction is made between the curing methods for specimens required for quality control and acceptance tests and those for field control tests.

5.2 Size of specimens

5.2.1
The concrete beams shall be of square cross-section with the thickness not less than four times the nominal maximum size aggregate in the concrete but in no case less than 100 mm. The minimum length of the specimen shall be three times the thickness plus 100 mm.

5.3 Apparatus

The following apparatus is required:

(a) *Moulds.* Watertight, non-absorbent moulds rigid enough to prevent spreading or warping. The inside surfaces of the mould to be plane with a permissible variation of 0.05 mm. When assembled with the base horizontal, the angles between the interior vertical surfaces and the interior bottom surface to be 90 ±0.5°. The interior depth and width of the mould is not to deviate from the nominal dimension by more than 1.0 %. The assembled mould to be lightly coated with mould oil.

(b) *Tamping rod.* A round straight steel rod approximately 16 mm diameter and approximately 600 mm long with one end rounded to a hemispherical tip.

5.4 Procedure

5.4.1
Compact the concrete in the moulds using one of the following procedures in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance.

(a) *Hand compaction*
Place the concrete in the mould in two or more approximately equal layers not more than 85 mm deep. Spread the concrete evenly along the length of the mould. Rod each layer with at least 50 strokes of the tamping rod. Distribute the bottom layer throughout its depth. Rod the upper layers so that the strokes penetrate into, but not through, the immediate underlying layer. Tap the sides of the moulds after each layer has been compacted to close any voids left by the rod. Ensure that compaction of the last layer leaves the mould overfull.

(b) *Compaction by vibrating table*
Where compaction is achieved by vibration, attach the moulds rigidly to the vibrating table and fill with concrete in two approximately equal layers. Apply vibration to each layer for a period sufficient to ensure complete compaction without significant segregation. Usually sufficient vibration has been applied as soon as the surface has become relatively smooth. During vibration of the last layer make small additions of concrete, as required, to keep each mould overfull.

5.4.2
Immediately after compaction by rodding or vibration, finish the surface of the concrete level with the top of the mould by screeding and trowelling. Then cover the moulds to reduce evaporation and to prevent exposure of the concrete surface to dripping or running water.

5.5 Curing

5.5.1
Specimens made in the laboratory
Immediately after moulding the specimens, place the moulds in an enclosure maintained at 21 ±2 °C and leave undisturbed until specimens are removed from the moulds. Remove the specimens from the moulds not earlier than 16 h nor later than 50 h after moulding and store at a temperature of 21 ±2 °C under moist conditions such that free water is maintained on the surface of the specimens at all times.

5.5.2
Specimens made in the field for quality control and acceptance tests
Immediately after moulding the specimens, store the moulds in a suitable enclosure such that the temperature remains within the range of 10 to 26 °C and leave undisturbed for at least 16 h. After this initial curing the specimens shall be either:

(a) Forwarded to the testing laboratory in their moulds so that they reach the laboratory not more than 80 h after moulding; or
(b) Removed from their moulds and immediately forwarded to the testing laboratory, or
(c) Removed from their moulds and stored on

site under moist conditions such that free water is maintained on the surface of the specimens at all times and the temperature remains within the range 10-26 °C until forwarded to the testing laboratory so that they reach the laboratory not more than 80 h after moulding, or

(d) Removed from their moulds not later than 80 h after moulding and stored on site at 21 ±2 °C under moist conditions such that free water is maintained on the surface of the specimens at all times until they are forwarded to the testing laboratory.

5.5.2.2
During transit to the testing laboratory, pack the specimens in damp sand, or sawdust or use other suitable means to prevent loss of moisture from them. Place the specimens in a suitable container to protect them from extremes of temperature and to ensure that they are not damaged in any way. Transit time from the site to the testing laboratory should be minimized but in no case shall it be greater than 64 h.

5.5.2.3
On receipt at the laboratory store all specimens at 21 ±2 °C under moist conditions such that free water is maintained on the surface of the specimens at all times.

5.5.3
Specimens for field control tests

5.5.3.1
Curing at ambient temperatures
Immediately after moulding the specimens, store the moulds in a suitable enclosure such that that temperature remains within the range 10-26 °C and leave undistrubed until specimens are removed from the moulds. Remove the specimens from the moulds not earlier than 16 h nor later than 80 h after moulding. Immediately after removal from the moulds, seal the specimens in plastic bags, and place these close to that point in the structure where the concrete from which the sample was taken has been placed. Protect the specimens from damage in any way and from direct sunlight. Transfer the specimens to the testing laboratory not more than 24 h prior to testing, protecting them from loss or gain of moisture, from extremes of temperature and from damage.

5.5.3.2

Accelerated curing
Where the specimens represent concrete that is to be subjected to accelerated curing, for example, low-pressure steam curing, place the moulded specimens in such a location that they are subjected to conditions of temperature and humidity not varying by more than ±5 °C and ±10 % relative humidity from the conditions to which the concrete they represent is subjected. Immediately after curing transfer the specimens to the testing laboratory, protecting them from loss or gain of moisture, from extremes of temperature and from damage, until they are tested.

6 DETERMINATION OF COMPRESSIVE STRENGTH OF MOULDED CONCRETE CYLINDERS

6.1 Scope

6.1.1
This method specifies the procedure for determining the compressive strength of moulded concrete cylinders moulded in accordance with section 3.

6.2 Compression testing machine

6.2.1
The machine shall comply as regards accuracy with the requirements of Grade B of NZS 1021, except where specific values of load lying below 20 % of the scale range are to be ascertained, locally relevant scale markings shall have a certified accuracy to within ±2 % of the scale readings in question. It shall be equipped with upper and lower steel bearing platens, the faces of which, with the exception of inscribed circles and the like, shall not depart from a plane by more than 0.025 mm at any point within the area of contact with the test specimen.

The bearing platens shall not deform irreversibly or wear excessively in normal use. It is recommended that the faces of the platens should have a surface hardness of not less than Rockwell hardness C55. The upper platen shall be spherically seated, the centre of the sphere coinciding with the central point of the platen. The spherical seating arrangement shall be such as to allow for free rotation of the bearing surface and tilting through small angles in any direction during the initial setting up of a test specimen.

6.2.2
The spherical surfaces of the ball seating may be coated thinly with light mineral oil to prevent corrosion but shall not be lubricated in such a way as to enable movement to occur under load.

NOTE – Lubricants designed to maintain a continuous film under high bearing pressures should not be used in ball seatings of testing machines. The intention is that the seating should enable the platen to accommodate itself initially to the shape of the test specimen but should thereafter be restrained from moving.

6.2.3
Both bearing faces shall be at least as large and preferably slightly larger than the surface of the concrete cylinder being tested. If the diameter of the lower bearing face or of an inscribed centering circle on the lower platen exceeds the diameter of the specimen by 12 mm or more, some positive means shall be employed to ensure accurate centering. Such lines shall not be taken into account when assessing planeness of the platens.

6.3 Test specimens

6.3.1
Test specimens cured in accordance with any one of the procedures laid down in 3.5.1. and 3.5.2 as soon as is practicable after removal from water or from the curing room. It is essential that such specimens be kept moist until tested.

6.3.2
Protect specimens cured in any other way from moisture loss or gain until tested.

6.3.3
Check the ends of each specimen for perependicularity to the generators of the cylindrical surface and for planeness. Any end whch deviates from perpendicularity by more than 0.5° (approximately 1 mm in 100 mm), or is convex or concave by more than 0.05 mm, or contains projections above the plane surface greater than 0.05 mm is unsatisfactory. Cap or grind such ends to conform to these limits. If a specimen end contains isolated depressions such as air voids which have any dimension in the plane of the surface greater than 10 mm, cap or grind it to provide a plane surface within 0.05 mm and acceptable depression dimensions.

Grind any specimen end requiring treatment as above if capping would result in a cap more than 4 mm thick over more than about one quarter of the total end surface area.

6.3.4
Where capping is required, have the procedure specified in section 4.

6.3.5
Check the edges of the specimen and note any defects.

6.3.6
Check the cross-section of the specimens. Any 2 diameters measured at approximately right angles to each other at about mid-height of the specimen shall not differ from each other by more than 2 % of their average. Record the 2 measured diameters to the nearest 0.1 mm.

6.3.7
When ready for test, measure the height of the specimen and record to the nearest 0.5 mm. The height to diameter ratio of the specimen, whether capped, uncapped, or ground, shall not be less than 1.90 and not greater than 2.10.

6.4
Test procedure

6.4.1

Determine the compressive strength in the following manner:

(a) Wipe the bearing faces of the platens and the ends of the test specimen.

(b) Locate the test specimen centrally on the lower platen and prepare the test machine for specimen loading.

NOTE — Aspects of necessary final preparation will vary, depending on the operating characteristics of the test machine. Where appropriate, load indicators should be set to zero, "tell-tales" returned, etc. In bringing the top platen to bear on the specimen, the procedure adopted should attempt to ensure that a uniform seating condition is attained.

(c) Begin the process of load application, taking care to avoid shock loading of the specimen and implementing whatever machine-control adjustments as may be necessary to secure a constant previously nominated rate of load increase within the range 10 to 20 MPa/min.

NOTE — In order to allow for any slight temporary lapses in control, it is recommended that a loading rate of 15 MPa/min be nominated as the "target" pace.

(d) Maintain the nominated rate of load increase until such time as this would require a rapid increase in the applied deformation rate. Cease making effective adjustments to the applied deformation rate at this stage and allow the test to proceed until the associated maximum load condition is surpassed.

NOTE — For most manually operated hydraulic test machines, progressive valve adjustments controlling ram displacements and applied deformation rates should cease whenever it becomes apparent that the initial (nominated) loading rate can no longer be sustained via gradual slight alterations to the valve settings. During the subsequent "hands-off" period, the load indicator will lag behind the pacing device.

(e) Record the maximum load carried by the specimen during the test.

(f) Calculate the compressive strength of the specimen by dividing the maximum load by the cross-sectional area based on the diameters determined via 6.3.6.

(g) Report the compressive strength of the specimen to the nearest 0.5 MPa together with defects noted under 6.3.5.

7
DETERMINATION OF FLEXURAL TENSILE STRENGTH OF CONCRETE

7.1
Scope

7.1.1
This method specifies the procedure for determining the flexural tensile strength of concrete beams moulded in accordance with section 5.

7.2
Apparatus

7.2.1
Suitable apparatus is shown in fig. 1. The apparatus ensures that forces on the beam are applied vertically without eccentricity.

7.2.2
Essential features of this apparatus are as follows:

(a) The load-applying and support blocks shall extend across the full width of the specimen. The bearing edges of these blocks shall have a Rockwell hardness of not less than C60 and shall not depart from a straight edge by more than 0.025 mm at any point.
(b) The distances between supports and points of load application shall remain constant.
(c) The load shall be applied at right angles to the loaded surface of the beam and in such a manner that eccentricity of loading is prevented.
(d) At all times during the test the direction of the reactions shall be parallel to the direction of the applied load.
(e) The testing machine shall be of a suitable capacity for the test and capable of applying the load at the rate specified in 7.4.1 (b). The machine shall comply as regards accuracy with the requirements of Grade B of NZS 1021, except where specific values of load lying below 20 % of the scale range are to be ascertained, locally relevant scale markings shall have a certified accuracy to within ±2 % of the scale readings in question.

7.3
Test specimen

7.3.1
Test specimens cured in accordance with any one of the procedures laid down in 5.5.1 and 5.5.2 as soon as is practicable after removal from the curing room. It is essential that such specimens be kept moist until tested.

7.3.2
Protect specimens cured in any other way from moisture loss or gain until tested.

7.4
Test procedure

7.4.1
Use the following procedure for testing the concrete specimens:

(a) Test the specimen over a span at least three times and not more than four times its depth as tested.
(b) Turn the test specimen on its side with respect to its position as moulded and centre on the bearing blocks. Bring the load-applying blocks into contact with the upper surface at the third points between the supports. Apply the load continuously and without shock at a constant rate of increase in extreme fibre stress within the range 1 to 2 MPa/min until the specimen fails. Record the maximum applied load.
(c) Measure to the nearest 1 mm the average width and the average depth of the specimen at the section of failure.
(d) Determine the distance between the line of fracture and the nearest support measured along the centre line of the bottom surface of the beam to the nearest millimetre.

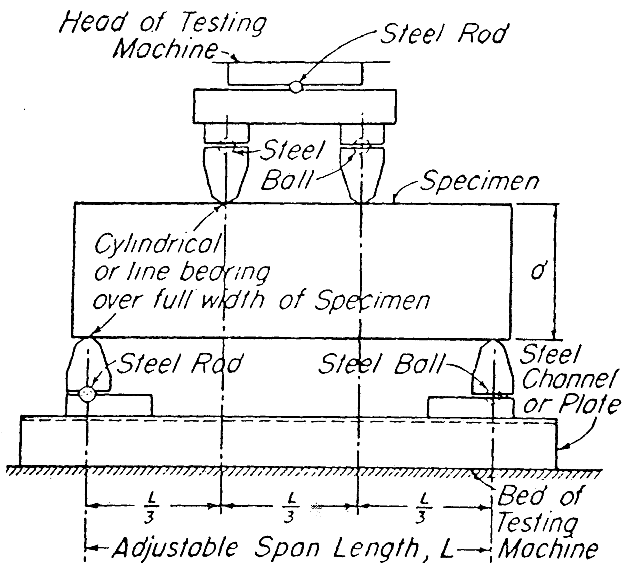

Fig. 1 APPARATUS FOR FLEXURE TEST BY THIRD POINT LOADING METHOD

7.5
Calculations and report

7.5.1
Where the fracture occurs within the middle third of the span length, calculate flexural tensile strength as follows:

$$T_f = \frac{PL}{bd^2}$$

where T_f= flexural tensile strength in megapascals;
P= maximum applied load in newtons
L= span length in millimetres
b= average width of specimen in millimetres; and
d= average depth of specimen in millimetres.

7.5.2
Where the fracture occurs outside the middle third of the span length by not more than 5 % of the span length, calculate the flexural tensile strength as follows:

$$T_f = \frac{3Pa}{bd^2}$$

where a = distance between line of fracture and the nearest support measured along the centre line of the bottom surface of the beam, in millimetres to the nearest millimetre.

7.5.3
Where the fracture occurs outside the middle third of the span length by more than 5 % of the span length, discard the results of the test.

7.5.4
Report the flexural tensile strength to the nearest 0.2 MPa.

8 DETERMINATION OF SPLITTING TENSILE STRENGTH OF MOULDED CONCRETE CYLINDERS

8.1 Scope

8.1.1

This method specifies the procedure for determining the splitting tensile strength of concrete cylinders moulded in accordance with section 3.

8.2 Apparatus

8.2.1

The following apparatus is required:

(a) *Testing machine.* The testing machine shall be of a suitable capacity for the test and capable of applying the load at the rate specified in 8.4.1(f). The machine shall comply as regards accuracy with the requirements of Grade B of NZS 1021, except where specific values of load lying below 20 % of the scale range are to be ascertained, locally relevant scale markings shall have a certified accuracy to within ±2 % of the scale readings in question. It shall be equipped with upper and lower steel bearing platens, the face of which, with the exception of inscribed circles and the like, shall not depart from a plane by more than 0.025 mm at any point within the area of contact with the test specimen. The bearing platens shall not deform irreversibly or wear excessively in normal use. It is recommended that the face of the platens should have a surface hardness not less than Rockwell hardness C55. The upper platen shall be spherically seated, the centre of the sphere coinciding with the central point of the face of the platen. The spherically seating arrangement shall be such as to allow for free rotation of the bearing surface and tilting through small angles in any direction during the initial setting up of a test specimen.

(i) The spherical surfaces of the ball seating may be coated thinly with light mineral oil to prevent corrosion but shall not be lubricated in such a way as to enable movement to occur under load.

NOTE — Lubricants designed to maintain a continuous film under high bearing pressures should not be used in ball seatings of testing machines. The intention is that the seating should enable the platen to accommodae itself initially to the shape of the test specimen but should thereafter be restrained from moving.

(ii) If the diameter of the bearing faces of the platens is less than the length of the specimen to be tested, it is necessary to insert supplementary steel bearing plates to distribute the load over the full length of the specimen. The plates shall have a width of at least 50 mm and a thickness of at least 25 mm. Their bearing surfaces shall be plane to within 0.025 mm.

(b) *Bearing strips.* Bearing strips shall be of hardboard of nominal 3 mm thickness, slightly longer than the specimen, and not less than 12 mm wide. They shall be inserted between the specimen and the bearing faces of the platens. Bearing strips shall not be re-used.

(c) *Locating jig.* A typical jig for locating the specimen and bearing strips in the testing machine is shown in fig.2.

8.3 Test specimens

8.3.1

Conduct splitting tensile tests on specimens cured in accordance with 3.5.1 or 3.5.2 as soon as is practicable after removal from the curing room. It is essential that such specimens be kept moist until tested.

8.3.2

Protect specimens cured in any other way from moisture loss or gain until tested.

8.4 Test procedure

8.4.1

Use the following procedure for testing the specimens:

(a) Determine and record the diameter of the specimen to the nearest 0.5 mm by averaging two diameters in the plane of test measured at opposite ends of the cylinder. Measure the length to the nearest 1 mm.

(b) Place the specimen in the locating jig with bearing strips above and below.

(c) Centre the locating jig in the testing machine.

(d) Check that the load indicator is at zero.

(e) Carefully bring the upper platen to bear on the specimen (through the hardboard strip) and rotate the movable portion gently to ensure uniform seating, then release the jig.

(f) Apply the load continuously and without shock at a constant rate so that the tensile stress increases at a rate between 1 and 2 MPa/min until the specimen fails.

(g) Record the load at failure.

8.5 Calculation

8.5.1
Calculate the splitting tensile strength of the specimens as follows:

$$T_s = \frac{2P}{\pi d \ell}$$

where T_s = *splitting tensile strength, in megapascals;*
P = *maximum load in newtons;*
d = diameter in millimetres; and
ℓ = length in millimetres.

8.5.2
Report the splitting tensile strength of the specimen to the nearest 0.2 MPa.

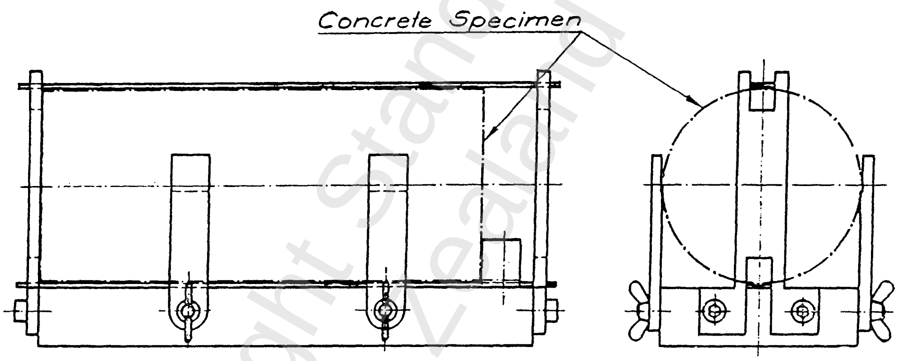

Fig. 2 JIG FOR HOLDING SPLITTING TENSILE STRENGTH SPECIMEN

9 DETERMINATION OF STRENGTH IN COMPRESSION OF DRILLED CONCRETE CORES

9.1 Scope

9.1.1
This method specifies the procedures for obtaining, preparing and testing cylindrical cores from hardened concrete for the determination of their strength in compression.

9.2 Obtaining test cores

9.2.1
Take cores as follows:

(a) Concrete should preferably be at least 28 days old before test cores are cut.
(b) Cut test cores with a diamond core drill.
(c) Ensure that coring is performed in such a way that the concrete in the core is not weakened by mechanical shock or by heating. During the cutting process, apply a cooling fluid, such as water, to the cutting edges.
(d) If possible, obtain cores from positions away from the edges of the section of the concrete being checked. Preferably take cores with the axis perpendicular to the surface of the concrete as cast.
(e) From concrete containing 19 mm nominal maximum aggregate size the preferred dimensions for cores are nominally 100 mm diameter by 200 mm long. In no case shall the diameter be less than four times the nominal maximum size of coarse aggregate. If the maximum aggregate size is unknown the core shall have a diameter of at least 100 mm.
(f) Where possible cut cores with a length to diameter ratio greater than 2
(g) If cores are drilled vertically cut off and discard the top 25 mm of the core where practicable.

9.3 Test core requirements

9.3.1
Ensure that the test cores meet the following requirements:

(a) Surfaces of cores shall be essentially smooth, plane, parallel and free from steps, ridges and grooves. Take care in handling cores to avoid chipping or cracking.
(b) The end surfaces of cores shall be moistened if necessary and examined for cracks prior to conditioning. If any such cracks are found saw off that end of the core so that the sawn-off piece extends at least 15 mm beyond any visible crack.
(c) If the core ends, after cutting, deviate from a plane by more than 0.05 mm, cap or grind them to conform to this limit before testing. In addition, ensure that the planes formed by the cut, capped or ground ends do not depart from perpendicularity to the axis by more than 0.5 °. Follow the procedures of section 4 when capping.
(d) Where necessary shorten cores by sawing or grinding to give a length to diameter ratio as close to 2 as is practicable.

9.4 Test conditions

9.4.1
Test cores in either the wet or the dry condition in accordance with 9.5. The method of conditioning to be adopted shall be specified when the cores are submitted for test and generally are to be tested dry unless the concrete concerned is more than superficially wet.

NOTE – Cores tested in the dry condition will usually indicate a higher strength than would be obtained if the cores were tested after wet conditionings. The relationship between wet and dry strengths will vary depending on a number of factors, such as the adequacy of curing which the concrete has received in situ and the type of cementitious material used.

9.4.2
Wet conditioning

(a) Completely submerge in water at room temperature for 48 h, test cores which are to be tested wet.
(b) Complete preparation of ends of cores, except capping, before the cores are submerged.

9.4.3
Dry conditioning

(a) Store in air at room temperature for 7 days before testing, test cores which are to be tested dry.
(b) Complete preparation of ends of cores, except capping, prior to the commencement of the 7-day period.

9.5 Test procedure

9.5.1
Test the cores as follows:

(a) Prior to testing record the presence and position of any reinforcement. After testing, record any apparent effect of such reinforcement on the fracture of the core under test.
(b) Determine the strength in compression of a core using the apparatus of 6.2 and the test procedure of 6.4.

NOTE – It is recommended that cores be tested to destruction to allow visual examination for defects not apparent prior to testing. Such defects as the presence of foreign inclusions, reinforcement, non-uniform moisture condition and excessive air voids should be recorded.

9.6 Records

9.6.1

Record the following information concerning the compression test:

(1) Identification of core.
(2) Visual description of core.
(3) Dates of coring and testing.
(4) Age of concrete in core at date of test.
(5) Dimensions of core.
(6) Mass of core immediately prior to capping.
(7) Size and position of any reinforcement.
(8) Length/diameter ratio of core.
(9) Type of "conditioning".
(10) Load at failure.
(11) Measured strength in compression calculated to nearest 0.5 MPa.
(12) Type of fracture, if unusual.
(13) Any defects in caps or core found after testing.

9.6.2

Where known, also record the following information concerning the concrete under investigation:

(1) Mix design details.
(2) Placing and compaction methods.
(3) Curing history.
(4) Description of concrete in vicinity of core.

10 STATISTICAL ANALYSIS OF STRENGTH TEST RESULTS

10.1 Scope

10.1.1
This method covers the procedures to be followed and the principles to be observed in the statistical analysis of concrete strength test results.

10.1.2
The procedures described herein are intended to be applied separately to each type of concrete of a particular specified strength. It is assumed that the variation of strength values during the continuing production of a particular type of concrete approximates to a normal frequency distribution.

10.2 Accumulation of test results

10.2.1
Accumulate a series of random strength test results from a sequence of test samples of a particular concrete, each test result being the mean strength for a test set of 2 or more specimens from a single sample of concrete. Except as provided for in 10.3.1, the number of specimens must be the same for each test result. Round off test results to the nearest 0.5 MPa. Record the strength of each specimen comprising a test set, the concrete mix design data, the measured properties of the fresh concrete and any unusual features noted about any specimen during testing.

10.2.2
Terminate the accumulation of strength test results and begin a new collation and analysis only when significant deliberate changes in concrete production occur, for example, changes in materials used or mix proportions.

10.3 Acceptance of data

10.3.1
Retain all individual specimen strength test values in the analysis except in one of the following cases:

(a) In the event of one specimen of the test set showing clearly discernable evidence of faulty moulding, curing or testing, exclude it when determining the test result.
(b) When more than one specimen is manifestly defective as described in (a), discard the test result. Do not discard test values solely by reason of scatter in the test set.

10.3.2
In the event that the within-test coefficient of variation derived from at least 12 consecutive test results exceeds 5 %, review the whole testing procedure critically to reduce the test variation.

10.4 Calculations

10.4.1
Mean strength of a test series

Calculate the mean strength of the test series to the nearest 0.5 MPa as follows:

$$\bar{X} = \frac{1}{n}(X_1 + X_2 + \ldots\ldots + X_n)$$

where $\bar{X}$ = mean strength of the test series; and
$X_1, X_2 \ldots\ldots X_n$ = the individual strength test results of the test series.
n = the number of test results in the test series.

10.4.2
Mean within-test range of a test series

Calculate the range between the highest and lowest strength in each test set and determine the mean within-test range for the test series to the nearest 0.1 MPa as follows:

$$\bar{R} = \frac{1}{n}(R_1 + R_2 + \ldots\ldots + R_n)$$

where $\bar{R}$ = the mean within-test range of the test series.
n = the number of test results in the test series; and
$R_1, R_2, \ldots\ldots R_n$ = the individual test set ranges.

10.4.3
Mean within-test standard deviation of a test series

Calculate the mean within-test standard deviation for the test series of n test sets as follows:

$$s = Z\bar{R}$$

where s = the mean within-test standard deviation of the test series (calculated to the nearest 0.1 MPa);
$\bar{R}$ = the mean within-test range of the test series;
Z = the appropriate coefficient selected from table 1.

10.4.4
Mean within-test coefficient of variation of a test series

Calculate the mean within-test coefficient of variation to the nearest 0.5 % as follows:

$$v = \frac{100s}{\bar{X}}$$

where v = the mean within-test coefficient of variation of the test series
s = the mean within-test standard deviation of the test series
$\bar{X}$ = the mean strength of the test series.

NOTE – Coefficients of variation are occasionally expressed as decimal fractions but generally as percentages.

Table 1
VALUES OF COEFFICIENT Z

Number of specimens in each test set	*Coefficient Z*
2	0.89
3	0.59
4	0.49
5	0.43
6	0.40

10.4.5
"Best estimate" overall production standard deviation

Using the method of squares of deviation from the mean strength, estimate the overall production standard deviation for the concrete under test to the nearest 0.1 MPa as follows:

$$d = \left(\frac{\Sigma X^2 - \frac{1}{n} (\Sigma X)^2}{n - 1} \right)^{1/2}$$

where d = the "best estimate" value of the production deviation
$\Sigma X = X_1 + X_2 + \dots\dots\dots X_n$
$X_1, X_2 \dots X_n$ = individual strength test results of the test series
n = *the number of test results in the test series.*

10.4.6
"Best estimate" overall production coefficient of variation

Calculate the "best estimate" value of the overall production coefficient of variation to the nearest 0.5 % as follows:

$$V = \frac{100d}{\bar{X}}$$

where V = the "best estimate" value of the overall production coefficient of variation
d = the "best estimate" value of the overall production standard deviation; and
$\bar{X}$ = the mean strength of the test series.

NOTES

NOTES

METHODS OF TEST FOR CONCRETE

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Part 2

TESTS RELATING TO THE DETERMINATION OF STRENGTH OF CONCRETE

AMENDMENT No. 1

March 1988

EXPLANATORY NOTE - Amendment No. 1 is issued as a consequence of NZS 1021 having been superseded by NZS 6507 relating to the force verification of materials testing machines.

To ensure receiving the next amendment to NZS 3112:Part 2:1986 please complete and return the amendment request form.

DECLARATION

Amendment No. 1 was declared on 25 March 1988 by the Standards Council to be an amendment to NZS 3112:Part 2:1986 pursuant to the provisions of section 23 of the Standards Act 1965.

(Amendment No. 1, March 1988)

RELATED DOCUMENTS

Delete the reference to NZS 1021 and **substitute:**

"NZS 6507:----	Materials testing machines and force verification equipment	
Part 1:1986	Specification for the grading of the forces applied by materials testing machines	6.2.1, 7.2.2 8.2.1

(Amendment No. 1, March 1988)

DETERMINATION OF COMPRESSIVE STRENGTH OF MOULDED CONCRETE CYLINDERS

In 6.2.1 **delete** the first sentence of the first paragraph and **substitute:**

"The testing machine shall be of a suitable capacity for the test and capable of applying the load at the rate specified in 6.4.1(c). It shall comply as regards accuracy with the requirements of Grade 2.0 of NZS 6507:Part 1."

(Amendment No. 1, March 1988)

7
DETERMINATION OF FLEXURAL TENSILE STRENGTH OF CONCRETE

In 7.2.2(e) **delete** the second sentence and **substitute:**

"The machine shall comply as regards accuracy with the requirements of Grade 2.0 of NZS 6507:Part 1."

(Amendment No. 1, March 1988)

8
DETERMINATION OF SPLITTING TENSILE STRENGTH OF MOULDED CONCRETE CYLINDERS

In 8.2.1(a) **delete** the second sentence and **substitute:**

"The machine shall comply as regards accuracy with the requirements of Grade 2.0 of NZS 6507:Part 1."

(Amendment No. 1, March 1988)

REQUEST FOR NEXT AMENDMENT

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

If this request slip has not been returned SANZ has no record that you wish to be advised of future amendments to this Standard. From 1 October 1986 a pricing system for amendments was introduced.

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

REQUEST FOR NEXT AMENDMENT

NZS 3112:Part 2:1986
Amendment No. 2

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METHODS OF TEST FOR CONCRETE
Part 2
TESTS RELATING TO THE DETERMINATION OF STRENGTH OF CONCRETE

AMENDMENT No. 2

July 2000

REVISED TEXT

EXPLANATORY NOTE

Amendment No. 2 provides for the use of a restrained rubber cap for compression testing of cylinders.

APPROVAL

Amendment No. 2 was approved on 4 July 2000 by the Standards Council to be an amendment to NZS 3112: Part 2:1986.

RELATED DOCUMENTS (page 3)

Add the following:

AUSTRALIAN STANDARD

AS 1523–1981	Elastomeric bearings for use in structures

ISO STANDARD

ISO 7500-1:- - - - Part 1:1999	Metallic materials – Verification of static uniaxial testing machines Tension/compression testing machines – Verification and calibration of the force-measuring system

(Amendment No. 2, July 2000)

3.4.2 (page 7)

Delete existing clause and **substitute** the following:

"**3.4.2**
Immediately after compaction, by rodding or vibration, use one of the following procedures:

(a) *Hardened vertically*. For all concrete strengths, the specimen may be hardened vertically in the following manner. Strike off the surplus concrete with a trowel to produce a flat even surface that is level with the edge of the mould and that has no depressions or projections larger than 1 mm.

(b) *Hardened horizontally*. For concrete strengths less than 50 MPa, the specimen may be hardened horizontally in the following manner. Work the top plates down on to the concrete with a sliding and rotary motion until they fit snugly against the top of the moulds. Then securely fasten the top plates to the moulds without distorting the plates. Immediately lay the moulds on their sides with their axes horizontal and maintain in this position until the specimens are removed from the moulds.

NOTE – The use of a restrained natural rubber capping system in accordance with 4.4.3 reduces the need to consider the use of horizontal hardening for concretes up to 50 MPa compressive strength. Vertical hardening gives a lower within test coefficient of variation ~~at all~~ strength levels."

(Amendment No. 2, July 2000)

3.5 (page 7)

Add non-mandatory note after the heading "Curing:"

"NOTE – The curing limits provided in clause 3.5, if utilized, may result in a scatter of results that is wider than can be attributed to variations in concrete quality. This applies particularly to higher strength concretes. Recommendations for concrete with strengths above 50 MPa that will give more consistent results are as follows:

Clause	Time limit given in clause	Recommended time for better result consistency
3.5.1	16 h 50 h	18 h 36 h
3.5.2.1	16 h 80 h (three places)	18 h 36 h (three places)
3.5.2.2	64 h	18 h
3.5.3.1	16 h 80 h	36 h 36 h

(Amendment No. 2, July 2000)

3.5.1 (page 8)

After the sentence ending "...top plates within 1 h of casting." **add**:

"A recessed top cover is beneficial in terms of reducing the formation of puddles of bleed water on top of the concrete and forming an airtight seal."

(Amendment No. 2, July 2000)

4.1 (page 9)

Add to the end of 4.1.1.
"Procedures are also specified for restrained natural rubber capping system for capping hardened concrete cylinders."

(Amendment No. 2, July 2000)

4.1 (page 9)

Add new clause 4.1.2.

"4.1.2
The cylinder end preparation methods shall be in accordance with table 4.1 according to the expected concrete compression strength and capping method."

(Amendment No. 2, July 2000)

4.2 (page 9)

Add new subclause 4.2.2.

"4.2.2
In the case of cylinders to be tested using a restrained natural rubber capping system in accordance with clause 4.4.3, end surfaces of the test cylinder shall be a plane within a tolerance of 3.0 mm and shall not depart from being perpendicular to the axis by more than 1.5°."

(Amendment No. 2, July 2000)

4.4.1 (page 9)

In the fourth line **delete** "20 MPa" and substitute "35 MPa".

(Amendment No. 2, July 2000)

4.4.1 (page 9)

Add the following to the end of the subclause.

"This material may be used for testing concretes within the strength ranges stated in table 4.1."

(Amendment No. 2, July 2000)

4.4.2 (page 9)

Delete subclause 4.4.2 (but not its Note) and **substitute:**

"4.4.2
Sulphur-based materials
These materials are composed of sulphur with or without inert fillers. To be suitable for capping, these materials shall be capable of developing the strengths set out in table 4.1. Both end surfaces of the capped cylinders shall be plane within 0.05 mm."

(Amendment No. 2, July 2000)

4.4.3 (page 9)
Add new subclause 4.4.3 and subclauses 4.4.3.1 to 4.4.3.3.

"4.4.3
Restrained natural rubber capping system

4.4.3.1
Apparatus
Moulded concrete cylinders of nominal 150 mm and 100 mm diameter may be capped and tested with a restrained natural rubber pad.

The capping system shall consist of a circular natural rubber pad inside a restraining device such as shown in figure 4.1. Other materials may be used for the restraining device provided they give equivalent results.

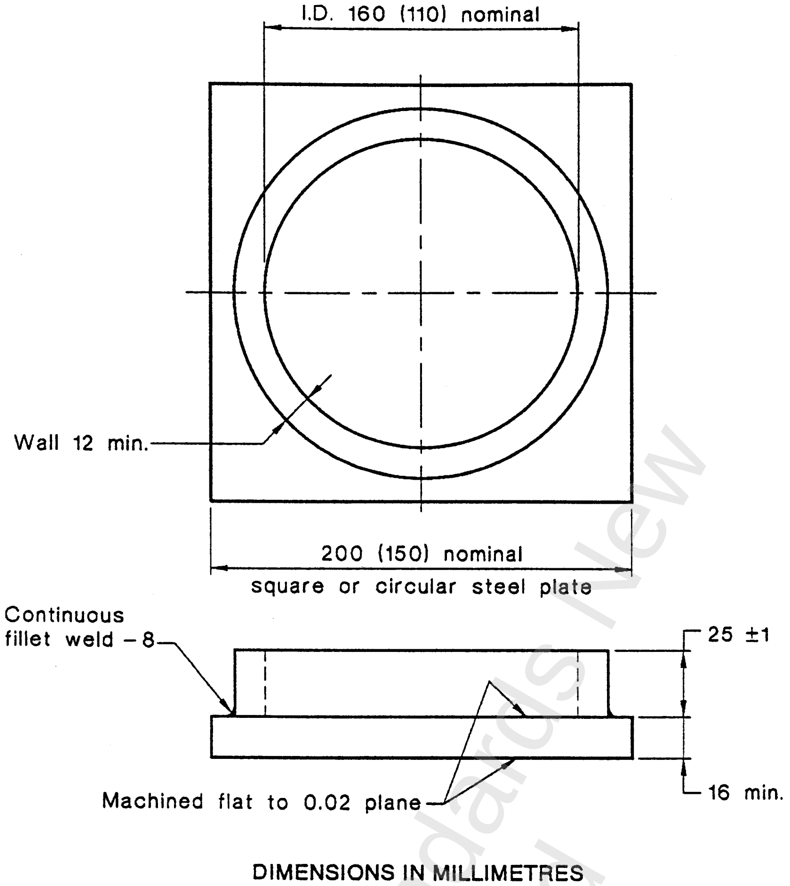
The pad shall be:

(a) For a nominal 150 mm diameter cylinder — 160 mm nom. dia. (e.g. snug fit to the restraining device) and a uniform thickness between 12 mm and 15 mm; or

(b) For a nominal 100 mm diameter cylinder — 110 mm nom. dia. (e.g. snug fit to the restraining device) and a uniform thickness between 12 mm and 15 mm; and

(c) Natural rubber as described in AS 1523 with a nominal Shore A Durometer hardness of 50 to 65.

NOTE – Under certain conditions and with certain testing machines, there may be an increase of sudden failures when the rubber capping system is used.



NOTE – Dimensions in brackets apply to nominal 100 mm diameter cylinders.

Figure 4.1 – Steel restraining device

4.4.3.2
Procedure
Apply capping system immediately prior to testing. Ensure that the rubber pad, cylinder and steel restraining device are concentric. Ensure that the concrete cylinder is not in contact with the steel restraining device.

4.4.3.3
Inspection
The capping system shall be inspected regularly for damage or wear. The initial use of pads will cause some deformation and flow of the rubber, however this shall not be a reason for rejecting the pad. The rubber pads may be reused provided that they are:

(a) Not torn or split; and

(b) Capable of providing contact over the whole area of the cylinder end."

(Amendment No. 2, July 2000)

4.5.1 (page 9)

Delete the first sentence of 4.5.1(b) and **substitute:**

"(b) Make caps as thin as is practicable, and no more than 2 mm thick for concrete with a compressive strength greater than 80 MPa and no more than 4 mm thick for concrete with a compressive strength less than 80 MPa."

(Amendment No. 2, July 2000)

Section 4 (page 10)
Add the following new table at the end of section 4:

"Table 4.1 – CAPPING METHODS

Capping material	Capping method – Expected compressive strength MPa		
	≤ 50	> 50 ≤ 80	> 80
Filled sulphur mixtures	Cap shall be at least 1 h old and average compressive strength of the sulphur mixture shall exceed 35 Pa (Note 1)	Cap shall be at least 2 h old and the average compressive strength of the sulphur mixture shall exceed 35 MPa (Note 1)	Cap shall be at least 2 h old and average compressive strength of the sulphur mixture shall exceed 50 MPa (Note 1)
Special gypsum plasters	Cap shall be at least 1 h old and compressive strength of the plaster mixture shall exceed 35 MPa when tested in accordance with clause 4.4.1	Not permitted	Not permitted
Restrained natural rubber capping system (Note 2)	Permitted for > 10 MPa	Permitted	Not permitted

NOTE –
(1) Sulphur mixture specimens shall be 50 mm to 75 mm cubes. To prepare a suitable cube specimen of sulphur mixture, it is advisable to place the molten mixture in thin layers (about 3 mm to 6 mm) in a mould that has been preheated to about 50 °C allowing each layer to partly solidify before the next layer is added. The average of 3 cube compressive strength results shall be used with testing carried out at least 2 hours after hardening.

(2) A restrained natural rubber capping system shall be in accordance with clause 4.4.3."

(Amendment No. 2, July 2000)

5.5.1 (page 11)

In the fifth line **delete** "not earlier than 16 h nor later than 50 h" and **substitute** "at approximately 48 h"

(Amendment No. 2, July 2000)

5.5.2 (page 11)

Delete the clause and its subclauses, 5.5.2.1, 5.5.2.2 and 5.5.2.3 and **substitute** the following:

"**5.5.2**
Specimens made in the field for quality control and acceptance tests

5.5.2.1
Immediately after moulding the specimens, store the moulds in a suitable enclosure such that the temperature remains within the range 10 °C to 26 °C and leave undisturbed for at least 18 h. No later than 36 h after moulding, place the flexure specimens in their moulds at a temperature of 21 ± 2 °C under moist conditions such that free water is maintained on the surface of the specimen at all times.

5.5.2.2
At approximately 48 h after moulding remove the specimens from the moulds and replace them into standard moist conditions at 21 ±2 °C as soon as possible, but not later than 3 h after demoulding and up to the time of testing.

5.5.2.3
When specimens are transported to a laboratory, they shall be carried in such a way that physical damage is avoided and loss of moisture and temperature extremes are prevented.

Transportation of the specimens to the laboratory may either be:

(a) Between 18 h and 36 h in their moulds.

(b) After 48 h from moulding where standard moist conditions are available on site.

NOTE – The curing time limits provided in clause 5.5.2, if utilized, may result in a scatter of results than is wider than can be attributed to variations in concrete quality. This applies particularly to higher strength concretes. Following recommendations similar to those given for clause 3.5 for concrete with strengths above 50 MPa will give more consistent results."

(Amendment No. 2, July 2000)

6.2.1 (page 13)

Delete at the beginning of the clause the words "The machine shall comply as regards accuracy with the requirements of Grade B of NZS 1021, except ..." and **substitute**:

"The machine shall comply as regards accuracy with the requirements of Grade 2 of ISO 7500-1, except..."

(Amendment No. 2, July 2000)

6.3.3 (page 13)

Add the following as a new paragraph to the end of 6.3.3.

"Where a restrained natural rubber capping system is used, the end surface of the test cylinder shall be a plane within a tolerance of 3.0 mm and shall not depart from being perpendicular to the axis by more than 1.5°."

(Amendment No. 2, July 2000)

6.3.4 (page 13)

Delete 6.3.4 and **substitute** the following:

"**6.3.4**
Where capping is required, use the procedures specified in section 4."

(Amendment No. 2, July 2000)

6.4.1(g) (page 14)

Add new note at the end of the clause:

"NOTE – Individual results may be recorded to 0.1 MPa but the average results do not have a precision better than 0.5 MPa."

(Amendment No. 2, July 2000)

10.4 (page 21)

After the heading "Calculations" **add** a non-mandatory note:

"NOTE – Results may be calculated and recorded to a greater precision than that required by section 10 but the final results do not have a precision better than 0.5 MPa or 0.1 MPa in the case of the overall production standard deviation."

(Amendment No. 2, July 2000)

STANDARDS NEW ZEALAND
PRIVATE BAG 2439
WELLINGTON 6020

APPROVED TO NEW ZEALAND STANDARD

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Declared on 28 November 1986 by the Standards Council to be a Standard specification pursuant to the provisions of section 23 of the Standards Act 1965.

First published	December 1980
New edition with Amendment No. 1 inc.	December 1986

The following SANZ references relate to this Standard:

Project No. P3112: Part 2
Draft for comment No. DZ3112: Part 2
CPT ref: KDMcl 10
Printing code: 1000-1986/2022/22689
Typeset by: Challis Datacom
Printed by: Milne Printers