AS/NZS 1314:2003
Reconfirmed 2016

AS/NZS 1314

Australian/New Zealand Standard™

Prestressing anchorages

Standards Australia

STANDARDS NEW ZEALAND
Paerewa Aotearoa

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee BD-084, Steel Reinforcing and Prestressing Materials. It was approved on behalf of the Council of Standards Australia on 9 April 2003 and on behalf of the Council of Standards New Zealand on 22 April 2003. It was published on 5 June 2003.

The following are represented on Committee BD-084:

Association of Consulting Engineers Australia
Australian Chamber of Commerce and Industry
Australian Post Tensioning Association
Australian Steel Association
Australian Wire Association
AUSTROADS
Bureau of Steel Manufacturers of Australia
Business New Zealand
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Institution of Professional Engineers New Zealand
Master Builders Australia
National Precast Concrete Association Australia
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This Standard was issued in draft form for comment as DR 00271.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

RECONFIRMATION

OF
AS/NZS 1314:2003
Prestressing anchorages

RECONFIRMATION NOTICE

Technical Committee BD-084 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

Certain documents referenced in the publication may have been amended since the original date of publication. Users are advised to ensure that they are using the latest versions of such documents as appropriate, unless advised otherwise in this Reconfirmation Notice.

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NOTES

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Australian/New Zealand Standard™

Prestressing anchorages

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-084, Steel Reinforcing and Prestressing Materials to supersede AS 1314—1972.

The objective of this Standard is to provide users and manufacturers with a test procedure to be used for establishing the performance of prestressing anchorages of various types for use in construction within Australia and New Zealand. It provides designers with test data from which they will be able to predict the ultimate capacity of the anchorage system when it is correctly installed in properly constructed concrete elements of the structure.

The Committee has reviewed several international standards in the preparation of the new Standard. These include BS 4447—*The performance of prestressing anchorages for post-tensioning construction*, FIP–*Recommendations for the acceptance of post-tensioning systems* and Post-tensioning Institute—*Acceptance Standards for Post-tensioning Systems.* The Committee recognized that it is important for joint Australian and New Zealand Standards to be compatible with other internationally recognized Standards so that no discrimination against Australia or New Zealand manufactured products can occur.

This revised Standard has removed various anomalies that existed in the 1972 edition of AS 1314, to bring it into line with current Standards in Europe and America.

The major changes are as follows:

(a) The Standard now references AS 3600 and NZS 3101.1, instead of AS 1481, for the design of bursting reinforcement. The amount of reinforcement required has been reduced from that previously required by AS 1481.

(b) The maximum crack widths for the anchorage efficiency test have been redefined. Previously this was defined as visible to the naked eye, which allowed many interpretations.

(c) Concrete strength for anchorage efficiency testing must be reported. Previously, the requirement was for concrete strength to be less than 50 MPa, but the strength did not need to be reported.

(d) An alternative test procedure using cyclic loading has been introduced for anchorage efficiency. The test is similar to the British Standard and FIP requirements.

(e) An efficiency test has been introduced for non-stressing anchorages.

The Standard applies to the manufactured hardware and not to the structural end use.

This Standard applies to monostrand and multistrand anchorage systems as well as bar systems. The Standard makes a distinction between the gripping efficiency of an anchorage and the ultimate strength of stressing and non-stressing anchorages.

The testing regimes prescribing the size of test prisms were developed so that consumers can make valid comparisons of systems for particular end uses.

The testing of restressable anchorages, such as may be used in permanent ground anchor applications, has not been directly addressed by the Committee.

Similarly, the Committee has not considered the requirements for cable-stayed bridge anchorage systems where very large tendons are subjected to two million load cycles before testing to failure. At present, no facilities exist in Australia and there are very limited facilities internationally for this type of testing.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

Statements expressed in mandatory terms in notes to figures are deemed to be requirements of this Standard.

CONTENTS

Page

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Prestressing anchorages

1 SCOPE

This Standard specifies minimum requirements for the—

(a) materials;

(b) manufacture; and

(c) methods of establishing the static or cyclic load performance, of prestressing anchorages and couplings intended for retaining the prestressing forces induced in wire, strand, or bar tendons and for transferring those forces to concrete members.

This Standard does not apply to the calculation of the stresses, or to the design of the concrete zones in which anchorages are embedded (see AS 3600 or NZS 3101.1).

Appendix B of the Standard is directly applicable to single tendon anchorages commonly employed by precast concrete manufacturers in pretensioning operations and multiple re-use of barrels and wedges.

Where multiple re-use of wedges occur, careful attention to the condition of the wedge teeth is essential. This is a management responsibility and beyond the scope of this Standard.

NOTE: Means for demonstrating compliance with this Standard are given in Appendix A.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS
1199 Sampling procedures and tables for inspection by attributes

1399 Guide to AS 1199—Sampling procedures and tables for inspection by attributes

1310 Steel wire for tendons in prestressed concrete

1311 Steel tendons for prestressed concrete—7-wire stress-relieved steel strand for tendons in prestressed concrete

1313 Steel tendons for prestressed concrete—Cold-worked high-tensile alloy steel bars for prestressed concrete

1379 Specification and supply of concrete

3600 Concrete structures

AS/NZS ISO
9000 Quality management and quality assurance standards
9000.1 Part 1: Guidelines for selection and use

9001 Quality management systems—Requirements

SAI
HB18 Guidelines for third-party certification and accreditation
HB18.28 Guide 28: General rules for a model third-party certification system for products

NZS		
3101	Concrete Structures Standard	
3101.1	Part 1:	The design of concrete structures
3108	Specification for concrete production – ordinary grade	

3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

3.1 Administrative definitions

3.1.1 *Customer*

The principal or the principal's agent, for whom the project incorporating the anchorage is being constructed.

NOTE: In the case of precast prestressed units, the customer would usually be the precaster.

3.1.2 *Designer*

A suitably experienced and competent person responsible for the design of the structure, or part thereof, in which the anchorage is intended to be used.

3.1.3 *Supplier*

The owner, or the agent of the owner, of any registered, mark, name, design or patent covering an anchorage.

NOTE: The supplier may, or may not, be the manufacturer of all or any of the anchorage components.

3.2 Technical definitions

3.2.1 *Anchor block*

The steel block in which the wedges are seated and grip the tendons, and where stressing may take place.

3.2.2 *Anchorage or anchorage assembly*

A mechanical device, usually incorporating several components designed to retain a stressed tendon and transmit the force in the tendon to the structure.

3.2.3 *Anchorage efficiency*

The ratio of failure load or maximum test load to the minimum specified load or tendon capacity the anchorage is designed to accommodate, when tested in accordance with Appendices C or D.

3.2.4 *Anchorage slip*

The movement of a tendon relative to its gripping device measured after completion of draw-in.

3.2.5 *Anchorage zone*

The local region in a structural member through which the tendon forces are transferred from the anchorage to the concrete.

3.2.6 *Characteristic strength*

That value of the material strength, as assessed by standard test, which is exceeded by 95% of the material comprising the tendon.

3.2.7 *Coupling*

An anchorage designed to join tendons end to end, including joining an already stressed tendon or joins to unstressed tendons.

3.2.8 *Draw-in*

The movement of a gripping device relative to the anchorage, which takes place during or subsequent to stressing and which is essential to the anchorage's gripping action.

3.2.9 *Excessive deformation*

Deflections that are equal or greater than the calculated bending deflection, or which are equal or greater than the upper level of elastic deformation prior to plastic deformation or evidence of punching shear occurring at the annular shear perimeters between loading plates.

3.2.10 *Failure load*

The load at which a test specimen is incapable of supporting any increase in load. Failure is any load less than 95% of the minimum tensile strength of the tendon where excessive deformation occurs.

3.2.11 *Gripping devices*

A mechanical device or component for anchoring the strand, wire or bar within an anchorage. Gripping devices include hardened steel wedges, either single or multiple pieces, nuts, compression fittings or similar device to grip or restrain the strand, wire or bar within the anchor plate or barrel without significant relative movement.

3.2.12 *Gripping efficiency*

The ratio of the failure load or maximum test load to the minimum specified load or tendon capacity the anchorage is designed to accommodate when tested in accordance with Appendix B.

3.2.13 *Maximum test load*

The failure load or the highest test load to which the test specimen is subjected where it is unsafe or unnecessary to test it to failure, expressed as a ratio of the specified capacity.

3.2.14 *Minimum specified load capacity*

The product of the maximum number of tendons, which the anchorage is designed to accommodate, and the characteristic tensile strength of the largest tendon force specified by the supplier for use in the anchorage.

3.2.15 *Non-stressing anchorage*

An anchorage, usually entirely encased in the concrete, at which it is intended that stressing not be carried out.

3.2.16 *Static tests*

Tests in which an increasing tensile test load is applied incrementally, by means of calibrated hydraulic jacks or a suitable testing machine, until the maximum or failure load is reached.

3.2.17 *Stressing*

The operation of inducing tension in a tendon.

3.2.18 *Stressing anchorage*

An anchorage located at an end of a tendon at which stressing can be carried out.

3.2.19 *Tendon*

A wire, strand, or bar complying with AS 1310, AS 1311 or AS 1313 respectively, or any discrete group of such wires, strands or bars, which may be stressed in one operation or individually.

3.2.20 *Tendon-anchorage assembly*

A tendon anchorage assembly for strand tendons includes wedges, anchor block, duct transition casing and for bar tendons includes the anchor nut, washer and bearing plate.

4 MATERIALS

4.1 Anchorage components

Materials for the anchorage components shall comply with the relevant Australian or New Zealand Standard with respect to both physical and mechanical properties or, if no Australian or New Zealand Standard exists, a relevant International Standard.

4.2 Tendons

Tendons used for testing the anchorage and its components shall comply with AS 1310, AS 1311 or AS 1313, as appropriate.

4.3 Concrete

Concrete used in the preparation of anchorage test specimens shall comply with AS 1379 or NZS 3108.

5 REQUIREMENTS FOR ANCHORAGES, COUPLINGS AND THEIR COMPONENTS

5.1 General

An anchorage, or a coupling, and its component parts shall be considered as a single entity and they shall together satisfy the requirements of Clauses 5.2 and 5.3.

5.2 Safety

When concrete in the anchorage zone has been reinforced, cast and cured in accordance with AS 3600 or NZS 3101.1, an anchorage, or a coupling, shall be capable of safely transferring the design forces to the concrete, both during the stressing operation and upon release of the stressing equipment.

5.3 Reliability

An anchorage or a coupling shall be capable of maintaining the design prestressing forces imposed on it throughout the service life of the member.

NOTE: In the design of an anchorage or coupling, account needs to be taken of some practical considerations including, but not limited to, the following:

(a) The shape of the assembly, which should maximize load transfer by bearing and should permit ready compaction of the concrete around it.

(b) Staged tensioning of tendons will cause non-uniform distribution of stresses in multiple-tendon anchorages.

(c) The likelihood of axial misalignment of the tendons relative to their anchorages. The supplier should specify the maximum deviation.

(d) Appropriate provisions for fixing the anchorage to the formwork and, where tendons are contained in permanent ducting, for fixing the ducting to the anchorage.

(e) Provision of an entry port for the grouting of post-tensioned tendons.

6 MANUFACTURE

Anchorages, couplings and their components shall be continually monitored during their manufacture to ensure that the completed assembly complies with the specification of a prototype tested in accordance with this Standard.

NOTE: Means for demonstrating compliance with this Standard are given in Appendix A.

Manufacturing quality control of wedges shall meet the requirements of Appendix E.

Suppliers shall keep sufficient records of inspections and tests so that the quality of the supplied product can be verified.

7 CALCULATIONS

7.1 Gripping efficiency

The gripping efficiency is the ratio of the failure load or maximum test load to the minimum specified load or tendon capacity the anchorage is designed to accommodate when tested in accordance with Appendices B or D.

7.2 Anchorage efficiency

The ratio of the failure load or maximum test load to the minimum specified load or tendon capacity the anchorage is designed to accommodate when tested in accordance with Appendices C or D.

8 PERFORMANCE REQUIREMENTS

8.1 General

To comply with this Standard, each type of anchorage, coupling or assembly shall be tested in accordance with this Clause. If a manufacturer produces a range of anchorages, couplings or assemblies that are geometrically similar and only differ in the number of tendons accommodated, then it may be sufficient to test only 30% of the representative sizes from the range, but not less than two sizes from the range. Where the bearing area of an anchorage and coupling differ, only that with the smaller bearing area should be tested.

A minimum of three identical specimens shall be used for each test of the representative sizes of anchorages, couplings or assemblies. The test specimens shall satisfy the performance criteria specified in Clauses 8.2 and 8.3, as appropriate.

If any of the three test specimens fail to satisfy the performance criteria of this Standard, three additional specimens of the same representative size shall be prepared. If five of the six specimens satisfy the performance criteria, the range of anchorages, couplings or assemblies represented by those specimens is deemed to have satisfied this Standard. Otherwise, the range of anchorages, couplings or assemblies represented by the specimens shall be rejected as not conforming to this Standard.

8.2 Tendon-anchorage assemblies and couplings

When tested in accordance with Appendices B and D, tendon-anchorage assemblies and couplings shall satisfy the following requirements:

(a) The calculated gripping efficiency is not less than 0.95.

(b) Failure of the tendon(s) is not to be induced by the failure of anchorage components.

NOTE: The mode of failure should be by the fracture of the tendon(s) away from the gripping device.

(c) The relative displacement between the anchorage components as well as between the tendon(s) and anchorage components becomes constant within the specified loading period.

(d) The total extension at failure load or maximum test load is not less than 1.8% of the tendon free length.

8.3 Anchorages

When tested in accordance with Appendices C and D, stressing and non-stressing anchorages shall be deemed to satisfy the test if they meet the following requirements:

(a) The calculated anchorage efficiency is not less than 0.95.

(b) No crack width exceeds—

  (i) 0.20 mm after 15 min at 90% of the minimum specified load capacity of the anchorage for the static test; or

  (ii) 0.25 mm on the last cycle of the cyclic test.

9 TEST REPORT

Reports of tests carried out in accordance with this Standard shall be prepared for each specimen tested and shall include the following information:

(a) A statement that the test has been carried out in accordance with the appropriate Appendix of this Standard.

(b) A statement that the test(s) satisfies the requirements of this Standard.

(c) Identification and complete technical details of the anchorage assembly, coupling or parts of the assembly tested, including the minimum specified load capacity.

(d) For tests carried out in accordance with Appendices B and D of this Standard, the calculated gripping efficiency achieved.

(e) For tests carried out in accordance with Appendices C and D this Standard, the calculated anchorage efficiency achieved.

(f) Method used to apply the load.

(g) For tests carried out in accordance with Appendices C or D of this Standard—

  (i) the dimensions of the concrete prism at the time of test;

  (ii) details and grade of steel reinforcement in the prism including arrangement and location of any confining reinforcement;

  (iii) concrete strength at the time of the test; and

  (iv) curing of prism.

(h) The type and details of the tendon used in the test(s) including the characteristic strength of the tendon.

(i) Identification of the testing organization and test supervisor.

(j) Date(s) on which tests were conducted.

APPENDIX A

MEANS OF DEMONSTRATING COMPLIANCE WITH THIS STANDARD

(Informative)

A1 SCOPE

This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

(a) Evaluation by means of statistical sampling.

(b) The use of a product certification scheme.

(c) Assurance using the acceptability of the supplier's quality system.

(d) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

A2 STATISTICAL SAMPLING

Statistical sampling is a procedure which enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a) The sample needs to be drawn randomly from a population of product of known history. The history needs to enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.

(b) For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199, guidance to which is given in AS 1399.

A3 PRODUCT CERTIFICATION

The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in HB 18.28 in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

A4 SUPPLIER'S QUALITY MANAGEMENT SYSTEM

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality management system or systems, this may provide the necessary confidence that the specified requirements will be met. The quality assurance requirements need to be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Information on establishing a quality management system is set out in AS/NZS ISO 9001 and AS/NZS ISO 9004.

A5 OTHER MEANS OF ASSESSMENT

If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed from the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

APPENDIX B
GRIPPING EFFICIENCY TEST
(Normative)

B1 SCOPE

This Appendix sets out a static test method for demonstrating the capability of a tendon-anchorage assembly, or a coupling, to transmit the maximum tensile force from a tendon of the appropriate size, to an anchorage assembly.

B2 PRINCIPLE

A tendon of the appropriate size is locked into the tendon-anchorage assembly, or coupling, by means of the tendon gripping device and, while the assembly is held in a fixed position, the tendon is tensioned until the failure load or the maximum test load is reached.

For anchorages designed to accommodate tendons of different diameters the gripping efficiency shall be determined separately for each tendon diameter.

B3 APPARATUS

B3.1 General

The apparatus shall consist of the following items:

(a) A mounting frame for holding the anchorages, couplings or assemblies in a fixed position.

(b) A tensioning mechanism for applying tensile loading to the tendon.

(c) A device for measuring and displaying, or recording, the load on the tendon at all times.

(d) Lengths of the maximum size tendon that can be accommodated in, or are recommended for, the gripping device being tested.

(e) A device for the measurement of wedge and tendon displacement.

NOTE: An example of a schematic arrangement of the apparatus is shown in Figure B1.

B3.2 Mounting frame

The mounting frame shall be capable of supporting the anchorage, coupling or assembly to be tested and the tensioning mechanism in a fixed position, and shall be sufficiently rigid to resist any reaction forces with negligible deformation. The bearing area between the frame and the test specimen shall be representative of the actual bearing area used by the system being tested.

B3.3 Tensioning mechanism

The tensioning mechanism shall be a calibrated hydraulic jack or a suitable tensile testing machine and shall be capable of exerting a tensile force of not less than 1.05 times the minimum specified load capacity of the largest size tendon to be tested.

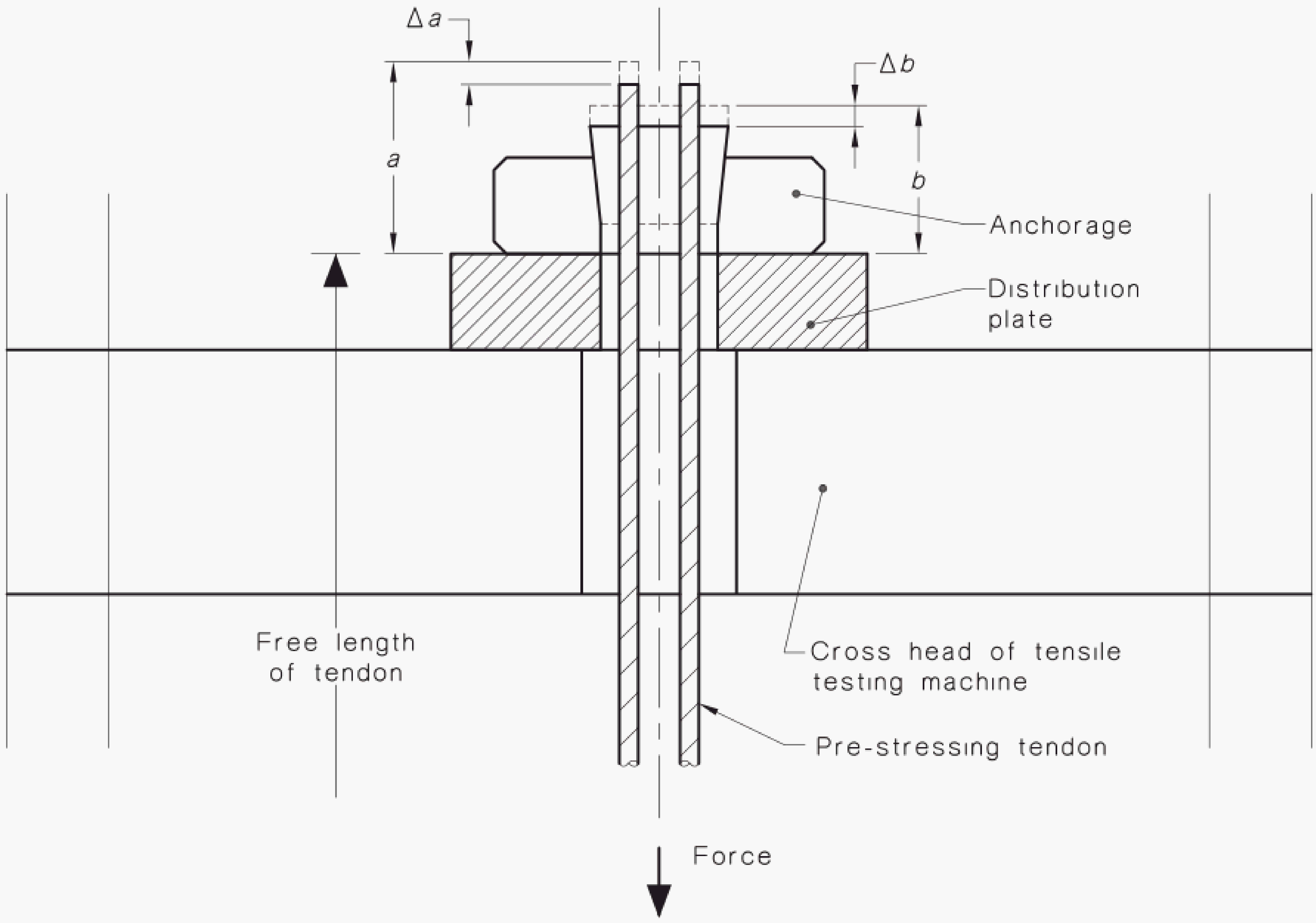
NOTE: A stressing jack of the type used in actual construction is a convenient tensioning mechanism.

B3.4 Load-measuring device

The load-measuring device shall be connected to the tensioning mechanism and shall be arranged and calibrated to display or record directly the tensile force in the tendon, to an accuracy of ±1.0%.

B3.5 Tendons

The tendon(s) to be used in a test shall be obtained from a single batch of tendons with a tensile strength proven by test to comply with the relevant Standard for the tendon. If the maximum size of tendon is available in different strength grades, the highest grade recommended by the anchorage supplier shall be used.



LEGEND

a, b = Measured values

Δa, Δb = Displacements in measured values for each load increment

FIGURE B1 SCHEMATIC ARRANGEMENT OF THE STATIC TENSILE TEST

B4 TEST SPECIMENS

The method of supporting the anchorage shall simulate the effect of any geometric deviation of any individual wire strand or bar within the anchorage.

Each test specimen shall consist of the following:

(a) *For stressing anchorages*—a gripping device attached to each end of the appropriate tendon, or a gripping device attached to one end of the tendon and a non-stressing anchorage or its equivalent attached to the other end.

(b) *For couplings*—the gripping-efficiency of each part of the coupler may be tested separately, the initial stressing of a coupler to be in accordance with Item (a). For subsequent stressing, the coupler to be secured so as to prevent its rotation or movement during testing. The efficiency of the subsequent stressing depends primarily on the method of securing the tendon to the coupler. The gripping-efficiency of each part of the coupler may be tested separately.

(c) *For tendons*—each to have a minimum free length of 3 m.

(d) *For non-stressing anchorages*—the gripping efficiency to be determined during testing carried out in accordance with Appendix D.

B5 TEST PROCEDURES

B5.1 General

The test procedure shall be as specified in Paragraph B5.2 for stressing anchorages and Paragraph B5.3 for couplings.

The extension of the tendon and the slippage of separate wires, bars or strands at all load increments and up to failure load or maximum test load shall be measured to within ±0.5 mm.

The tests shall be carried out at ambient temperatures in the range 10°C to 35°C, with the test loads being applied at the end of the tendon remote from the gripping device or couplings being tested.

For anchorages designed to accommodate tendons of different diameters, the gripping efficiency shall be determined separately for each tendon diameter.

B5.2 Procedure for stressing anchorages

The procedure shall be as follows:

(a) Assemble the tendon(s) and anchorage to simulate, as closely as practicable, a field installation. Mount this assembly in the testing rig so that the centroidal axis of both the anchorage and the tensioning device is aligned coaxially with the anchorage being separated from the tensioning mechanism, by no less than 3 m of tendon.

(b) Attach the tensioning mechanism and the load-measuring device to the opposite end of the tendon.

(c) Slowly apply load to the tendon, up to approximately 10% of the minimum specified load capacity of the tendon, until the gripping device is firmly in contact (set) with the tendon. Install extension and slippage-measuring devices and record initial readings. Inspect and record any initial reading of displacement-measuring device. Check that alignment has remained essentially coaxial and that anchorage bearing surfaces are in full contact with the mounting frame.

(d) For *stress relieved tendons*, increase the load incrementally to 20%, 40%, 60% and 80% of the minimum specified load capacity of the tendon, at a rate in each increment not exceeding a corresponding tensioning rate equivalent to 200 MPa per min. At the 80% level, maintain a constant load for 5 min.

For *non-stress relieved tendons*, increase the load incrementally to 20%, 40%, 60% and 70% of the minimum specified load capacity of the tendon, at a rate in each increment not exceeding a corresponding tensioning rate equivalent to 200 MPa per minute. At the 70% level, maintain a constant load for 5 min.

NOTE: High tensile bars are usually non-stress relieved.

At the end of each load increment and after the 5 min period, record the corresponding relative displacement of the tendon with respect to the anchorage and the gripping device.

(e) Decrease the tensioning rate to half the previous rate and continue loading at 5% increments until the applied load exceeds 95% of the minimum specified load capacity of the tendon(s) or until failure occurs.

(f) Stop loading and detension the tendon. In the event of failure record the mode of failure.

B5.3 Procedure for couplings

The procedure shall be as follows:

(a) Mount the test specimen in the mounting frame, ensuring that the gripping devices, the tendons and the coupling being tested are coaxially aligned, using a free length of tendon of not less than 3.0 m on each side of the coupling.

(b) Attach the stressing mechanism and the load-measuring device to the tendon at the stressing anchorage.

(c) Slowly apply load to the tendon, up to approximately 10% of the minimum specified load capacity of the tendon, until the gripping device is firmly in contact (set) with the tendon. Install extension- and slippage-measuring devices and record initial readings. Inspect and record any initial reading of displacement-measuring device. Check that alignment has remained essentially coaxial and that anchorage bearing surfaces are in full contact with the mounting frame.

(d) For *stress relieved tendons*, increase the load incrementally to 20%, 40%, 60% and 80% of the minimum specified load capacity of the tendon, at a rate in each increment not exceeding a corresponding tensioning rate equivalent to 200 MPa per min. At the 80% level, maintain a constant load for 5 min.

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(e) Decrease the tensioning rate to half the previous rate and continue loading at 5% increments until the applied load exceeds 95% of the minimum specified load capacity of the tendon(s) or until failure occurs.

(f) Stop loading and detension the tendon. In the event of failure, record the mode of failure.

APPENDIX C

STRESSING ANCHORAGE EFFICIENCY TEST

(Normative)

C1 SCOPE

This Appendix sets out methods for demonstrating the capability of an anchorage or coupling to transmit its minimum specified load capacity to the concrete by either—

(a) a static test to failure; or

(b) a cyclic test followed by a static test to failure.

C2 PRINCIPLE

The test anchorage is cast into a concrete prism, which is reinforced in accordance with AS 3600 or NZS 3101.1, as appropriate, so that the external face of the cast-in anchorage is exposed.

The prism is rigidly supported on the face opposite to the exposed face of the cast-in anchorage, and load applied to the anchorage, either by tensioning tendons anchored within it or by loading the exposed face directly using a testing machine through an area equivalent to that of the anchor block.

For the static test, the anchorage is progressively loaded until the concrete prism fails or the minimum specified load capacity is reached, whichever occurs first.

For the cyclic test, the anchorage is progressively loaded to 80% of its minimum specified load capacity for stress-relieved tendons or 70% for non-stress relieved tendons, and the load then varied continuously between this value and 15% of its minimum specified load capacity for the specified number of cycles.

C3 APPARATUS

C3.1 General

The apparatus shall consist of the following items:

(a) A mounting frame for supporting the concrete prism with cast-in anchorage in a fixed position.

(b) A mechanism for applying compressive loads to the prism via the anchorage, in the direction and along the axis of the resultant stressing force.

(c) A device capable of measuring, and displaying or recording, the total load on the anchorage at all times.

NOTE: Examples of arrangements of the apparatus and the test specimen are shown in Figure C1.

C3.2 Mounting frame

The mounting frame shall be capable of supporting the assembly to be tested and the tensioning mechanism in a fixed position, and shall be sufficiently rigid to resist any reaction forces with negligible deformation.

C3.3 Loading mechanism

The test loads shall be applied using a calibrated hydraulic jack or a suitable testing machine, capable of exerting loads on the anchorage of not less than 1.05 times the minimum specified load capacity of the anchorage.

NOTE: A calibrated stressing jack of the type used in actual construction is a convenient loading mechanism.

C3.4 Load-measuring device

The load-measuring device shall be connected to the loading mechanism and shall be arranged and calibrated to display, or record directly, at all times, the total force being transferred to the concrete prism, to an accuracy of ±1.0%.

C4 TEST SPECIMEN

The test specimen shall consist of a cast-in anchorage, with tendon duct attached, cast into a reinforced concrete prism. The anchorage shall include all parts that in practice will be in contact with, and transmitting forces to, the concrete, and shall be coaxially aligned along the long axis of the prism.

The dimensions of the prism shall be as shown in Figure C2. The prism shall be reinforced, in accordance with AS 3600 or NZS 3101.1, to resist the specified bursting forces. Any additional confining reinforcement required by the supplier as part of the system shall be provided. Secondary reinforcement of not more than the smaller of 75 kg/m^3 or 500 mm^2/m width shall be distributed in both directions in each side face of the prism, with a clear cover of not less than 10 mm or greater than 20 mm. At the time of testing, the mean strength of the concrete in the prism shall be not less than 22 MPa nor greater than 50 MPa.

Where required, the steel base plate supporting the end of the prism shall have overall dimensions of not less than those of the prism cross-section and shall be not less than 20 mm thick.

C5 TEST PROCEDURE

C5.1 General

The test procedure shall be as specified in Paragraphs C5.2 or C5.3, as appropriate. The test specimens shall be tested at ambient temperatures in the 10°C to 35°C range.

NOTE: The test specimens should be cast from the same batch of concrete and tested at a concrete age difference, not exceeding 5 days.

Test specimens may be tested individually or in pairs (see Figure C1).

C5.2 Static test procedure

The procedure shall be as follows:

(a) Locate the test specimen in the mounting frame, ensuring that the anchorage being tested and the loading mechanism are coaxially aligned.

(b) Attach the loading mechanism and load-measuring device to the anchorage.

(c) Apply load slowly to the anchorage until approximately 10% of the minimum specified load capacity of the anchorage is reached. Before proceeding further, check that alignment has remained essentially coaxial and that the prism bearing surface is in complete contact with the mounting frame or bearing plate. Remove any temporary supports.

(d) Increase the load by at least four equal increments, at a loading rate not greater than the equivalent of 200 MPa per min, until the applied load reaches 85% for stress-relieved tendons or 75% for non-stress-relieved tendons of the minimum specified load capacity of the anchorage. At the end of each increment, pause for 1 min to examine the test prism and record the size (width and length) of any visible cracks.

(e) Continue increasing the load in increments of 5% of the minimum specified load capacity of the anchorage but at a rate not greater than the equivalent of 100 MPa per min. Pause for 1 min to inspect for and record increases in crack widths up to 90% of the specified load capacity. When the applied load reaches 95% of the minimum specified load capacity, maintain this load for 10 min.

NOTE: Crack width measurements should be discontinued after 90% of the specified load capacity unless remote crack width measurement equipment is used.

(f) If failure occurs before the end of the holding period, record the length of time the 95% load level was maintained.

(g) At the end of the 10 min period, continue loading at the last loading rate until the applied load reaches the minimum specified load capacity of the anchorage or until failure occurs, whichever occurs first. Record the maximum applied load.

C5.3 Cyclic test procedure

For the cyclic test, the anchorage is progressively loaded to 80% for stress-relieved tendons or 70% for non-stress-relieved tendons of its minimum specified load capacity, and the load is then varied continuously between this value and 15% of its minimum specified load capacity for a limited number of cycles.

The procedure shall be as follows:

(a) Locate the test specimen in the mounting frame, ensuring that the anchorage being tested and the loading mechanism are coaxially aligned.

(b) Attach the loading mechanism and load-measuring device to the anchorage.

(c) Apply load slowly to the anchorage until approximately 10% of the minimum specified load capacity of the anchorage is reached. Before proceeding further, check that alignment has remained essentially coaxial and that the prism bearing surface is in complete contact with the mounting frame or bearing plate. Remove any temporary supports.

(d) Increase the load, at a rate not greater than the equivalent of 200 MPa per min, until the applied load reaches 80% for stress-relieved tendons or 70% for non-stress-relieved tendons of the minimum specified load capacity of the anchorage.

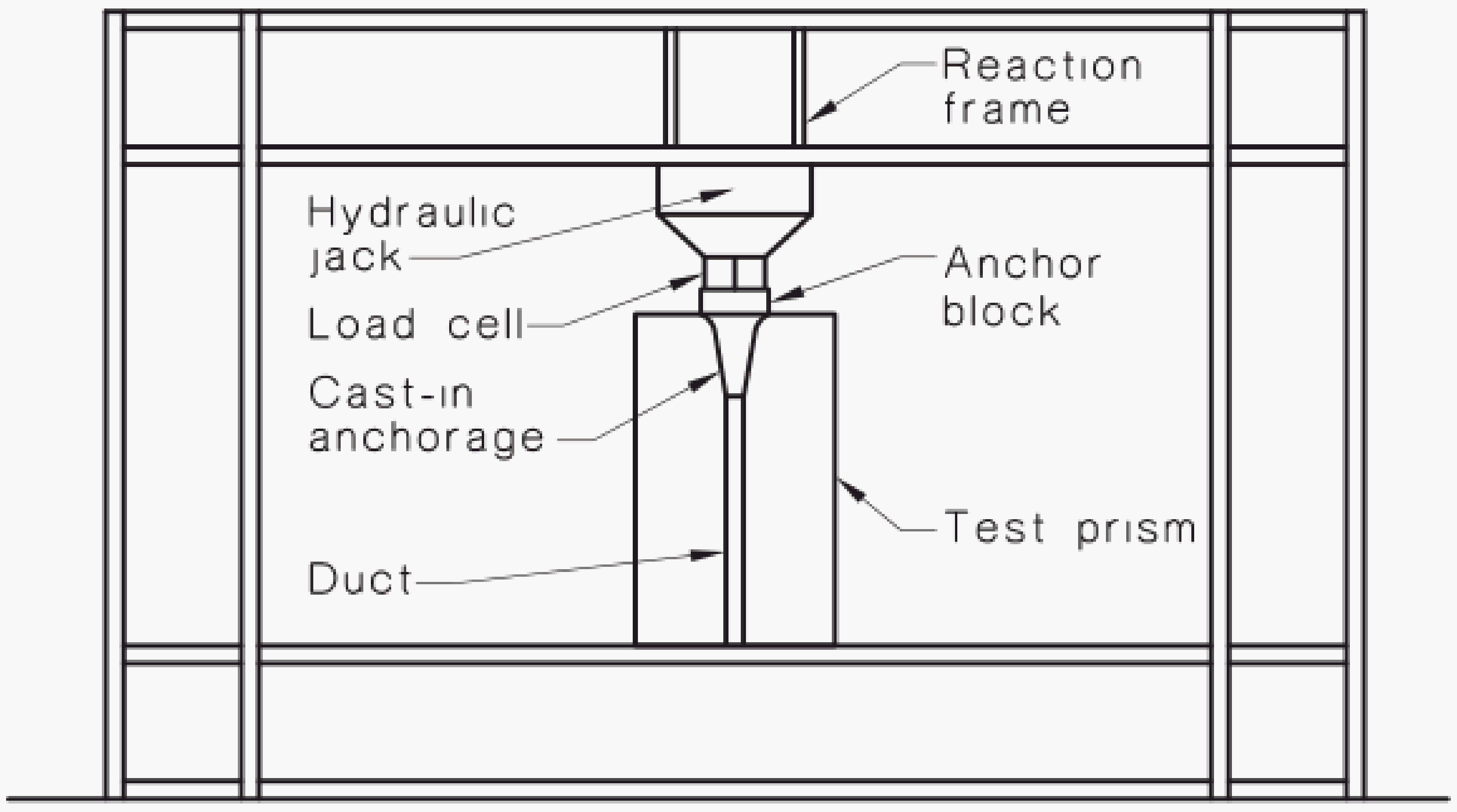
(e) Cycle the load between an upper level of 80% for stress-relieved tendons and 70% for non-stress relieved tendons, and a lower level of 15% of the minimum specified load capacity of the anchorage for a minimum of 10 cycles and until the crack widths stabilize. Stabilization of crack width in this Standard is defined as when the maximum crack width does not increase by more than 0.02 mm in 2 successive cycles, i.e., 3 consecutive readings at the upper load level. At the maximum load in each cycle, pause to examine the test specimen and record the location and size (width and length) of any visible cracks in the prism.

(f) At the end of the last cycle and after the examination has been completed, continue increasing the loading at a rate not greater than the equivalent of 100 MPa per min, until the applied load reaches 95% of the minimum specified load capacity and maintain this load for 15 min.

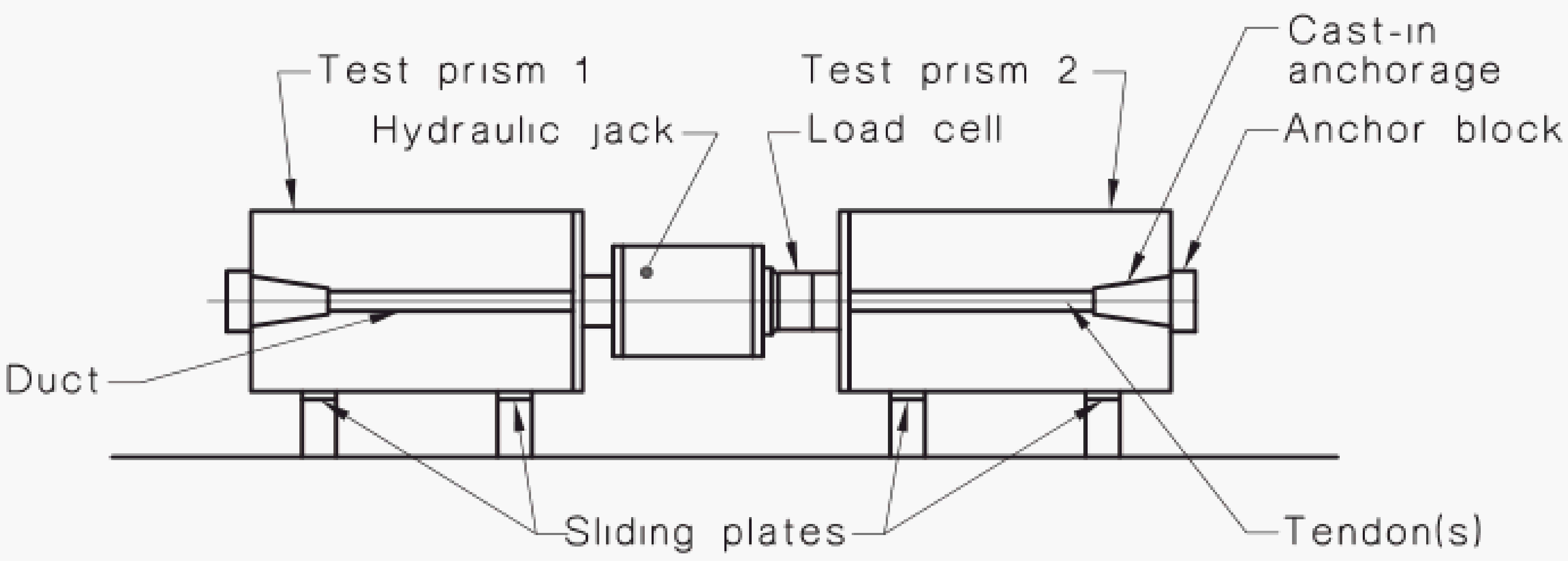
(g) If failure occurs before the end of the holding period, record the length of time the 95% load level was maintained.

(h) At the end of the 15 min period, continue loading at the last loading rate until the applied load reaches 105% of the minimum specified load capacity or until failure occurs. Record the maximum applied load.

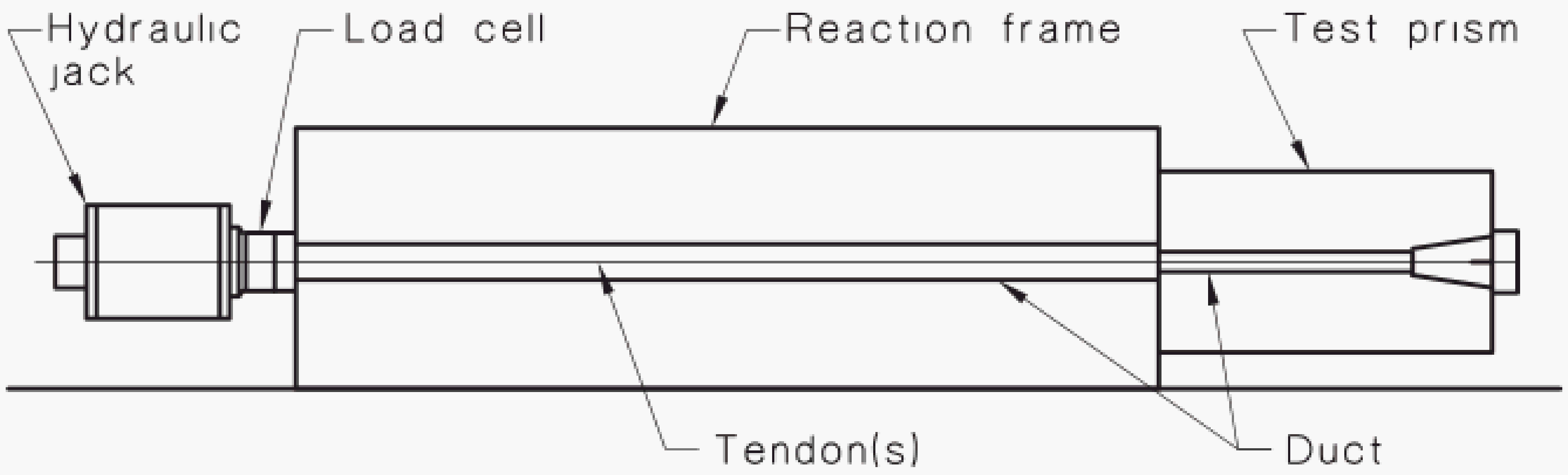
(i) Record the load at failure or the number of cycles to failure as appropriate.



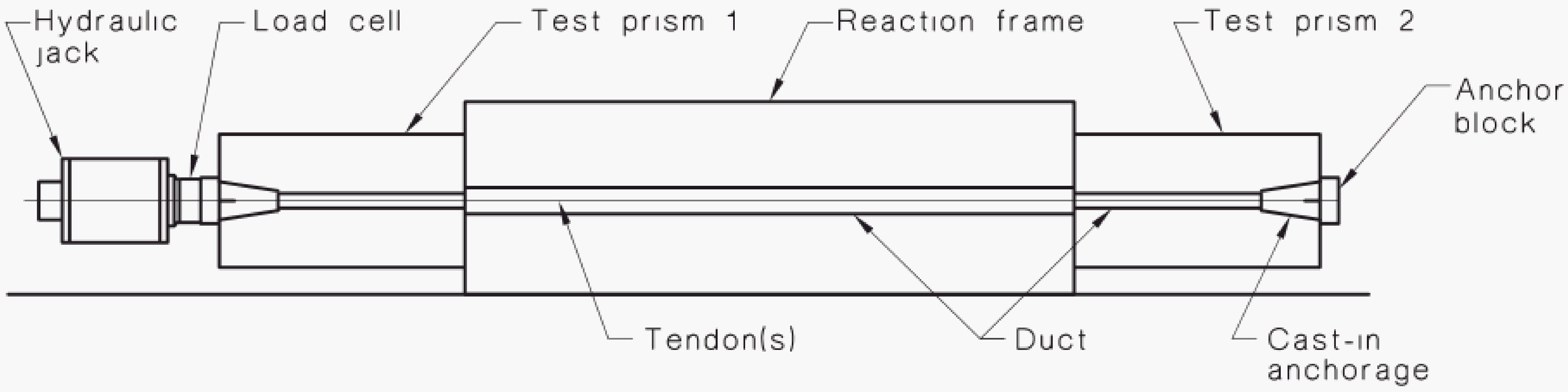
(a) Single prism



(b) Two prisms simultaneously

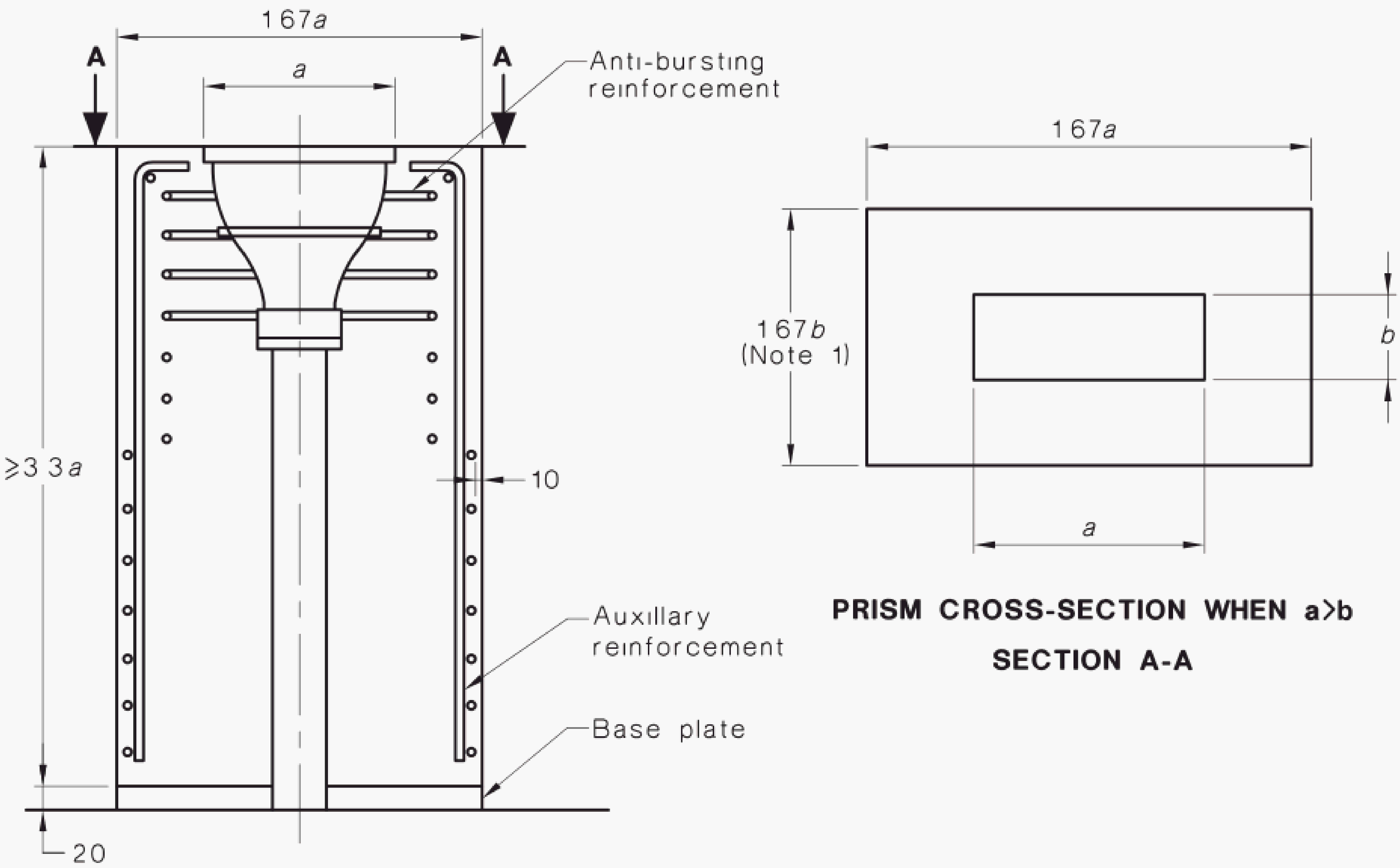


(c) Single prism



(d) Two prisms simultaneously

FIGURE C1 SCHEMATIC ARRANGEMENT OF TEST COMPONENTS



NOTES:

1 When b<100 mm then the smaller dimension of the prism shall not be less than 2.0b.

2 For circular anchorage the bearing area a^2 shall be taken as the area of the circular anchorage.

DIMENSIONS IN MILLIMETRES

FIGURE C2 DETAILS OF TEST PRISM FOR STRESSING ANCHORAGES

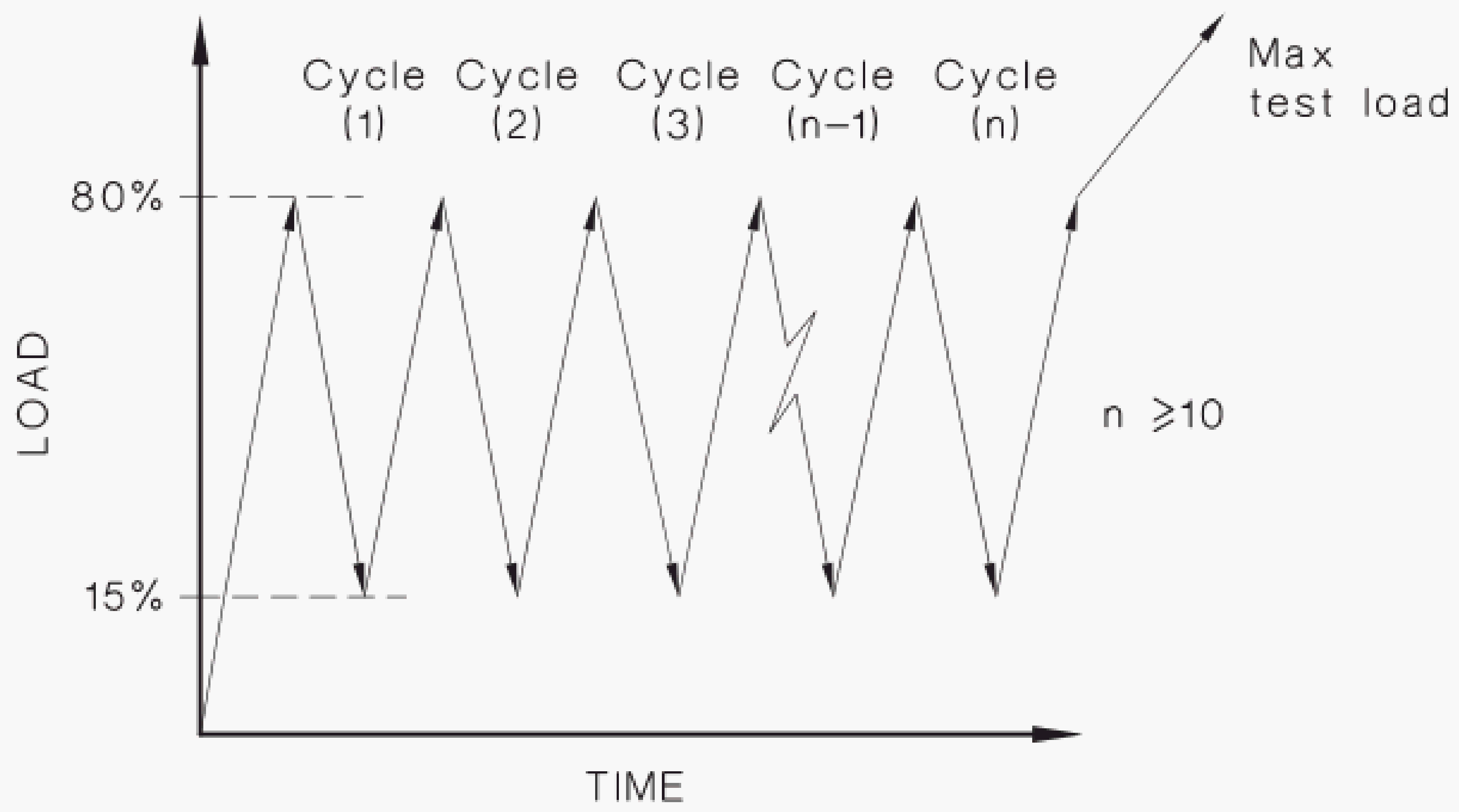


FIGURE C3 CYCLIC TEST

APPENDIX D
NON-STRESSING ANCHORAGE EFFICIENCY TEST
(Normative)

D1 SCOPE

This Appendix sets out methods for demonstrating the capability of a non-stressing anchorage to transmit the minimum specified load capacity of the anchorage to the concrete by either—

(a) a static test or;

(b) a cyclic test followed by a static test to failure.

D2 PRINCIPLE

The test anchorage is cast into a concrete prism, which is reinforced in accordance with AS 3600 or NZS 3101.1, as appropriate.

The prism is rigidly supported on the face opposite to the face of the anchorage side, and load applied to the anchorage by tensioning tendons anchored within it.

For the static test, the anchorage is progressively loaded until the concrete prism fails or the minimum specified load capacity is reached, whichever occurs first.

For the cyclic test, the anchorage is progressively loaded to 80% of its minimum specified load capacity for stress-relieved tendons or 70% for non-stress-relieved tendons and the load is then varied continuously between these values and 15% of the its minimum specified load capacity for a limited number of cycles.

D3 APPARATUS

D3.1 General

The apparatus shall consist of the following items:

(a) A mounting frame for supporting the concrete prism and cast-in anchorage in a fixed position.

(b) A mechanism for stressing the test prism via the cast-in tendon, in the direction and along the axis of the tendon.

(c) A device capable of measuring, and displaying or recording, the total load on the anchorage at all times.

NOTE: Schematic arrangements of the apparatus and test specimen are shown in Figure D1.

D3.2 Mounting frame

The mounting frame shall be capable of supporting the assembly to be tested and the tensioning mechanism in a fixed position, and shall be sufficiently rigid to resist any reaction forces with negligible deformation.

D3.3 Tensioning mechanism

The tensioning mechanism shall be a calibrated hydraulic, or suitable, tensile testing machine, capable of exerting a stressing force on the anchorage of not less than 1.05 times the minimum specified load capacity of the anchorage.

NOTE: A calibrated stressing jack of the type used in actual construction is a convenient loading mechanism.

D3.4 Load-measuring device

The load-measuring device shall be connected to the tensioning mechanism and shall be arranged and calibrated to display, or record directly, at all times, the total force being transferred to the prism, to an accuracy of ±1.0%.

D4 TEST SPECIMEN

The test specimen shall consist of a non-stressing anchorage and duct located at the deviation distance specified for the anchorage, cast into a reinforced concrete prism. The anchorage shall include all parts that, in practice, will be in contact with, and transmitting forces to, the concrete, and shall be coaxially aligned along the long axis of the prism. The test prism shall be cast with its largest dimension in the horizontal position.

The dimensions of the prism shall be as shown in Figure D2. The prism shall be reinforced, in accordance with AS 3600 or NZS 3101.1, to resist the expected bursting forces. Any additional confining reinforcement required by the supplier as part of the system shall be provided. Secondary reinforcement of not less than the smaller of 75 kg/m^3 or 500 mm^2/m width shall be distributed in both directions in each side face of the prism, with a clear cover of not less than 10 mm or greater than 20 mm. At the time of testing, the mean strength of the concrete in the prism shall not be less than 22 MPa nor greater than 50 MPa.

Where required, the steel base plate supporting the end of the prism shall have overall dimensions not less than those of the prism cross-section and shall be not less than 20 mm thick.

D5 TEST PROCEDURE

D5.1 General

The test procedure shall be as specified in Paragraphs D5.2 or D5.3, as appropriate. The test specimens shall be tested at ambient temperatures in the 10°C to 35°C range.

NOTE: The test specimens should be cast from the same batch of concrete and tested at a concrete age difference not exceeding 5 days.

Test specimens may be tested individually (see Figure D1) or in pairs.

D5.2 Static test procedure

The procedure shall be as follows:

(a) Locate the test specimen in the mounting frame, ensuring that the anchorage being tested and the loading mechanism are coaxially aligned.

(b) Attach the loading mechanism to the free end of the tendon and a load-measuring device to the tendon anchorage in the loading device.

(c) Apply load slowly to the anchorage until approximately 10% of the minimum specified load capacity of the anchorage is reached. Before proceeding further, check that alignment has remained essentially coaxial and that the prism bearing surface is in complete contact with the mounting frame or bearing plate. Remove any temporary supports.

(d) Increase the load by at least four equal increments, at a loading rate not greater than the equivalent of 200 MPa per min, until the applied load reaches 85% of the minimum specified load capacity for stress-relieved tendons or 75% for non-stress relieved tendons. At the end of each increment, pause for 1 min to examine the test prism and record the size (width and length) of any visible cracks in it.

(e) Continue increasing the load in increments of 5% of the minimum specified load capacity but at a rate not greater than the equivalent of 100 MPa per min. Pause for 1 min to inspect for and record maximum crack widths up to 90% of the specified load capacity. When the applied load reached 95% of the minimum specified load capacity, maintain this load for 10 min.

NOTE: Crack width measurements should be discontinued after 90% of the specified load capacity unless remote crack width measurement equipment is used.

(f) If failure occurs before the end of the holding period, record the length of time the 95% load level was maintained.

(g) At the end of the 10 min period, continue loading at the previous loading rate until the applied load reaches the minimum specified load capacity or until failure occurs.

D5.3 Cyclic test procedure

For the cyclic test, the anchorage is progressively loaded to 80% for stress-relieved tendons or 70% for non-stress-relieved tendons of its minimum specified load capacity, and the load is then varied continuously between this value and 15% of its minimum specified load capacity for a limited number of cycles.

The procedure shall be as follows:

(a) Locate the test specimen in the mounting frame, ensuring that the anchorage being tested and the loading mechanism are coaxially aligned.

(b) Attach the loading mechanism and load-measuring device to the anchorage.

(c) Apply load slowly to the anchorage until approximately 10% of the minimum specified load capacity of the anchorage is reached. Before proceeding further, check that alignment has remained essentially coaxial and that the prism bearing surface is in complete contact with the mounting frame or bearing plate. Remove any temporary supports.

(d) Increase the load, at a rate not greater than a stressing rate of 200 MPa per minute, until the applied load reached 80% of the minimum specified load capacity for stress-relieved tendons or 70% for non-stress relieved tendons.

(e) Cycle the load between an upper level of 80% of the minimum specified load capacity for stress-relieved tendons and 70% for non-stress relieved tendons, and a lower level of 15% for a minimum of 10 cycles and until the crack widths stabilize, or for more cycles if agreed by the supplier. Stabilization of crack width in this Standard is defined as when the maximum crack width does not increase by more than 0.02 mm in 2 successive cycles, i.e., 3 consecutive readings at the upper load level. At the maximum load in each cycle, pause to examine the test specimen and record the location and size (width and length) of any visible cracks in the prism.

(f) At the end of the last cycle and after the examination has been completed, continue increasing the loading, at a rate not greater than the equivalent of 100 MPa per min, until the applied load reaches 95% of the minimum specified load capacity and maintain this load for 15 min.

(g) If failure occurs before the end of the holding period, record the length of time the 95% load level was maintained.

(h) At the end of the 15 min period, continue loading at the last loading rate until the applied load reaches the minimum specified load capacity or until failure occurs. Record the maximum applied load. Record the load at failure or the number of cycles to failure as appropriate.

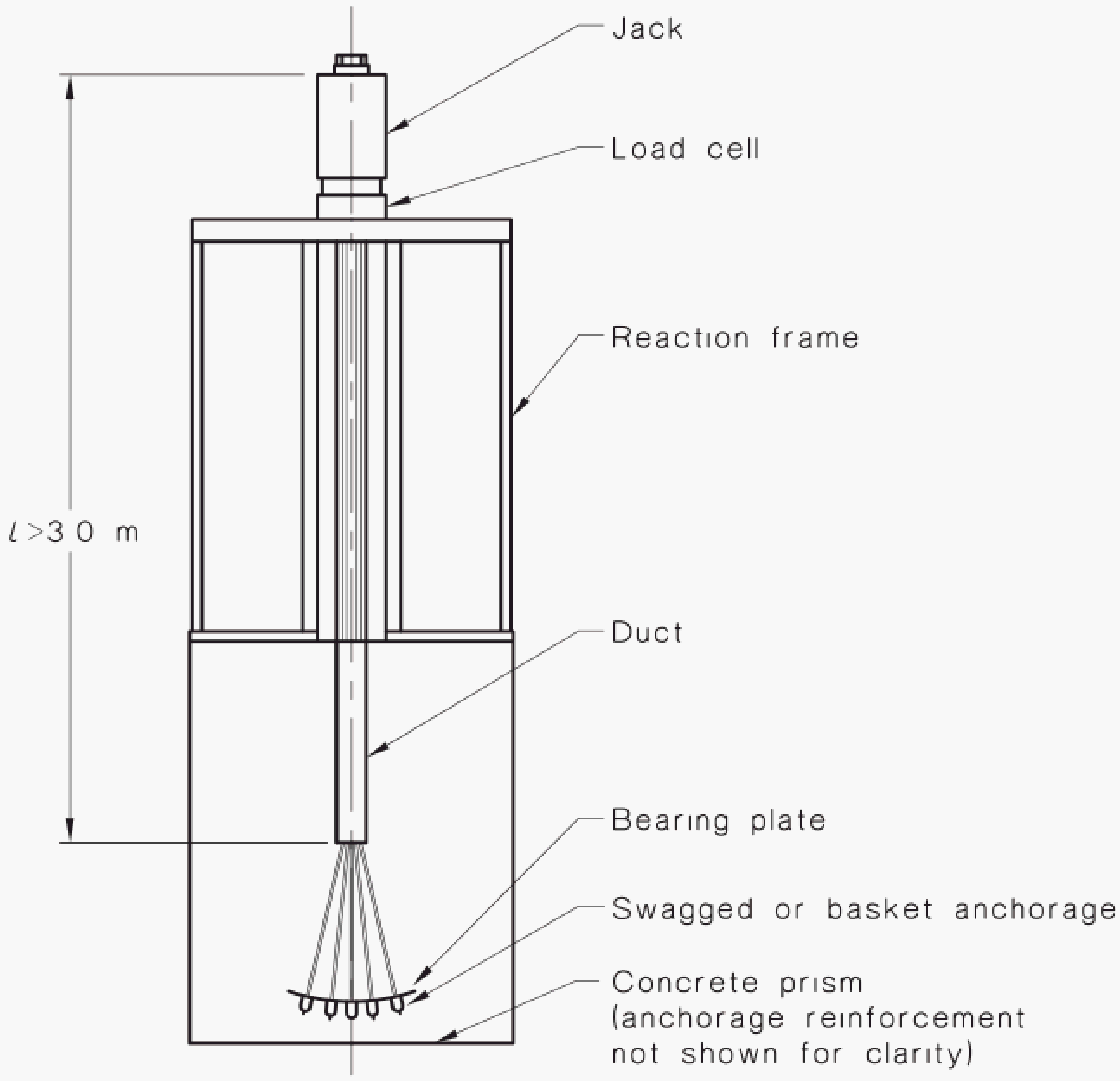
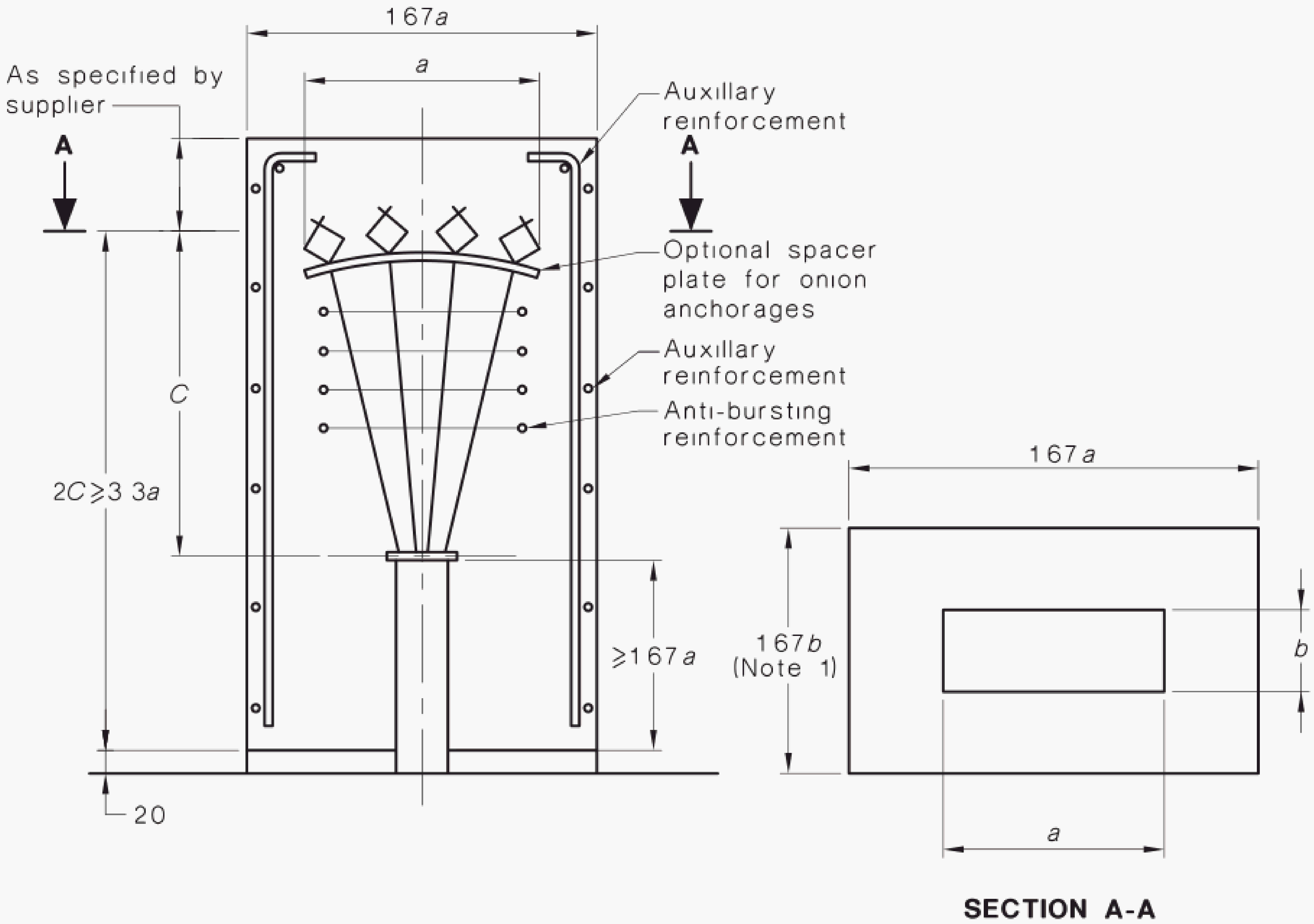


FIGURE D1 SCHEMATIC ARRANGEMENT OF TEST COMPONENTS



NOTE: $C > 600$ mm

NOTES:

1 When $b<100$ mm then the smaller dimension of the prism shall not be less than 2.0b.

2 For circular anchorage the bearing area a^2 shall be taken as the area of the circular anchorage.

DIMENSIONS IN MILLIMETRES

FIGURE D2 DETAILS OF TEST PRISM FOR NON-STRESSING ANCHORAGES

APPENDIX E

MANUFACTURING QUALITY CONTROL OF WEDGES

(Normative)

E1 SCOPE

This Appendix sets out the performance requirements and the minimum quality control requirements for each type of wedge during manufacturing.

E2 SPECIFIED PROPERTIES

Manufacturing quality control shall assure uniform quality of the manufacturer's specified wedge properties including—

(a) dimensions and tolerances;

(b) minimum specified surface hardness;

(c) minimum depth of surface hardness (case depth); and

(d) maximum core hardness.

E3 TESTING FOR COMPLIANCE

NOTE: See Appendix A for means for testing for compliance of wedges.

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