AS 3610.1—2010

Australian Standard®

Formwork for concrete

Part 1: Documentation and surface finish

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This Australian Standard® was prepared by Committee BD-043, Formwork. It was approved on behalf of the Council of Standards Australia on 13 October 2009.
This Standard was published on 2 February 2010.

The following are represented on Committee BD-043:

- Association of Consulting Engineers Australia
- Australian Aluminium Council
- Australian Industry Group
- Concrete Institute of Australia
- Engineers Australia
- Master Builders Australia
- National Precast Concrete Association of Australia
- Engineered Wood Products Association of Australasia
- University of Technology, Sydney
- University of Western Sydney
- WorkCover New South Wales

This Standard was issued in draft form for comment as DR 08167.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

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Australian Standard®

Formwork for concrete

Part 1: Documentation and surface finish

First published in part as AS CA70—1971.
AS CA72.1 first published in 1971.
AS 1082 first published in 1971.
AS CA70—1971 revised and redesignated AS 1509—1974.
AS CA72.1—1971 revised and redesignated AS 1510.1—1974.
AS 1082—1971, AS 1509—1974 and AS 1510.1—1974 revised, amalgamated and redesignated as AS 3610—1990.
Second edition 1995.
AS 3610—1995 revised and redesignated, in part, AS 3610.1—2010.

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Published by Standards Australia GPO Box 476, Sydney, NSW 2001, Australia

ISBN 0 7337 9358 4

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PREFACE

This Standard was prepared by the Standards Australia Committee BD-043, Formwork, to supersede, in part, AS 3610—1995, *Formwork for concrete*.

The objective of this Standard is to provide formwork architects; engineers; builders and construction contractors; and formwork designers, suppliers and contractors with requirements for the documentation, fabrication, erection and stripping of formwork, as well as for the assessment and evaluation of completed surface quality and repairs.

The full review of AS 3610 has not been completed and it was considered desirable to issue the Standard in two Parts:

(a) AS 3610.1, *Formwork for concrete*, Part 1: *Documentation and surface finish* (this Standard), which focuses on surface finish and covers various types of documentation applicable to formwork.

(b) Part 2, when published, will cover aspects of design and testing.

Prior to the publication of Part 2, AS 3610 and AS 3610.1 will coexist. Sections 2, 3, 4 and 5 in this Standard (Part 1) supersede Sections 2, 3 and 5, as well as Clause 4.7 of AS 3610—1995.

A Commentary has been added to Table 3.5.3 to clarify the intent of tonal ranges.

Photographic charts for the assessment of colour and surface finish are provided in the appendices. Additional copies of these charts are available as AS 3610 Supp 1, *Formwork for concrete—Blowhole and colour evaluation charts (Supplement to AS 3610—1995)*.

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

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.

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CONTENTS

Page

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STANDARDS AUSTRALIA

Australian Standard
Formwork for concrete

Part 1: Documentation and surface finish

SECTION 1 GENERAL

1.1 SCOPE

This Standard sets out the requirements for project, formwork and proprietary documentation, as well as the specification, evaluation of the off-form or as-repaired in situ or precast concrete surface. It also sets out the requirements for the fabrication, erection, inspection and stripping of formwork.

1.2 APPLICATION

The requirements in the project documentation, construction documentation, formwork documentation and proprietary documentation shall comply with Section 2.

The concrete surface finish shall comply with Section 3.

The fabrication, erection, inspection and stripping of formwork shall comply with the requirements and procedures set out in Section 4.

Procedures for evaluation of the off-form or repaired concrete surface shall comply with Section 5.

This Standard has limited applications for unformed concrete surfaces (e.g., tops of slabs).

1.3 NORMATIVE REFERENCES

The following are normative documents referenced in this Standard.

AS

1657 Fixed platforms, walkways, stairways and ladders—Design, construction and installation

3600 Concrete structures

3610 Formwork for concrete

AS/NZS

1576 Scaffolding
1576.1 Part 1: General requirements
1576.3 Part 3: Prefabricated and tube-and-coupler scaffolding
1576.6 Part 6: Metal tube-and-coupler scaffolding—Deemed to comply with AS/NZS 1576.3

1892 Portable ladders
1892.1 Part 1: Metal
1892.2 Part 2: Timber

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1.4 ALTERNATIVE CONCEPTS AND MATERIALS

Alternative concepts, materials, designs, methods of assembly and procedures, which are not mentioned in this Standard, may be used provided it can be demonstrated that the resulting formwork satisfies the requirements specified in this Standard.

1.5 DEFINITIONS

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

1.5.1 Administrative definitions

1.5.1.1 *Acceptable*

Complies with the criteria set out in this Standard.

1.5.1.2 *Authorities*

Bodies having statutory powers to regulate the design and erection of formwork.

1.5.1.3 *May*

Indicates the existence of an option.

1.5.1.4 *Construction documentation*

Documents that set out information on the planned construction method for the permanent structure, which are required for the formwork design and construction.

1.5.1.5 *Project documentation*

Drawings, specifications and associated documents that set out the information required for the construction of the permanent structure.

1.5.1.6 *Proprietary documentation*

Brochures, catalogues, drawings, specifications and associated documents that detail proprietary formwork.

1.5.1.7 *Shall*

Indicates a mandatory statement, which has to be strictly followed for compliance with this Standard.

1.5.1.8 *Should*

Indicates a recommendation.

1.5.2 Technical definitions

1.5.2.1 *Access platform*

A platform that is only used or intended to be used to provide access for persons, or for persons carrying material moving to and from places of work.

1.5.2.2 *Action*

Set of concentrated or distributed forces acting on a structure (direct action), or deformation imposed on a structure or constrained within it (indirect action).

NOTE: The term load is also often used to describe direct actions.

1.5.2.3 *Backpropping*

A process by which adjustable supports are placed to give support to the cast in situ concrete during the removal of the soffit formwork, which may also remain in position to act as multistorey shoring (see Figure 1.5.1).

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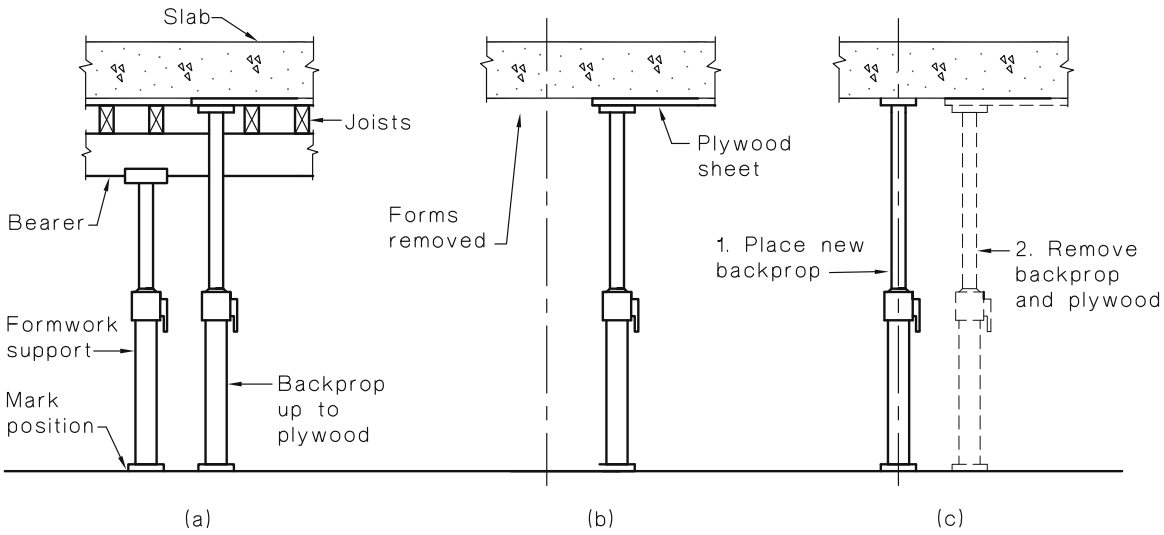

FIGURE 1.5.1 EXAMPLE OF BACKPROPPING

1.5.2.4 *Blowhole*

Shallow pocket or void in the formed surface of the concrete caused by a bubble of fluid or air trapped against the form face.

1.5.2.5 *Bracing*

Members that normally do not support gravity loads but are required to provide lateral stability to other members or to transfer horizontal loads to anchorage or reaction points.

1.5.2.6 *Camber*

The intentional curvature of formwork prior to concrete placement to compensate for the deflection of the formwork or element under load.

1.5.2.7 *Cast in situ concrete*

Concrete that is placed, as plastic concrete, in its final location.

1.5.2.8 *Class of surface finish (or 'Class')*

Standard of the untreated concrete surface of the formed concrete.

1.5.2.9 *Colour control*

The limitation of tonal range of cast in situ concrete and precast concrete.

1.5.2.10 *Component*

A structural member.

1.5.2.11 *Construction joint*

A joint, including a joint between precast segments, that is located for the convenience of construction.

1.5.2.12 *Deflection*

Flexural movement of a structural member or assembly in response to the forces acting on it.

1.5.2.13 *Design working life*

The period for which the formwork is designed to be in use.

1.5.2.14 *Deviation*

The divergence from the specified position.

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1.5.2.15 *Element*

That concrete portion of the permanent structure defined by the formed concrete faces, mandatory joints, construction joints and the completed concrete surfaces, which is cast in one continuous operation.

1.5.2.16 *Falsework*

A part of the formwork that supports the form and transfers all the loads to a stable surface(s) prior to, during and following concrete placement.

1.5.2.17 *Flatness*

The variations in the formed surface resulting from movement of the formwork.

1.5.2.18 *Footing*

A part of the falsework in direct contact with, and transmitting load to, the supporting foundation. A footing may be purpose built, such as a simple sole plate, concrete footing or pile. Alternatively, an element may be used as a footing.

1.5.2.19 *Form*

A part of the formwork that contains and moulds the cast in situ concrete to the required dimensions. It includes the form face and framing.

1.5.2.20 *Form face*

That part of the form which comes in direct contact with the plastic concrete.

1.5.2.21 *Form face deflection*

The undulation of the concrete surface resulting from the deflection of the form face between members of the support framing.

1.5.2.22 *Form liner (also called 'form lining')*

Non-structural material placed on, or part of, the form face to achieve a desired surface finish.

1.5.2.23 *Form tie*

A device that penetrates the formwork, extends through the void for the cast in situ concrete and restrains the formwork movement due to concrete pressure. Also known as 'wall tie' or 'tie rod'.

1.5.2.24 *Formwork*

Temporary works erected to mould and support cast in situ concrete. It consists of a form and, where appropriate, falsework, form bracing and form ties.

1.5.2.25 *Foundation*

Soil, subsoil or rock, whether built up or natural, upon which the permanent structure or the formwork is supported.

1.5.2.26 *Frame*

A falsework component assembled from three or more pieces into a planar unit.

1.5.2.27 *Framing*

Part of the form consisting of primary members and secondary members that support the form face.

1.5.2.28 *Grout loss (also called 'mortar loss')*

The loss of fine material, cement and fine aggregate, from plastic concrete due to openings in the form face.

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1.5.2.29 *Hog*

Negative deflection of a concrete element.

1.5.2.30 *Limit state*

A state beyond which the structure no longer satisfies the design performance requirements.

NOTE: Limit state separate desired state (no failure) from undesired state (failure).

1.5.2.31 *Mandatory joint*

A joint specified in the project documentation.

1.5.2.32 *Permanent form*

A form that it is not stripped.

NOTE: Examples of permanent forms include horizontal precast concrete elements and profiled steel sheeting.

1.5.2.33 *Permanent structure*

The subject of the project documentation.

1.5.2.34 *Plastic concrete*

Concrete that has not yet achieved an initial set.

1.5.2.35 *Precast concrete*

A concrete element produced in a location other than its final location in the permanent structure.

1.5.2.36 *Primary members*

Framing members that directly support the secondary members, (e.g., soldiers, bearers, beams).

1.5.2.37 *Prop*

A structural member loaded in compression.

1.5.2.38 *Proprietary formwork*

Multiple-use or mass-produced formwork systems and/or components.

1.5.2.39 *Reshoring*

The complete strip or relaxation of the soffit formwork followed by the immediate installation or resetting of adjustable supports, which may also remain in position to act as multistorey shoring (see Figure 1.5.2).

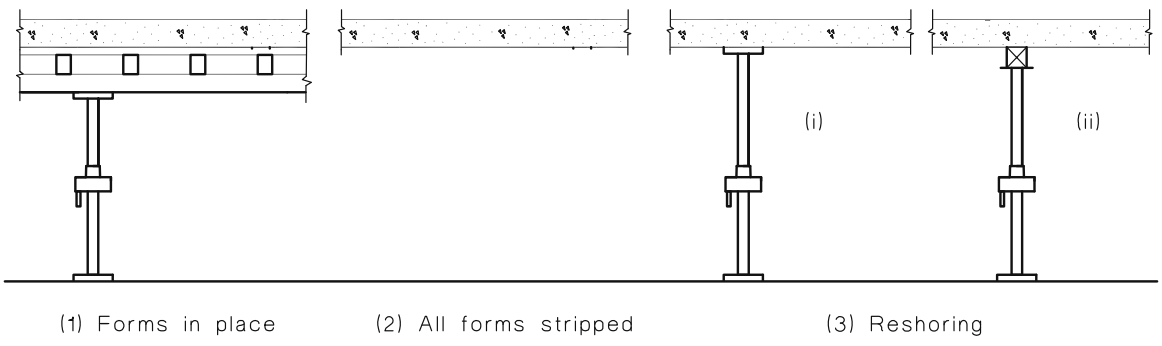

FIGURE 1.5.2 EXAMPLE OF RESHORING

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1.5.2.40 *Secondary members*

Framing members that directly support the form face (e.g., joists and walers).

1.5.2.41 *Service load*

The permanent and superimposed design loads on the permanent structure.

1.5.2.42 *Serviceability limit state*

A limit state of acceptable in-service condition.

1.5.2.43 *Single-use formwork*

Formwork components or systems that are used once.

1.5.2.44 *Soffit formwork*

Formwork for the undersides of slabs, beams, and other similar structural members.

1.5.2.45 *Stacked materials*

Construction materials, such as formwork, bricks and reinforcement, that temporarily load either the formwork or the previously placed concrete.

1.5.2.46 *Strain movement*

Any forced change in the position or dimension of the permanent structure.

1.5.2.47 *Strength limit state*

A limit state of collapse or loss of structural integrity.

1.5.2.48 *Stripping (also called 'striking')*

The removal of formwork from the surface of the hardened concrete.

1.5.2.49 *Structural infill panel*

A panel that does not require backing rails to transfer edge protection design loads to the supporting posts.

1.5.2.50 *Supports*

The falsework members that transmit all or part of the loads to a lower level. This term includes undisturbed supports and equipment for backpropping and reshoring.

1.5.2.51 *Surface treatment*

The removal of a specified depth of the concrete of the permanent surface by a nominated chemical or mechanical means such as acid etching, sand blasting or jack picking. This does not include applied finishes such as coatings or paint.

1.5.2.52 *Surface undulation*

The undulation of the concrete surface resulting from the aggregation of form face deflection, framing deflection and the aggregation of errors in setting, movement of support points and material dimensional tolerances.

1.5.2.53 *Test panel*

A concrete element constructed, prior to the commencement of construction of the permanent structure, as an example of materials and quality of work.

1.5.2.54 *Tolerance*

Permitted variation in dimension.

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1.5.2.55 *Tonal scale*

The graded set of grey tones provided in this Standard, or specified in the project documentation when special-class concrete is used, for evaluation of the colour of the concrete surface.

1.5.2.56 *Undisturbed support*

A support that, as part of a soffit formwork, remains undisturbed until that part of in situ concrete structure is strong enough to support itself even though the soffit form may have been removed earlier, which may also remain in position to act as multistorey shoring (see Figure 1.5.3).

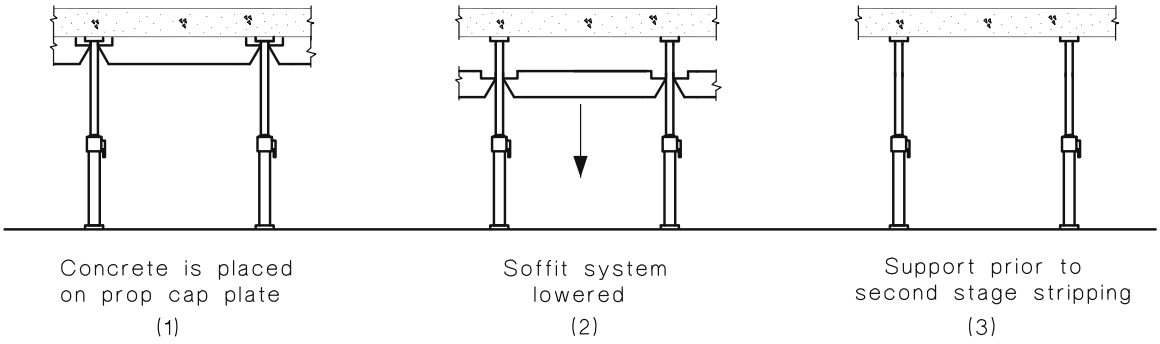

FIGURE 1.5.3 EXAMPLE OF UNDISTURBED SUPPORT

1.5.2.57 *Working platform*

A platform used to provide a working area to support persons and their materials and equipment.

1.5.2.58 *Wrecking strip*

A small strip of formwork that is destroyed to facilitate stripping.

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SECTION 2 DOCUMENTATION

2.1 SCOPE OF SECTION

This Section lists the information that shall be provided in the project, construction, formwork and proprietary documentation.

2.2 PROJECT DOCUMENTATION

2.2.1 General

The project documentation shall include the specific requirements of the project including—

(a) a description of the concrete element and any conditions relating to its production; and

(b) matters associated with the formwork construction, concrete placement or stripping, which are critical to the strength and serviceability of the permanent structure.

NOTES:

1 The purpose of the project documentation is to ensure that all necessary requirements are fully and accurately communicated to those concerned with the design, construction and stripping of the formwork.

2 Attention is drawn to the need to review the formwork documentation to ensure it meets the requirements of the project documentation.

2.2.2 Documentation

The project documentation shall include the following information, where applicable:

(a) Plans, elevations and sections showing details and dimensions of the elements to be formed.

(b) Minimum stripping times and procedures.

(c) Any limitations on the magnitude and locations of construction loads (e.g., stacked materials) in relation to the minimum concrete strength to be achieved prior to the application of the loads.

(d) The method of multistorey shoring (e.g., undisturbed shores, backpropping or reshoring), the minimum number of levels, layout and load distribution among the supports relative to the type of formwork, timing and sequence of its use, the anticipated time between construction of subsequent floors and the expected ambient temperature during construction of the permanent structure.

(e) Limitations on the use of the permanent structure or existing structures for the restraint of the formwork.

(f) Information on the magnitude, location and any redistribution of construction loads the formwork must support (e.g., the effect of post-tensioning procedures).

(g) Location of any mandatory joints and any special procedures for locating construction joints.

(h) Sequence of placement of the concrete, if this is critical.

(i) Requirements for propping of any composite construction.

(j) Details of the camber of any slabs or beams.

(k) Service loads.

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(l) Details of any inserts, waterstops, specially formed shapes, or penetrations to be constructed, that are critical to the serviceability of the permanent structure.

(m) Any information about the foundation that is relevant to the design of the footings for the falsework.

(n) Information about any permanent form systems, together with any limitations on deflection and any special requirements for their erection and concreting.

(o) Information on the critical face of elements (see Clause 3.3.3.3), any special measuring points and more stringent tolerances for any small areas (see Table 3.3.2).

(p) The details set out in Table 3.3.1 relating to surface finish, colour control, surface treatment, critical elements, tolerances and repairs, where relevant, for all surfaces of the permanent structure.

(q) Details of any special-class concrete required under Clause 3.4.2 with the tonal scale to be used under that Clause if the concrete colour is unsuited to the tonal scale shown in Appendix A.

(r) Where an 'X' suffix is used as defined in Clause 3.2, all relevant information relating to Tables 3.3.1 and 3.3.2.

(s) Details of test panels [see Clause 3.5 and Clause 5.2.1(c)].

(t) Information on any architectural details to be cast into the concrete.

(u) Information on specified concrete ingredients or admixtures that may affect the concrete finish by, but not limited to—

(i) retarding setting of the concrete;

(ii) causing excessive blow holes on the surface of the concrete; and

(iii) affecting colour control.

2.3 CONSTRUCTION DOCUMENTATION

2.3.1 General

The construction documentation shall set out specific requirements of the planned construction that affect the formwork.

NOTES:

1 The purpose of the construction documentation is to ensure that all necessary requirements are fully and accurately communicated to those concerned with the design, construction and stripping of the formwork.

2 Attention is drawn to the need to review the formwork documentation to ensure it meets the requirements of the construction documentation.

2.3.2 Documentation

The construction documentation shall include the following, where applicable:

(a) Details of any anticipated changes to the project documentation.

(b) Construction method, sequence and schedule.

(c) Location of construction joints required in addition to those specified in the project documentation.

(d) Relevant details of the plant and equipment to be used in the construction.

(e) Details of the interface between the formwork and other construction equipment and activities.

(f) Information on construction activities and constraints that affect the formwork.

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(g) Information on construction loads the formwork must support and any redistribution of loads.

(h) Requirements of access, egress and edge protection that affect the formwork.

(i) Documentation for equipment, material or components to be incorporated in the formwork.

(j) Plans for transporting, handling, moving and re-use of the formwork.

(k) Method and rate of concrete delivery, placement sequence, discharge heights and rate of rise.

(l) Information on the concrete ingredients or admixtures that may affect the concrete finish by but not limited to—

  (i) retarding setting of the concrete;

  (ii) causing excessive blow holes on the surface of the concrete; and

  (iii) affecting colour control.

2.4 FORMWORK DOCUMENTATION

2.4.1 General

The formwork documentation shall set out the requirements of the formwork design. The formwork design shall comply with the project and construction documentation. The formwork documentation shall contain a statement that the formwork design and documentation complies with AS 3610.

2.4.2 Documentation

The formwork documentation shall include the following, where applicable:

(a) Plans, elevations and sections sufficient to depict the general arrangement of the formwork and to identify and locate all members, including bracing.

(b) Details sufficient to fully describe important or unusual features of the design.

(c) Method statement covering the erection and stripping of formwork.

(d) Reference to proprietary documentation (see Clause 2.5).

(e) Where non-destructive test methods are to be used to evaluate the structural capacity of formwork, the appropriate test load and details of the test procedure.

(f) Acceptance criteria for single-use formwork.

(g) The areas of the formwork designed to carry stacked materials.

(h) Requirements of the project and construction documentation that relate to formwork, as specified in Clauses 2.2 and 2.3.

(i) Method of field adjustment of the formwork.

(j) Where required, location of inserts, weepholes, vibrator holes, clean-out holes, and inspection openings.

(k) Sequence and method of concrete placement and the minimum elapsed time between adjacent placements.

(l) Location and details of construction joints.

(m) Stripping procedures, including details and placement of wrecking strips and other details relating to stripping.

(n) Details of deviation indicators, if required.

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(o) The design assumptions in accordance with AS 3610, as follows:

(i) Permanent actions.

(ii) Imposed actions.

(iii) Accidental actions.

(iv) Concrete pressure and the parameters used to determine its magnitude including wet density of concrete, rate at which concrete rises vertically up the formwork, type of cement, percent content of fly ash and slag, concrete temperature at placement, form height, concrete discharge height and vertical pour height.

(v) Whether the design allows for any admixture that has a retarding effect to be used in the concrete.

(vi) Environmental actions.

(vii) Other actions.

(viii) Permitted imperfections.

(p) The footing design assumptions, such as foundation material description, minimum bearing value, limitations on settlement during Stages I, II and III. Reference to information sources such as geotechnical reports should also be included.

(q) Preparation of the foundation, such as filling, compaction, drainage and precautions against flooding.

(r) The footing details such as type, size and relevant levels.

(s) Details of materials and components; including the type, quality, grade and, where applicable, the relevant Australian Standard.

(t) Application and type of form oil and any other specialist surface finish requirements such as rope finish.

2.5 PROPRIETARY DOCUMENTATION

2.5.1 General

The proprietary documentation shall set out the information required for the correct use of proprietary formwork.

2.5.2 Documentation

Proprietary documentation shall include the following information:

(a) Drawing or pictorial representation that clearly identifies the formwork to which it refers.

(b) Adequate information to fully describe its intended use and any limitations thereto.

(c) Instructions for use and, where applicable, maintenance of the formwork.

(d) The strength and serviceability limit state capacities in accordance with AS 3610.

(e) The working load capacity as calculated in accordance with AS 3610.

(f) A statement that the formwork depicted in the documentation complies with AS 3610.

(g) Detailed information including, where appropriate—

(i) part number;

(ii) dimensions;

(iii) section properties;

(iv) weight;

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(v) any permanent camber built into the item;

(vi) details of any special attachments (e.g., access brackets, hand rail posts, plumbing feet); and

(vii) locations for tie bolts or support points.

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SECTION 3 SURFACE FINISH AND COLOUR CONTROL

3.1 SCOPE OF SECTION

This Section sets out the classification of surface finish and specifies requirements for the physical quality and colour for both cast in situ concrete and precast concrete and the matters to be advised in relation to these in the project documentation.

It applies to—

(a) the surface finish of formed and stripped concrete surfaces;

(b) the requirements for the project documentation related to surface finish as listed in Section 2; and

(c) the provisions and use of test panels for both cast in situ concrete and precast concrete.

This Section does not apply to unformed concrete surfaces, treated surfaces (for example, where the surface is treated with a secondary finishing operation using chemical or mechanical means), or to the faces of concrete elements constructed using permanent forms.

3.2 CLASSES OF SURFACE FINISH AND COLOUR CONTROL

3.2.1 General

There are five classes of surface finish. The physical qualities of each of these classes, and their applicability, shall be as specified in Table 3.2.1.

3.2.2 Notation

The selected class of surface finish shall be denoted by the appropriate numeral from 1 to 5. Where colour control is incorporated this shall be denoted by the suffix C following the surface finish class numeral (see Note 1). Where any additional feature (extra) is specified in the project documentation, the suffix ‘X’ shall be added (see Note 3).

NOTES:

1 Attention is drawn to Clause 3.4.1, which prohibits colour control for Class 4 and Class 5.

2 Attention is drawn to Table 3.3.2, which limits the extent to which values that are more stringent than those assigned to the selected class can be specified.

3 For example, 2C denotes Class 2 with colour control. 2X and 2CX are valid descriptors of surface specifications that are either extra or exceptions to the Standard.

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TABLE 3.2.1

APPLICABILITY OF SURFACE CLASSES

	Class 1 (see Note 1)	Class 2	Class 3	Class 4	Class 5
	Visual quality important			Visual quality not significant	
Visual characteristics	Highest quality attainable Subject to close scrutiny Best possible uniformity of texture Excellent quality of edge and joint details	Uniform quality and texture over large areas Built to close tolerances Consistently good quality to edge and joint details	Good visual quality when viewed as a whole	Texture not important Good general alignment	Alignment and texture not important
Suitable uses	Selected small elements contained in a single pour Areas of special importance in limited quantities	General external and internal facades intended to be viewed in detail	General external and internal facades intended to be viewed as a whole	Surfaces concealed from general view Surfaces to have thick applied finishes after preparation	Totally concealed areas
Surface treatment	Not applicable	Reference shall be made to acceptable surface appearance and measurable deviations prior to surface treatment			Not suitable
Situations where not to be used	Trafficable slopes, soffits, formed tops of slopes except where means to dissipate entrapped air are employed, form liners. Not applicable where treatment is to 100% of surface	Formed tops of slopes except where means to dissipate entrapped air are employed	No restriction		
Colour control	May be specified. Refer to Clause 3.5.3(b) for the limits of the best colour consistency that can be expected			Excluded	
General	If Class 1 and Class 2, Class 3, Class 4 and Class 5 are required they shall be specified in the project documentation		If Class 1 and Class 2, Class 3, Class 4 and Class 5 are not specified in the project documentation, selection of appropriate class shall be by the visual characteristics and suitable uses set out above		

NOTES:

1 Class 1 is the highest standard with the most rigorous specification and is only recommended for use in very special features of buildings of a monumental nature. Class 1 shall not be specified for whole elevations or extended surface areas.

2 Different methods of forming elements and repair may affect the texture of the surface finish. It is essential that test panels take this into account.

3.3 PHYSICAL QUALITY

3.3.1 General

The physical quality of the concrete surface shall be specified under a class numeral in accordance with Table 3.2.1. If the class is not specified in the project documentation, the quality of the off-form surface is not required to be superior to Class 3.

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3.3.2 Project documentation requirements for surface finish

The project documentation shall include, where appropriate, the information required in Table 3.3.1.

3.3.3 Tolerances

3.3.3.1 *General*

The tolerances given in this Section shall be read in conjunction with those given in AS 3600. These tolerances apply to the as-cast formed surface prior to surface treatment, if any.

Tolerances in AS 3600 take precedence where more stringent than those specified in this Section.

NOTE: Surface treatment includes applied finishes, acid etching, sandblasting and polishing.

3.3.3.2 *Measurement*

The tolerances given in this Section shall apply to the permanent structure. Other than for those cases where strain movement of the permanent structure is possible, including the effects of prestress and post-tensioning, the deviations shall be measured on the surface of the concrete after the removal of any forms or supports and before any surface treatment. Where strain movement of the concrete is possible, deviations shall be measured prior to removal of any forms or supports or application of prestress or post-tensioning. Evaluation of the completed work shall comply with the requirements of Clause 5.2.2.

NOTES:

1 In some circumstances, the measurement of deviations prior to the removal of the formwork will be impractical (e.g., where formwork rests on ground). In such cases, a practical procedure should be specified in the project documentation.

2 Requirements on the frequency and distribution of the measurement of deviations are given in Tables 3.3.2, 3.3.3, Clause 3.3.5 and Section 5. The value of prestress or post-tensioning strain (hog and shortening) is influenced by variation in material properties in a similar way to that of other permanent load effects (see AS 3600).

3.3.3.3 *Critical face*

Where a concrete element has several faces each with an equal class of surface finish, the project documentation shall specify which faces take precedence in the checking of deviations. Where the opposite faces are of different classes then the face with the higher quality shall take precedence in the checking.

3.3.4 Acceptable quality of surface finish

Table 3.3.2 gives tolerances for surface defects, flatness and out-of-plumb which represent the acceptable quality appropriate to each class.

Tolerance values more stringent than those given in Table 3.3.2 shall not be specified for the whole area of the element. In particular circumstances, for small areas, more stringent tolerances, which are achievable, may be specified in the project documentation.

NOTES:

1 This should be considered when designing junctions with other forms of construction such as window framing, brickwork, etc.

2 For elements where light shown across a surface at a flat angle, particularly in the case of smooth glossy finishes, the surface tolerances specified in the Table 3.3.2 may not be appropriate and alternative finishes should be considered.

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3.3.5 Precast concrete elements

3.3.5.1 *General*

For the specified class of surface finish, as appropriate, Clause 3.3.4 shall apply to precast concrete, except for where the shape of a precast unit is such that there is conflict between Clause 3.3.4 and Clauses 3.3.5.2, 3.3.5.3 in which case Clauses 3.3.5.2 and 3.3.5.3 shall take precedence.

3.3.5.2 *Tolerance classification for precast concrete*

Tolerances for precast concrete shall be classified as follows:

(a) *Type L—Tolerances in linear dimensions* Tolerances in linear dimensions cover thickness, width, length, and cross-section (see Figure 3.3.1).

(b) *Type A—Tolerances in angular dimensions* Tolerances in angular dimensions cover squareness or trueness to any specified angle (see Figure 3.3.2). Angular tolerance for squareness shall be expressed in terms of the distance by which a shorter side of the precast unit deviates from a straight line perpendicular to the longer side and passing through the corner of the unit. Trueness to an angle other than 90° shall be expressed in similar terms, but setting the check line in the specified angle.

(c) *Type P—Tolerances in profile* Tolerances in profile cover flatness, straightness, warp and twist (see Figure 3.3.3) as follows:

(i) Flatness tolerance shall be expressed as the maximum acceptable distance by which any point on a nominally plane surface may be from a 3 m long straightedge placed anywhere on the surface and parallel to the nominally plane surface.

(ii) Straightness tolerance shall be expressed as the maximum distance by which any point on an edge of a unit may be from a straight line drawn through the extremities of the particular edge.

(iii) Warp tolerance shall be expressed as the maximum acceptable distance of any point on a surface from a plane containing any three corners of the surface or points on the perimeter of the unit. If the surface is not a rectangle these three corners shall be those points on the surface that are the corners of a rectangle covering the greatest possible surface area of the unit.

(iv) Twist tolerance shall be expressed as the rotation of one end relative to the other end or relative to some other line or surface specified by the project documentation.

NOTE: The sequence for checking the above tolerances is defined in Clause 5.3.1.

3.3.5.3 *Tolerance values*

Precast concrete shall be manufactured within the acceptable deviations given in Table 3.3.3.

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TABLE 3.3.1

PROJECT DOCUMENTATION REQUIREMENTS FOR CLASS OF SURFACE FINISH

		Class 1	Class 2	Class 3	Class 4	Class 5	Reference
1	Test panels:						
	For untreated surfaces	TBS	TBS	OPT	N/A	N/A	Clause 3.5
	For colour control	TBS	TBS	TBS	N/A	N/A	
	For treated surfaces	TBS	TBS	TBS	N/A	N/A	
2	Form tie pattern	SIA	SIA	OPT	N/A	N/A	
3	Form liner details, pattern and accuracy	N/A	SIA	SIA	N/A	N/A	Table 3.2.1
4	Surface pattern details and accuracy	SIA	SIA	SIA	N/A	N/A	
5	Surface treatment pattern of part of surface	SIA	SIA	SIA	N/A	N/A	Table 3.2.1
6	Surface treatment of whole of surface	N/A	SIA	SIA	N/A	N/A	Table 3.2.1
7	Form face span and direction of span	OPT	OPT	N/A	N/A	N/A	Table 3.3.2
8	Critical faces of elements	SIA	SIA	SIA	SIA	N/A	Clause 3.3.3.3
9	Face steps	OPT	OPT	OPT	N/A	N/A	Table 3.3.2
10	Plumb of elements height >8 m	SIA	SIA	SIA	SIA	SIA	
11	Repairs (See Note)	OPT	ACC	ACC	ACC	ACC	Clause 5.5
12	Colour control	SIA	SIA	SIA	NA	NA	Clause 3.4

LEGEND:

TBS To be specified—these are mandatory project documentation requirements for all work where the particular class of surface finish has been specified

NA Not applicable—these are matters that are not applicable to the particular class of surface finish

OPT Optional—these are matters that may be included in the project documentation

SIA Specify if applicable—these are mandatory where the particular feature is included in the project documentation

ACC Acceptable—repairs to these classes are acceptable.

NOTE: Repairs to Class 2, Class 3, Class 4 and Class 5 marked ACC shall not be excluded by the specification.

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TABLE 3.3.2
ACCEPTABLE QUALITY OF SURFACE FINISH

	Quality of surface finish	Class 1	Class 2	Class 3	Class 4	Class 5	Ref. Clause
1	Blowholes (see Appendix A) (visual quality at least equivalent to)	Photo 1(a), 1(b)	Photo 2(a), 2(b)	Photo 3(a), 3(b)	N/A	N/A	5.2.1(a)
2	Form face deflection (not greater than)	Lesser of 2 mm or span/360	Lesser of 3 mm or span/270	Span/270	Span/270	N/A	5.2.2(b)

		Maximum tolerance for straight elements with smooth surface, in mm										
	Percentage of readings	**95**	**100**	**90**	**100**	**80**	**100**	**70**	**100**	**70**	**100**	
3	Face step:											5.2.2(d)
	(a) Within the element	1	2	2	3	3	5	5	8	*	*	
	(b) At in situ construction joint	2	3	2	3	3	5	5	8	*	*	
4	Surface undulations											
	(a) l = 300											
	$(a - b) \leq$	1	2	2	4	3	4	5	7	*	*	5.2.2(c)
	(b) l = 1500											
	$(a - b) \leq$	2	4	3	6	5	7	8	10			
5	Flatness:											5.2.2(e)
	(a) 1.25 m grid	4	5	6	7	7	10	*	*	*	*	
	(b) at 5 m over 10 m (not applicable to precast concrete)	5	7	7	10	10	15	*	*	*	*	
6	Out-of-plumb:											5.2.2(f)
	(a) height <3 m	3	5	4	6	5	7	*	*	*	*	
	(b) 3 ≤ height <8 m (not applicable to precast concrete)	6	8	8	10	10	12	*	*	*	*	

LEGEND
N/A 'Not Applicable'

NOTES:

1 The photos in Appendix A shall be used only for the purpose of evaluating blowholes sizes and distribution.

2 The Table provides tolerances for surface finish which may vary from those given in AS 3600.

3 Where tolerances are marked with an asterisk (*) this indicates that AS 3600 tolerances can generally be adopted; however, larger dimensions may require a maximum to be specified.

4 The values given in the Table for the acceptable minimum quality for a particular class of surface finish may be relaxed. This relaxation shall be signified by the use of 'X' suffix to the notation.

5 Tolerances in AS 3600 govern where more stringent than those specified in this Section (in particular when the acceptable minimum quality may be relaxed as signified by the use of 'X' suffix to the notation). Full details of such matters shall be given in the project documentation.

6 Where surface treatment is specified, recognition should be made of the facility for the surface treatment to remove irregularities. Less stringent tolerances may then be appropriate.

7 The percentage of readings means that of all the readings taken, the nominated percentage shall not exceed the specified tolerance, that is, for face Step (a), 95% of the readings shall have a face step not exceeding 1 mm and 100% readings shall have a face step not exceeding 2 mm.

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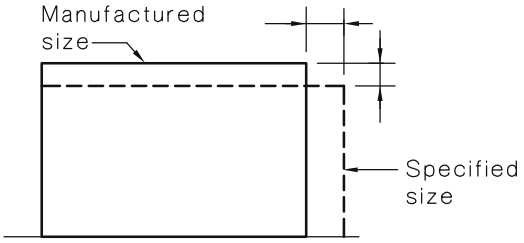
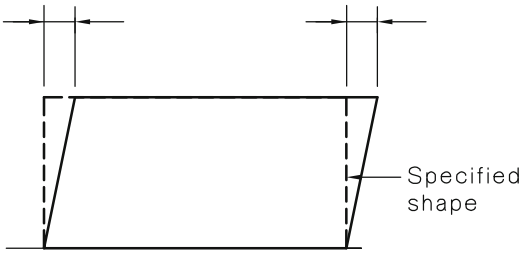


FIGURE 3.3.1 PRECAST CONCRETE—TOLERANCES IN LINEAR DIMENSIONS



NOTE: Out-of-squareness may affect measurement of tolerances in linear dimensions.

FIGURE 3.3.2 PRECAST CONCRETE—TOLERANCES IN ANGULAR DIMENSIONS

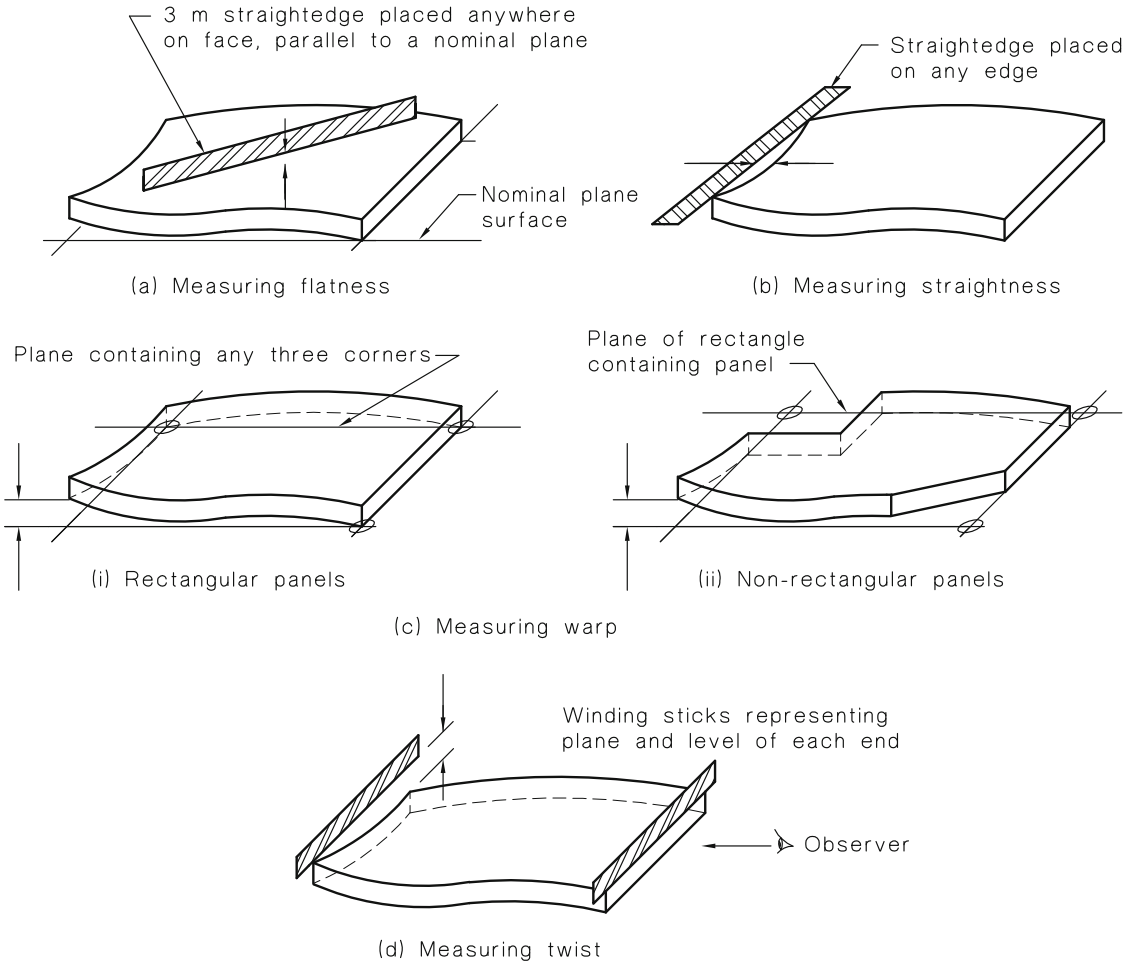


FIGURE 3.3.3 PRECAST CONCRETE—TOLERANCES IN PROFILE

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TABLE 3.3.3
ACCEPTABLE DEVIATIONS FOR PRECAST CONCRETE UNITS

Tolerance classification	Description			Acceptable deviation, mm	
				Plus	Minus
Linear dimensions	Dimensions of flat panels	Panel length or width	<3 m	3	3
			≥3 m <6 m	6	6
			≥6 m	6	6
		Panel thickness at any location		3	3
		Openings length or width		3	3
	Dimensions of units other than flat panels	Cross-section overall dimensions	<600 mm	3	3
			≥600 mm <1500 mm	6	6
			≥1500 mm	10	6
		Cross-section, dimensions of parts such as webs, ribs or flanges	≤1500 mm	6	6
			>1500 mm	10	6
		Length, critical dimensions of abutting members		0	6
		Length, non-critical	<6 m per metre length	3	3
			≥6 m per metre length	6	6
	Features in all units	Diameter or side dimensions of core holes, ducts or similar		3	3
		Width or depth of grooves		2	2
		Location of grooves and fastenings for window frames, doorframes and similar features		3	3
		Location of grooves or strips for flashings		6	6
		Location of electrical outlets and similar features		12	12
		Other requirements		As specified*	As specified*
		Irregular curved or unusual shapes		As specified*	As specified*
		Position of individual connecting bolts, bolt holes, projecting metal or other devices in any associated group (e.g., the joint of two precast units), with respect to their position in the group		3	3
		Longitudinal location of any group of bolts, bolt holes, projecting metal or other devices, with respect of its true position in the unit in which the group is cast		6	6
Angular dimensions	Squareness of corners	Up to 2 m on shorter side		3	3
		Over 2 m, up to 4 m		5	5
		Over 4 m		6	6
Profile	Straightness of edges and flatness of surfaces				
	Warp	Per metre width, in 3 m length		3	3
	Twist	Per metre width, in 3 m length		3	3

* As given in the project documentation

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3.4 COLOUR CONTROL OF SURFACES TO REMAIN UNTREATED

3.4.1 General

The control of the colour of concrete surfaces may only be imposed on surface finish Class 1, Class 2 and Class 3.

NOTE: Attention is drawn to Clause 3.2.2, which specifies the notation to be used when colour control is specified.

3.4.2 Concrete colour

Where colour control is required, the concrete for this work shall be specified as 'special-class concrete' in accordance with AS 3600. The project documentation shall be consistent with the achievement of the required colour.

NOTE: Methods for specifying concrete colour include tonal scales similar to that in Figure A4, Appendix A, for grey concrete, laboratory samples, test panels, etc.

3.4.3 Range of tonal variations

For concrete that is grey in colour, the tonal scale specified in Appendix A may be used. For concrete of other colours or where the grey is not within the range of Figure A4, Appendix A, the project documentation shall contain a means of determining and recording the acceptable tonal range.

3.4.4 Acceptable tonal range

The acceptable tonal range for the cast in situ and precast concrete shall be determined from the accepted test panel and the requirements of Clause 3.5.3(b). Where a tonal scale is used, the tonal range of the accepted test panel shall be recorded as set out in Clause 5.4.

Elements that exhibit a range of tones, when evaluated in accordance with Clause 5.4, which are not outside the range of tones recorded from the test panel, shall be deemed to comply with Clause 3.4.

3.5 TEST PANELS

3.5.1 General

The provision of test panels are as follows (see Table 3.3.1):

(a) *Mandatory use* Test panels shall be provided where any of the following have been specified:

  (i) Class 1 or Class 2 untreated surfaces.

  (ii) Colour control.

  (iii) Surface treatment.

(b) *Optional use* For work having Class 3 surface finish, test panels may be specified.

(c) *Exclusion* Test panels are not applicable to work having Class 4 or Class 5 surface finish, and shall not be specified.

3.5.2 Details

3.5.2.1 *Precast concrete*

Test panel(s) for precast concrete shall either be—

(a) a single panel to serve more than one application (see Clause 3.5.1(a)); or

(b) separate test panels, detailed and specified in the project documentation for each of the three applications required in Clause 3.5.1(a).

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3.5.2.2 *Cast in situ concrete*

Test panel(s) for cast in situ concrete shall comply with either one of the following:

(a) The requirements of Clause 3.5.2.1.

(b) If there are no details given in the project documentation, a test panel complying with this Standard and consistent with the relevant surface area shall be required. The panel(s) shall incorporate all relevant features of the surface (e.g., the form tie pattern and type, joints to adjacent elements, grooves, rebates, openings and corners) and shall be consistent with the requirements of the project documentation. The test panel(s) shall be reinforced in a manner similar to the cast in situ concrete.

3.5.3 Evaluation

Test panels shall comply with the following requirements:

(a) *Physical quality* When evaluated in accordance with Clause 5.2, the surface of the test panel shall comply with the requirements of Table 3.3.1, Table 3.3.2 or Table 3.3.3, as applicable.

(b) *Colour control* The tonal range of the accepted test panel, as well as the final work, shall be determined by the use of either the tonal scale or the other means referred to in Clause 3.4.3. For surfaces with colour control, the appropriate test panel shall be used to fix the standard required for the final work. The tonal (colour) range to be accepted within the test panel is given in Table 3.5.3.

NOTE: Where the concrete colour is such that the grey tonal scale is not suitable, then the approved test panel may have tonal variations that are consistent with the intent of Table 3.5.3.

TABLE 3.5.3

TONAL RANGES, GREY SCALE
(See Appendix A)

Class	Minimum tonal range (tones)
1	4
2	5
3	6

CTable 3.5.3 *The tonal range illustrated in Figure A4, Appendix A, is not intended to represent the actual colour of the concrete but to indicate a range in the tones of the colour specified in Table 3.5.3. Hence, Class 1 concrete may have a colour towards the dark end of the range in Figure A4, provided the tonal range is not less than 4 tones. For the specified Class, the project documentation may permit a greater tonal range than the minimum number of tones shown in Table 3.5.3.*

(c) *Surface treatment* The surface treatment of the test panel shall comply with the project documentation in accordance with Table 3.3.2 and shall have acceptable surface details and texture.

(d) *Surface repair* The surface repair of a test panel shall comply with the project documentation in accordance with Table 3.3.2 and shall have acceptable surface details and texture.

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SECTION 4 CONSTRUCTION

4.1 SCOPE OF SECTION

This Section sets out the requirements for the construction of formwork. Specific requirements are included for—

(a) acceptance criteria for formwork;

(b) fabrication, erection and stripping of formwork; and

(c) multistorey structures.

4.2 APPLICATION OF SECTION

This Section applies to the construction of the formwork for both in situ and precast concrete. The requirements of this Section apply in addition to the instructions given in the formwork documentation (see Clause 2.4).

4.3 GENERAL REQUIREMENTS

4.3.1 General

The formwork shall be erected, used and maintained in a manner that will ensure—

(a) stable formwork throughout all stages of construction;

(b) compliance with the project documentation, construction documentation and formwork documentation; and

(c) there is no partial or complete dislodgment of any component.

NOTE: Clause 2.4 sets out requirements for the content of the formwork documentation.

4.3.2 Stages of construction

The various stages of construction are as follows:

(a) *Stage I* Prior to placement of concrete, including the period—

  (i) during handling and erection of the formwork; and

  (ii) when the formwork is erected, but prior to placement of concrete.

(b) *Stage II* During placement of concrete.

(c) *Stage III* After placement of concrete, and until the formwork is removed.

4.3.3 Access and edge protection

4.3.3.1 *Access*

Safe access to and egress from all formwork areas shall be provided. Access may take the form of access platforms, stairways, portable ladders or other means.

Access platforms and stairways constructed of scaffolding shall comply with AS/NZS 1576.1 and AS/NZS 1576.3 or AS/NZS 1576.6. Portable ladders shall be single ladders complying with the industrial grade requirements of AS/NZS 1892.1 or AS 1892.2.

Other means of access shall comply with the performance requirements of AS 1657.

4.3.3.2 *Edge protection*

Where edge protection is required, it shall be provided by one of the following means:

(a) Safety screens extending from one working platform to the working platform above.

(b) Edge protection complying with AS 1657.

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(c) Scaffolding equipment.

Safety screens shall comply with the performance requirements of AS 1657. Scaffolding equipment shall comply with AS/NZS 1576.1 and AS/NZS 1576.3 or AS/NZS 1576.6. Scaffolding equipment used as edge protection shall comply with the operational requirements specified in AS/NZS 1576.1.

NOTE: Attention is drawn to authorities' requirements on working at heights.

4.3.3.3 *Omission of edge protection*

Edge protection or components of edge protection may be omitted at points of access from a ladder, stairs or at edges of platforms adjacent to the floor or face of a building or structure, provided the operational requirements of AS/NZS 1576.1 are complied with.

4.3.4 Components

All formwork components shall be of the specified type and material grade (see Clause 4.3.5).

Proprietary formwork shall comply with—

(a) the acceptance criteria of Table 4.3.1; or

(b) where components do not meet these criteria they shall be deemed to comply following satisfactory proof testing under the provisions of AS 3610.

Single-use formwork shall comply with the acceptance criteria specified in the formwork documentation.

All formwork components shall be assembled in accordance with the formwork documentation and requirements of this Section.

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TABLE 4.3.1

ACCEPTANCE CRITERIA FOR ASSEMBLIES AND COMPONENTS

Component	Required condition	Acceptable deviations		Connections	End-to-end bearing surfaces	Eccentricity of loading
		Out-of-straightness	Out-of plumb			
Tube and coupler	Free from splits, cracks, visible tube deformations, rust and dents (see Notes 3 and 4)	For tube, not to exceed *L*/300 mm. Refer to Figure 4.3.1(a)	Verticals to be within *L*/200 or a maximum of 40 mm, unless more stringent requirements are specified in the formwork or proprietary documentation. Refer to Figure 4.3.1(b)	Centre-lines of tubes at node points to be as close as possible and never more than 150 mm apart. See Figure 4.3.1(d)	Where the junction of members intended to be assembled with end to end bearing and compression have been damaged, they shall have the mating surfaces within 1° of square with no local protrusion in excess of 1 mm. Refer to Figure 4.3.1(c)	For components intended to be placed centrally under supported members, the eccentricity shall not exceed the more stringent criteria specified in the formwork documentation and proprietary documentation
Props	Inner and outer tubes free from splits, cracks, visible deformations, rust and dents (see Notes 3 and 4)	For each member (inner and outer), not to exceed *L*/300 mm of individual length. Refer to Figure 4.3.1(a)		As per formwork and proprietary documentation	As per formwork and proprietary documentation	
Frames and modular shoring systems	Free from splits, cracks, visible tube deformations, rust and dents (see Notes 3 and 4)	For each member not to exceed *L*/300, where *L* is the overall length of each member in the frame, unless more stringent requirements are specified in the formwork or proprietary documentation				
Threaded component	Threads free from visible wear and deformation. In the case of threaded hollow sections, free from splits, cracks, visible tube deformations, rust and dents (see Notes 3 and 4)					

(*continued*)

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TABLE 4.3.1 (*continued*)

Component	Required condition	Acceptable deviations		Connections	End-to-end bearing surfaces	Eccentricity of loading
		Out-of-straightness	Out-of plumb			
Other proprietary components	As specified in the proprietary documentation					
Timber assemblies and components	All timber and timber products shall be in accordance with the relevant Australian Standard. Assemblies and components shall be used in accordance with the proprietary documentation					

NOTES:

1 Attention is drawn to the possibility of cumulative errors and the need to consider this effect on the total system.

2 Attention is drawn to the possibility of the formwork documentation or proprietary documentation specifying more stringent accuracy than those specified in this Table.

3 Visible deformations and dents for tubes, props, frames and modular scaffolds should not normally exceed 4 mm or 1/15th of the member diameter.

4 Assemblies and components shall be free from the results of corrosion (e.g., rust), which may impair their strength or efficiency.

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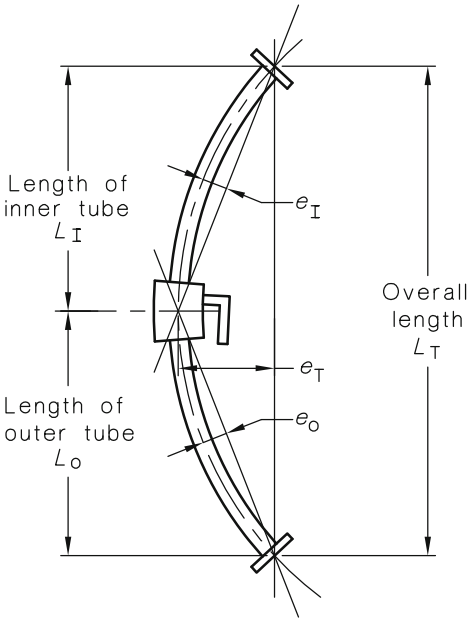


e_o shall not be more than $\frac{L_o}{300}$

e_I shall not be more than $\frac{L_I}{300}$

e_T shall not be more than $\frac{L_T}{300}$

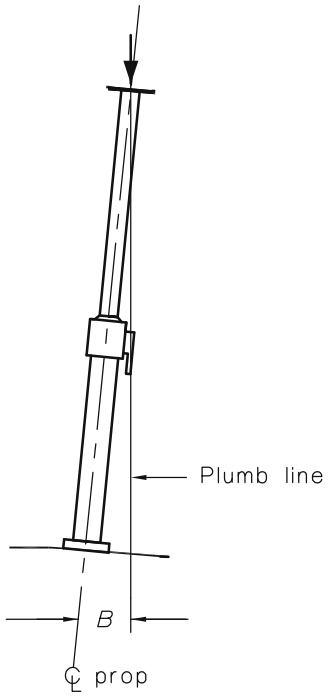
where

e_o = eccentricity of outer tube

e_I = eccentricity of inner tube

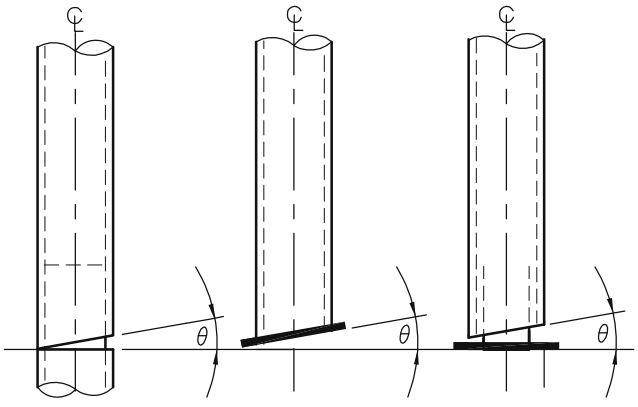
e_T = eccentricity of overall prop length

(a) Out of straightness



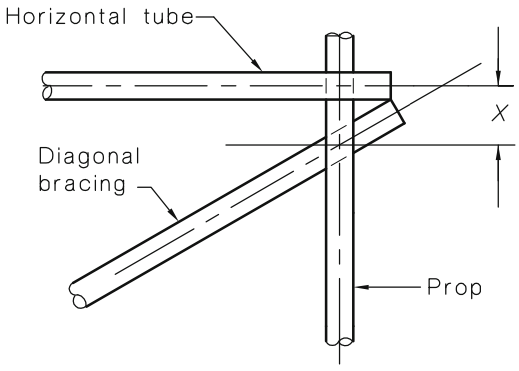
B shall be the lesser of $\frac{L}{200}$ or max. 40 mm

(b) Column inclination



θ shall be not more than 1°

(c) Ends of bearing surfaces



X shall be not more than 150 mm

(d) Node point connection

FIGURE 4.3.1 ACCEPTABLE DEVIATIONS

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4.3.5 Materials

All materials used in formwork shall be in accordance with the relevant Australian Standards. Used materials shall have structural characteristics at least equal to those of the specified materials. Where there is no relevant Australian Standard, the materials shall be demonstrated as having structural characteristics that will result in the formwork satisfying the requirements of this Standard and, in particular, being suitable for use as formwork during its design working life (see Clause 1.4).

4.3.6 Unidentified components and materials

Where it is not possible to identify components or materials as being of the type and grade specified in the formwork documentation they shall not be used in the formwork.

4.4 FORMWORK CONSTRUCTION—IN SITU CONCRETE

4.4.1 Stage I of construction—Formwork erection

4.4.1.1 *General*

All formwork shall be—

(a) in accordance with the formwork documentation; and

(b) erected so that the finished concrete is within the required tolerances.

4.4.1.2 *Foundations*

The formwork shall be founded on material that complies with the formwork documentation.

4.4.1.3 *Footings*

Where the falsework is not supported on a permanent structure, the footings shall be constructed in accordance with the formwork documentation.

Where on-site foundation conditions differ from those described in the formwork documentation, a revised design shall be obtained. Alternatively, the foundation material may be modified to satisfy the requirements of the formwork documentation.

4.4.1.4 *Stability*

The stability of the formwork shall be maintained throughout the erection procedure.

4.4.1.5 *Deviation indicators*

Where specified by the formwork documentation, deviation indicators shall be installed to monitor formwork movements.

4.4.1.6 *Forms*

The forms shall be constructed in accordance with the formwork documentation.

The form face material shall be compatible with the specified class of surface finish.

4.4.2 Stage I of construction—Formwork inspection

4.4.2.1 *General*

The formwork shall be inspected during Stage I, when complete and prior to the placement of concrete during Stage II. The inspection(s) shall confirm compliance with the requirements of the formwork documentation and AS 3610.

The criteria for acceptance of the formwork shall be as specified in Clauses 4.4.2.2 or 4.4.2.3, as appropriate.

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4.4.2.2 *Formwork documentation*

The formwork shall comply with the requirements of the formwork documentation. In particular, the following shall be checked:

(a) *Scope of formwork documentation* The formwork documentation provides the requirements for the foundation, footings, falsework and forms.

(b) *Design assumptions* The design assumptions specified in the formwork documentation are valid, in particular—

(i) design loads;

(ii) sequence and method of concrete placement;

(iii) concrete materials and admixtures;

(iv) vibration equipment and methods; and

(v) foundation material and preparation.

(c) *General arrangement* All the members, including bracing, shown on the formwork documentation are identified as present.

(d) *Materials and components* All materials and components can be identified as the type and grade specified in the formwork documentation. Components shall meet the acceptance criteria specified in Table 4.3.1.

(e) *Proprietary components* All proprietary components are used in accordance with the proprietary documentation.

(f) *Connections* All components are connected in accordance with the formwork documentation and cannot be partially or completely dislodged. All connection devices are securely fixed and cannot be unintentionally disconnected.

(g) *Eccentricities* The eccentricity of loads applied to supports or at joints does not exceed the limitations specified in the formwork documentation.

(h) *Out-of-plumb* The out-of-plumb of all components is with in the acceptance criteria specified in Table 4.3.1.

(i) *Adjustment* The formwork is fitted with devices to facilitate adjustment of the formwork.

(j) *Stripping* The formwork is designed to allow stripping in a controlled manner.

(k) *Surface quality* The formwork has the potential to achieve the required class of surface finish.

4.4.2.3 *Inspection during erection*

During erection of the formwork, regular inspections shall be carried out to ensure that the formwork is being erected in accordance with the formwork documentation. Inspections should check the orientation and location of components, especially bracing members, the use of temporary supports and the proper installation of the correct connectors, couplers and fittings.

During installation, components shall be inspected for damage. Damaged components shall be segregated and not installed.

4.4.2.4 *Inspection of formwork prior to placement of concrete*

After erection of the formwork and prior to placement of concrete, the formwork and the foundation shall be inspected to determine that the requirements of the formwork documentation have been fulfilled.

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As a minimum, the inspection shall verify the following:

(a) The erection conforms to the formwork documentation.

(b) The dimensional accuracies, plumb and straightness are within the specified tolerances.

(c) The foundations are adequate; they are not likely to be disturbed and that they and the lower parts of the supporting structure are not liable to damage by interference, accident, traffic, scouring or undermining.

(d) Soleplates, if required by the formwork documentation, are properly bedded down, levelled and, where necessary, adequately supported.

(e) Members are correctly positioned and connected.

(f) The stipulated limits of adjustable components (e.g., adjustable jacks and U-heads) have not been exceeded.

(g) All required components, pins, bolts, nuts, clips, and similar components are undamaged and are of the correct type and have been correctly inserted and are secure.

(h) Formwork is clear of debris.

The results of the inspection and action taken to correct any non-compliance shall be recorded in writing.

4.4.2.5 *Non-compliance*

Where the formwork does not meet the acceptance criteria in Clause 4.4.2.2, the non-complying formwork shall be rectified to comply with the project, construction and formwork documentation prior to the commencement of Stage II.

NOTE: In some circumstances, it may be necessary to redesign the formwork.

4.4.3 Stage II of construction—Concrete placement

4.4.3.1 *Safety considerations*

Prior to the concrete being poured, a method of communication between the supervising personnel and the placing crews shall be established.

Where applicable—

(a) indicators shall be monitored to facilitate the detection of undue settlement or distortion during concrete placement; and

(b) the concrete and concrete placement, including mounding, shall be monitored to ensure compliance with the formwork documentation.

During the placement of the concrete, there shall be continuous supervision of the process, including observation of the formwork, to ensure early detection of potentially dangerous situations. If component failure, undue settlement or distortion of the formwork is observed, the placement of concrete shall be stopped immediately. An assessment shall be made and action taken, which shall not jeopardize the safety of any personnel working on it or in the vicinity.

NOTE: It may be necessary to review and amend the formwork documentation, rectify and re-inspect the formwork construction.

4.4.3.2 *Surface finish*

Concrete shall be placed and compacted in a manner that is compatible with the specified quality of class of surface finish.

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4.4.4 Stage III of construction—After placement of concrete and formwork stripping

4.4.4.1 *Construction loads*

Loads on the newly poured concrete (e.g., stacked materials) shall not exceed those nominated in the project documentation, construction documentation and the formwork documentation (see Clauses 2.2.2, 2.3.2 and 2.4.2).

4.4.4.2 *Stripping times*

Stripping of formwork from in situ concrete shall not be undertaken earlier than as specified in the project and construction documentation.

NOTE: Appendix B provides guidance on stripping times in particular circumstances.

4.4.4.3 *Stripping procedures*

General stripping of formwork shall comply with procedures specified in the project documentation, the construction documentation and the formwork documentation. It shall be carried out in a controlled and planned manner that ensures the gradual transfer of load, from the formwork or the supports, to the permanent structure or existing structure. Procedures that have the potential to cause damage to the permanent structure or existing structure shall not be used.

4.4.5 Multistorey supports

4.4.5.1 *General*

Multistorey formwork systems for in situ construction and procedures that involve the use of undisturbed supports, backpropping or reshoring shall be in accordance with the project documentation, construction documentation and formwork documentation.

4.4.5.2 *Reshoring*

Reshoring procedures shall be supervised to ensure—

(a) they are carried out in strict accordance with the project documentation, construction documentation and formwork documentation; and

(b) there are no visible detrimental effects to the permanent structure from the loading of early-age concrete (for example, cracking or deflections that may impair the strength or serviceability of permanent structure).

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SECTION 5 EVALUATION OF COMPLETED WORK AND REPAIRS

5.1 SCOPE OF SECTION

For cases where evaluation is called for, this Section specifies the procedures for checking that the completed off-form work, as-cast or, where appropriate, as-repaired, complies with the relevant surface finish requirements of Clauses 3.4 and 3.5. Specific requirements are included for—

(a) evaluation of completed surface quality and alignment; and

(b) repairs.

5.2 PHYSICAL QUALITY

5.2.1 Surface appearance

Where it is required to check the completed work for compliance with the specified criteria, evaluation of surface appearance shall include the assessment of the following:

(a) *Blowholes* Blowholes shall be evaluated by comparison of the completed work with the relevant photograph from Figures A1 to A3 of Appendix A for the specified class, as shown in Figure 5.2.1. The 1:1 scale photograph shall be held against the surface and viewed from a distance that is not less than the greater of 2 m or the closest distance from which the subject area will normally be observed when the project is completed.

NOTE: Photocopies of Figures A1 to A3 of Appendix A or printouts of the Standard that has been electronically downloaded and printed do not produce consistent results with an original printed photograph and should not be used for evaluation purposes.

(b) *Other defect* For Class 1, Class 2 or Class 3, any other defects (e.g., grout loss, honey combing) shall be repaired to the requirements of Clause 5.5.

(c) *Surface treatment* Surface treatment shall be evaluated by a visual comparison of the completed work and the accepted test panel required for the specified class. For the purpose of this evaluation, the test panel should be placed alongside the completed work and both shall be viewed from a distance that is not less than the greater of 2 m or the closest distance from which the subject area will normally be viewed when the project is completed. To meet the criteria the surface of the completed work shall show a consistent surface texture within the acceptable variation of the surface treatment in which the test panel is included. The tonal scale referred to in Clause 3.5.3 shall not apply to this evaluation.

5.2.2 Measurable deviations

To ensure compliance with the appropriate requirements of Table 3.3.2, the measurements set out below shall be taken. For off-form work these measurements shall be taken before surface treatment, if any. The required measurements are as follows:

(a) *Form face span* The form face span shall be checked by inspection of the formwork prior to placing the concrete.

(b) *Form face deflection* At least 10 readings shall be taken at regular intervals but not closer than 300 mm. These shall be measured by placing a straightedge against the concrete surface, in line with the direction of the span of the form face, and measuring the gap between the concrete face and the straightedge as shown in Figure 5.2.2(A).

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The length of the straightedge shall be equal to or longer than the form face span.

Surface undulations Surface undulations shall be ascertained by using two straightedges, a short one of 300 mm and a long one of 1500 mm. The straightedge shall be longer than the span of the formwork member whose deflection caused the surface undulation being measured. The straightedge shall be used systematically over the whole face of the element to ensure even coverage, but shall not be used across construction joints. Two offsets, namely '*a*' and '*b*', are taken as shown in Figure 5.2.2(B) and the reading for evaluation is $(a - b)$.

NOTE: It is recommended that for elements greater than 2 m in any direction, at least 30 readings be taken.

(c) *Face steps* Readings shall be at 200 mm intervals for the full length of the visible step. The face step spacing shall be measured from visible step to step on the concrete surface. Face steps shall be measured within an element by placing a straightedge against the concrete surface at right angles to the line of the step and measuring the gap between the concrete face and the edge of the straightedge, as shown in Figure 5.2.2(C).

(d) *Flatness* Flatness shall be measured on the critical face of the element. The readings shall be used for evaluating any relative variations in the surface flatness or line of the element. They shall not be used as an evaluation of the absolute position of the element (see AS 3600).

The readings shall be taken using a suitable instrument, a stringline in still air conditions or other equivalent method. For elements or series of elements of the permanent work that are intended to be straight, with any overall dimension not less than 15 m, the check may be made along any straight line measuring more than 15 m. The readings shall be measured in 10 m sections, with each overlapping by 5 m, and with the variations from the straight determined by measurements at the ends and middle of each 10 m section, as shown in Figure 5.2.2(D).

Within these 10 m sections, and for elements less than 15 m, the flatness shall be checked by taking measurements on a 1.25 m × 1.25 m grid with no measurements taken within 300 mm of any edge of the element, as shown in Figure 5.2.2(E).

The deviation at any point shall be taken as the difference between the offset reading at that point and the mean of all the offset readings taken for this area.

(e) *Out-of-plumb* Readings shall be taken along the length of walls, on the critical face only, at not more than 5 m centres. Not less than two readings shall be taken.

Unless specified otherwise, the plumb of columns shall be checked at two positions as follows:

(i) *Rectangular columns* On adjacent faces, at two positions at right angles.

(ii) *Circular columns and irregular shapes* At specified positions.

Plumb shall be measured from a point 300 mm from the top of the vertical surface and to a point 300 mm from the bottom, as shown in Figure 5.2.2(F).

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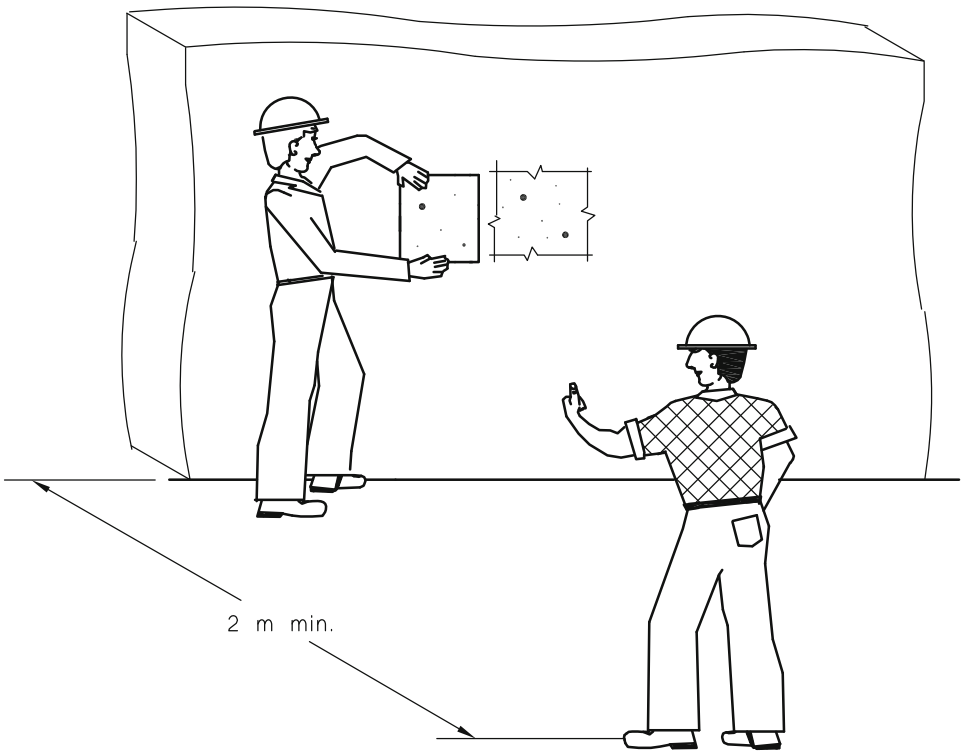

FIGURE 5.2.1 COMPARISON OF PHOTOGRAPH WITH FINISHED WORK

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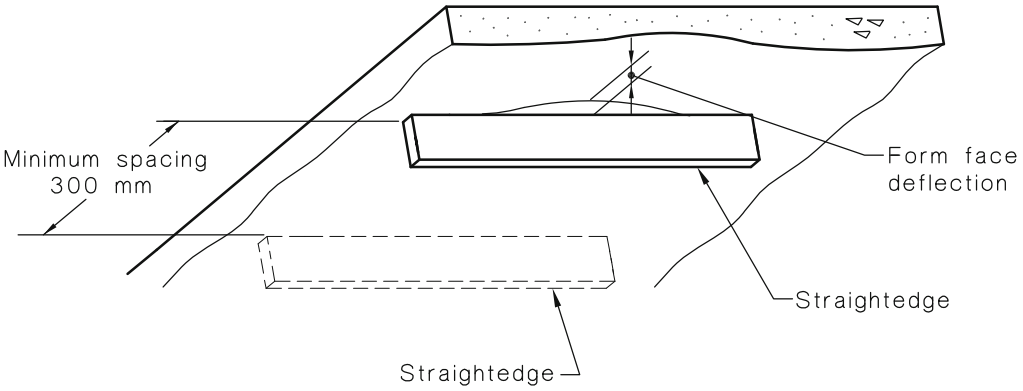
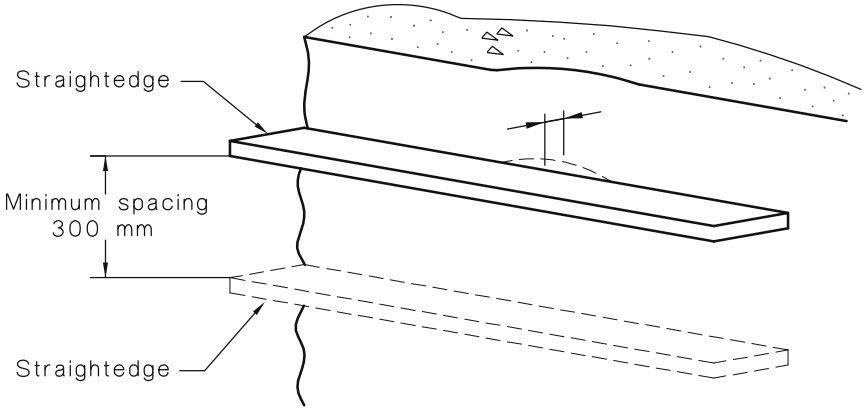


(a)



(b)

FIGURE 5.2.2(A) MEASUREMENT OF FORM FACE DEFLECTION

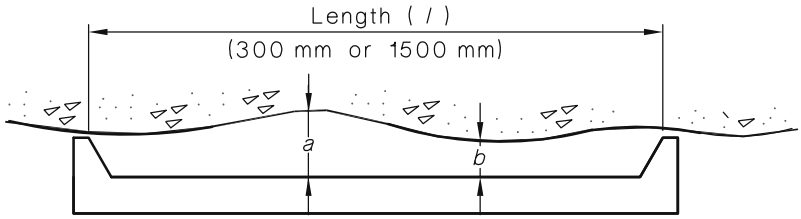


FIGURE 5.2.2(B) MEASUREMENT OF SURFACE UNDULATIONS

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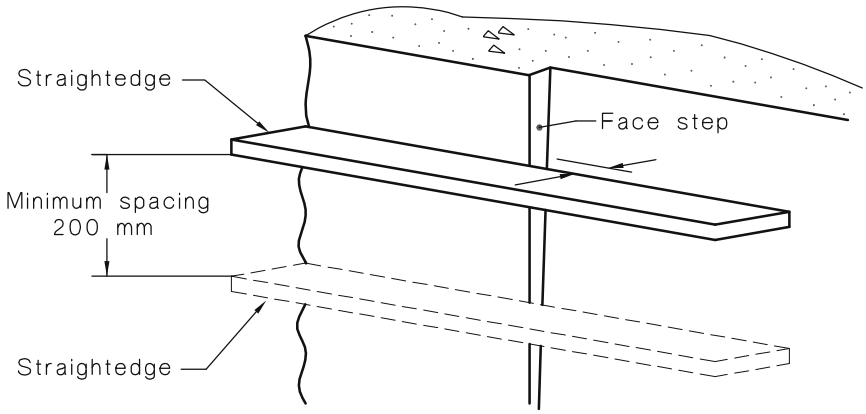

FIGURE 5.2.2(C) MEASUREMENT OF FACE STEPS

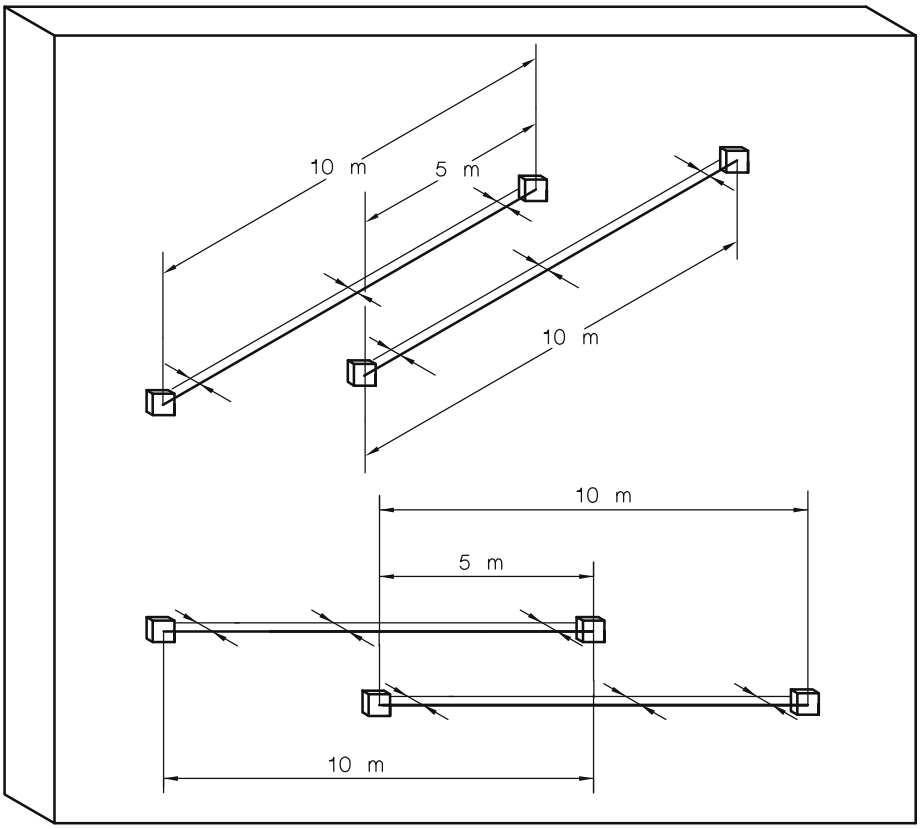

FIGURE 5.2.2(D) FLATNESS MEASUREMENTS FOR ELEMENTS OVER 10 m LONG

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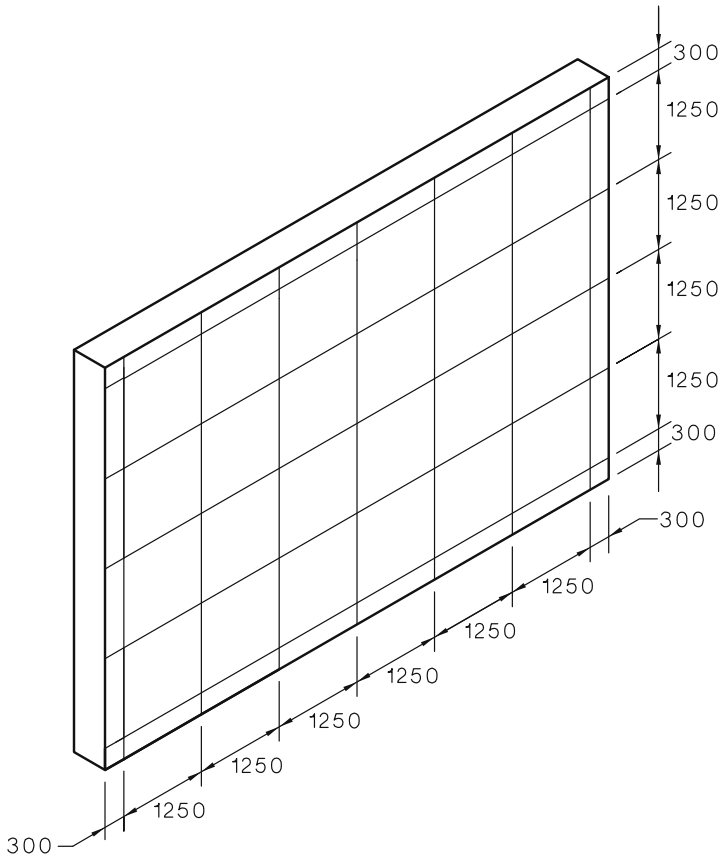
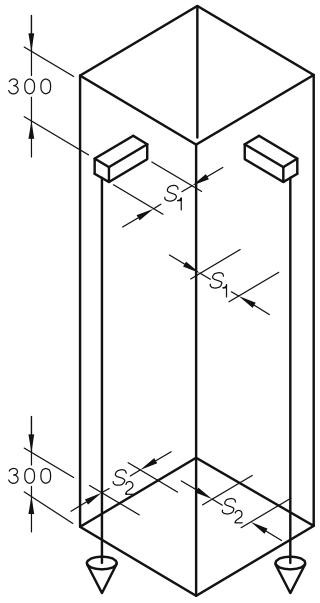


DIMENSIONS IN MILLIMETRES

FIGURE 5.2.2(E) PATTERN OF FLATNESS MEASUREMENTS FOR ELEMENTS UP TO 10 m LONG



DIMENSIONS IN MILLIMETRES

FIGURE 5.2.2(F) MEASUREMENT OF OUT-OF-PLUMB

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5.3 PHYSICAL QUALITY OF PRECAST CONCRETE

5.3.1 Sequence

Where it is required to check the dimensional accuracy of precast concrete units for compliance with the specified values, the sequence of checking shall be as follows:

(a) Check surface finish for compliance with tolerances specified in accordance with Clause 3.3.5.1.

(b) Check linear dimensions for compliance with tolerances specified in accordance with Clause 3.3.5.2(a).

(c) If the linear dimensions checked under Item (b) above comply with the specified tolerances, check the angular dimensions for compliance with the tolerances specified in accordance with Clause 3.3.5.2(b).

(d) If the angular dimensions checked under Item (c) above comply with the specified tolerances, check the profile for compliance with the tolerances specified in accordance with Clause 3.3.5.2(c).

5.3.2 Procedures

The evaluation procedures specified in Clause 5.2.2 shall also apply to precast concrete, as appropriate. Optical instruments, jig frames or string lines shall be used, as applicable. There shall be adequate checking to ensure that all the units are consistent with the required tolerances.

5.4 COLOUR EVALUATION

Where the colour range is being checked by use of a tonal scale similar to that in Figure A4 of Appendix A, the chosen tonal scale shall be held against the surface area being examined and a comparison shall be made between the tonal scale and the concrete surface.

NOTE: Photocopies of Figure A4 or printouts of the Standard that has been electronically downloaded do not produce consistent colour results. Where it is intended to use such printouts for grey evaluation of concrete surfaces, such evaluation should be done only with copies printed on the same printer using the same type and grade of paper.

The light conditions at the time of evaluation and the period of time after the stripping of the form before evaluation is carried out shall be consistent for all elements with similar requirements.

For other cases, the method of evaluation shall be appropriate to the means used to record the permitted tonal range.

5.5 REPAIRS

5.5.1 General

Where the surface does not achieve the specified quality of finish, repairs are acceptable for all classes, except for the case where the project documentation states that repairs to Class 1 are not permitted (see Table 3.4.1, Item 11).

5.5.2 Repair technique

The proposed repair technique shall be satisfactory in the following respects:

(a) Structural characteristics.

(b) Durability.

(c) Durability of adhesion.

(d) Appropriateness of materials.

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(e) Appearance (including surface finish and texture).

(f) Any additional specified criteria.

5.5.3 Evaluation

When repaired, the element shall meet the criteria of Clause 5.5.2 in addition to any specified requirements. These specified requirements may include physical quality and colour.

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APPENDIX A

BLOWHOLE AND COLOUR EVALUATION CHARTS

(Normative)

A1 GENERAL

The blowhole evaluation charts given in Figures A1 to A4 are published as Supplement to this Standard, i.e., AS 3610 Supp 1.

NOTE: Figures A1 to A4 are published separately as the printing of downloaded electronic copies may be inconsistent and will vary depending on paper and printer types.

A2 BLOWHOLE EVALUATION PHOTOGRAPHS

The photographs in Figures A1 to A3 shall be used only for evaluating blowhole size and distribution as permitted in Clause 3.4 and in accordance with Section 5 (see Clause 5.4). Photographs are in pairs consisting of—

(a) a general photograph at scale 1:5, which gives a clear idea of expected variation in blowhole size and distribution; and

(b) a close-up photograph at scale 1:1, which shows an area that is representative of the general photograph.

In conjunction, the photographs set limits of acceptability in each of Class 1, Class 2 and Class 3.

NOTE: It is possible that there will be small sections of the 1:5 scale photograph that exhibit a greater concentration of blowholes, or ones of larger size than are shown in the 1:1 scale photograph. This is consistent with the intention of Table 3.3.2.

A3 COLOUR EVALUATION CHART

The chart in Figure A4 is suitable for use with most grey concretes as set out in Clauses 3.4, 3.5 and Section 5. Similar charts, or other suitable means, should be developed for use with other colours of concrete.

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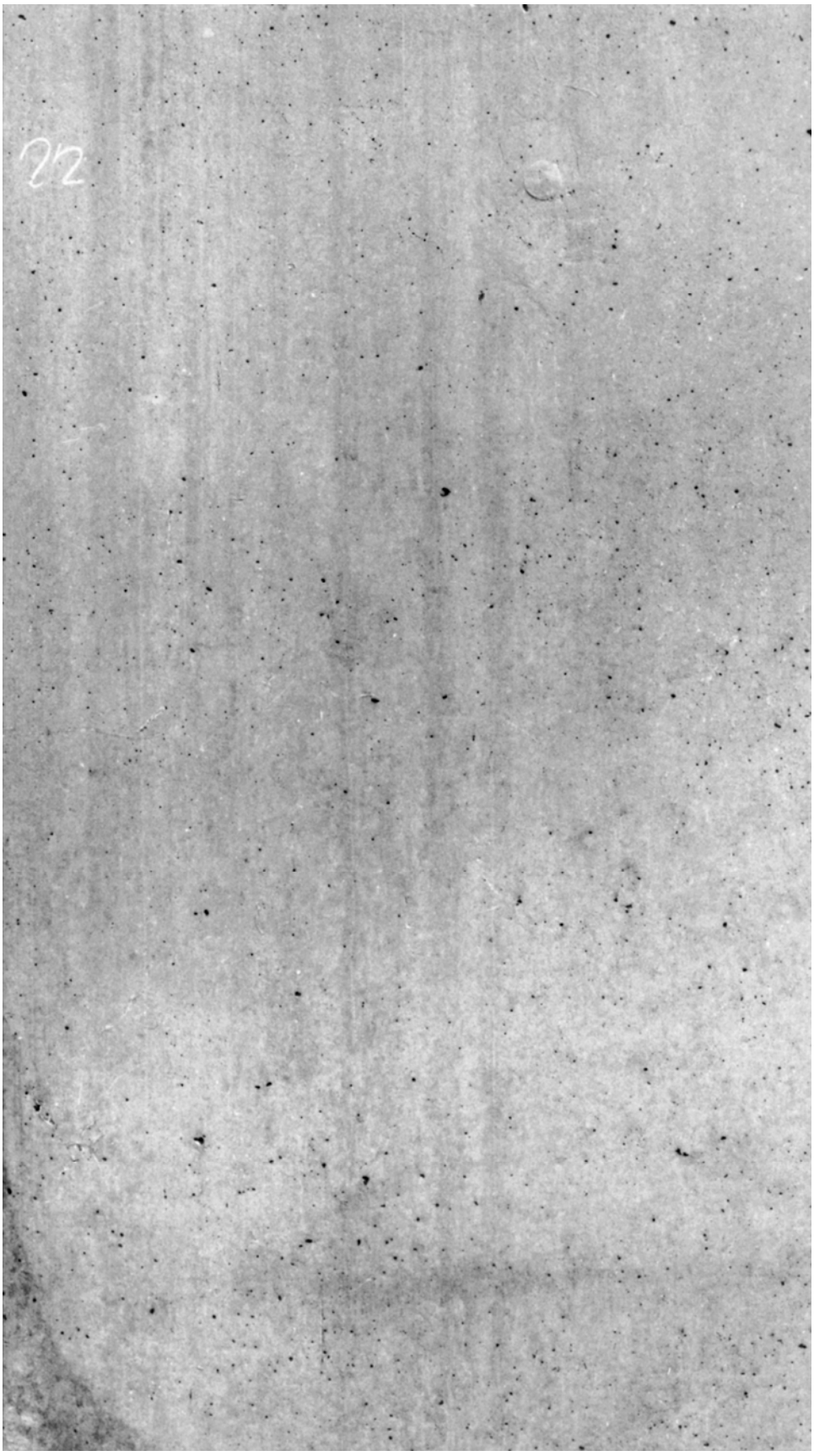

(a) Scale 1:5

FIGURE A1 CLASS 1 FINISH (in part)

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(b) Scale 1:1

FIGURE A1 CLASS 1 FINISH (in part)

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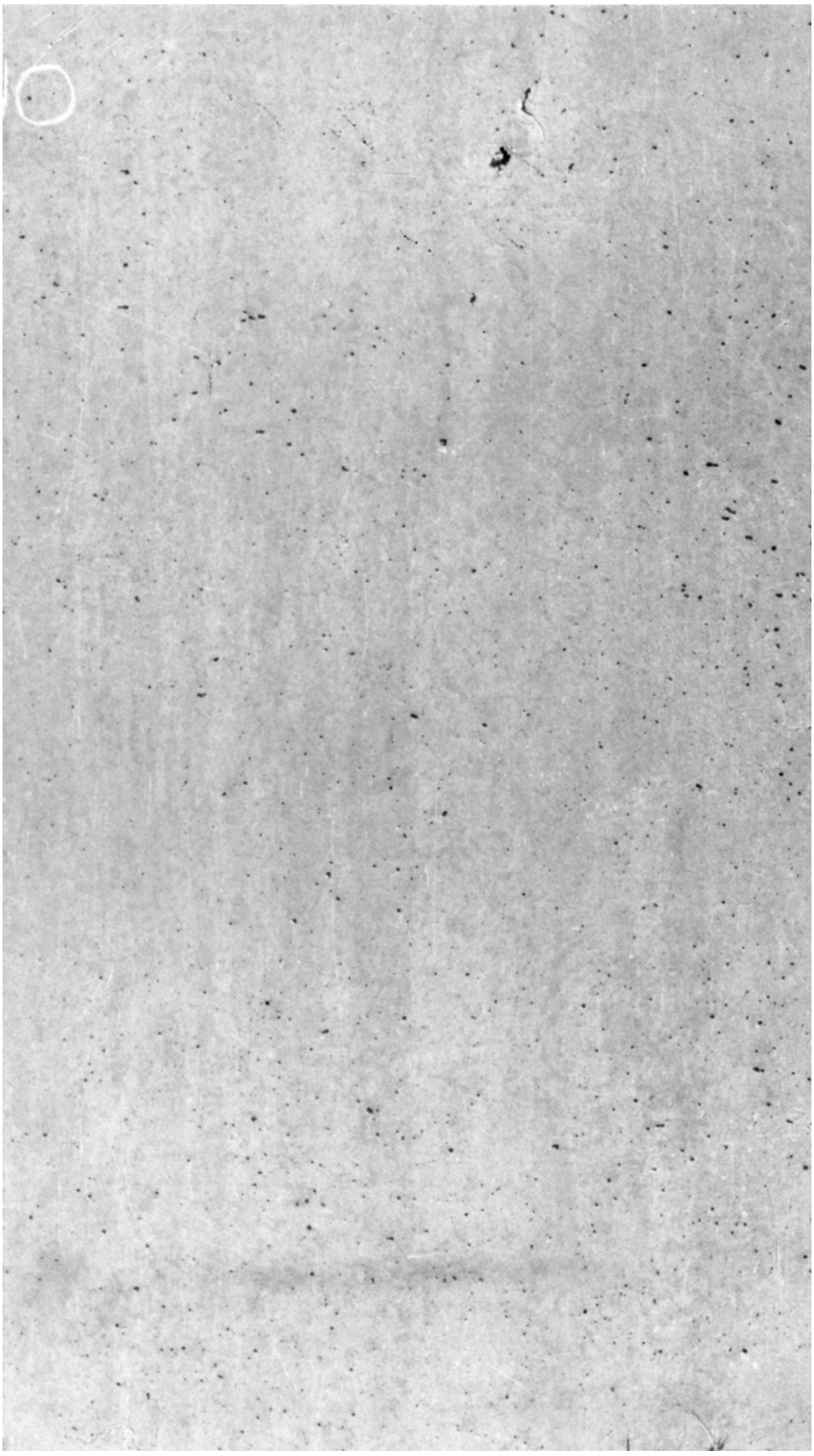

(a) Scale 1:5

FIGURE A2 CLASS 2 FINISH (in part)

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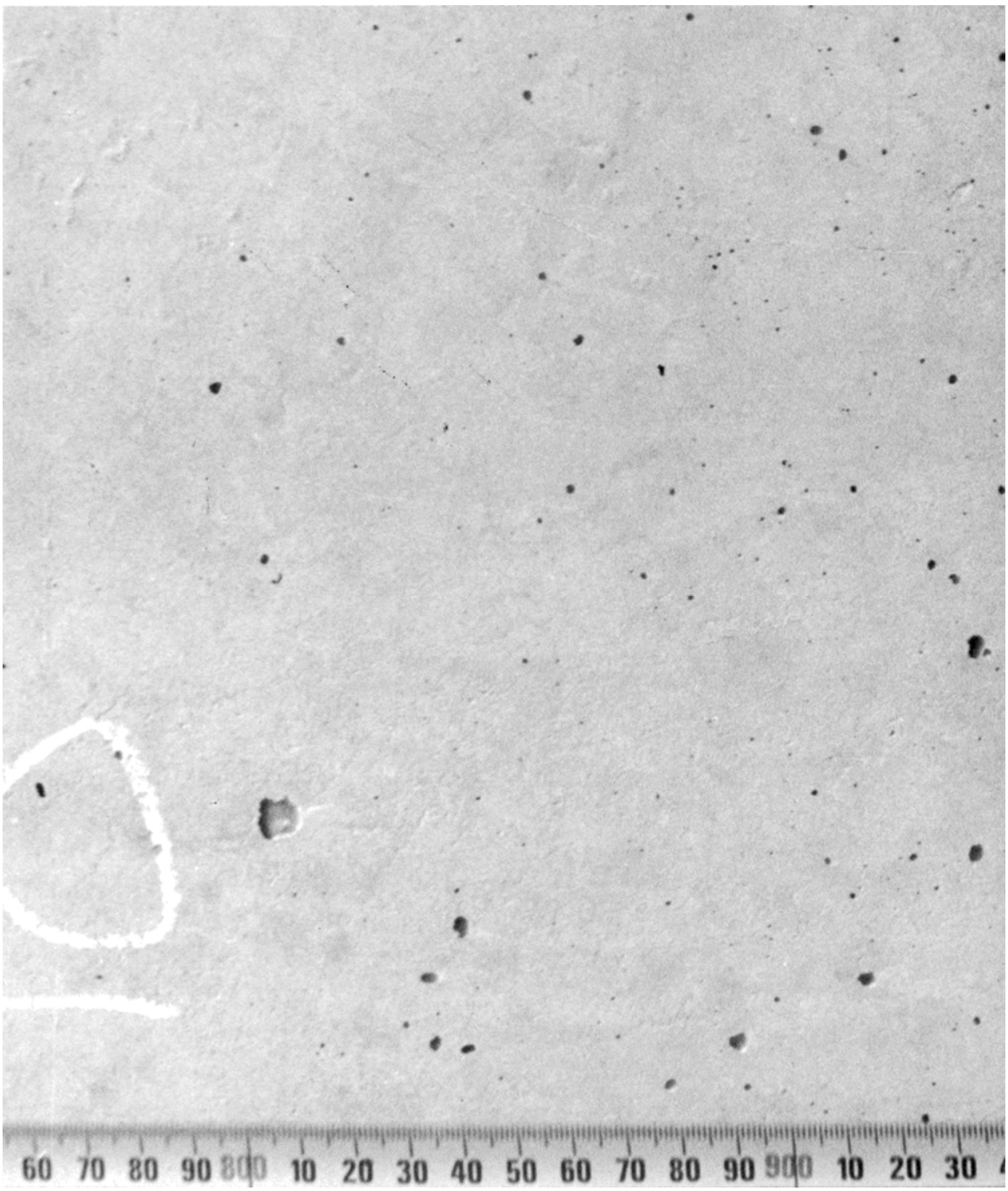

(b) Scale 1:1

FIGURE A2 CLASS 2 FINISH (in part)

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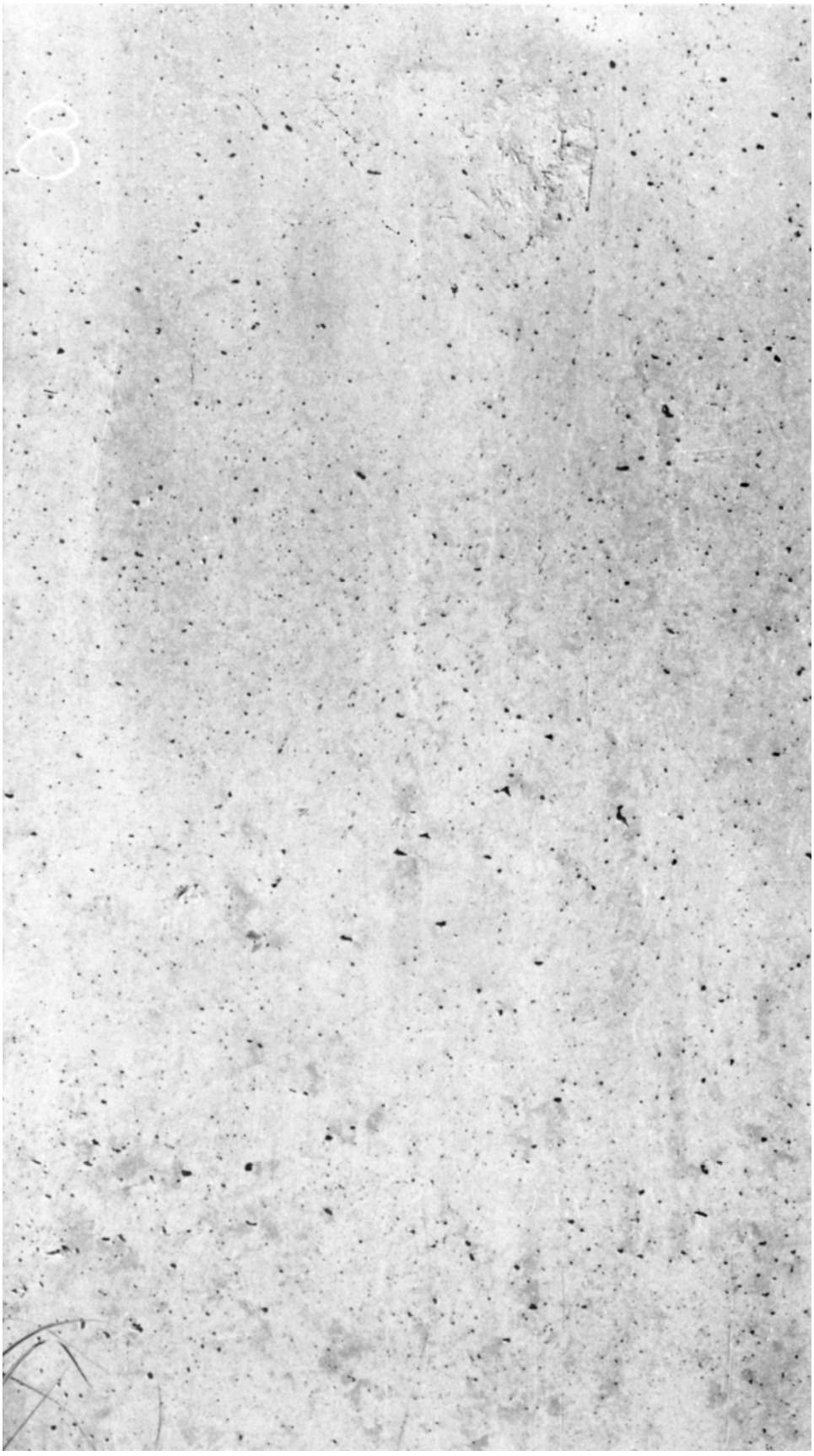

(a) Scale 1:5

FIGURE A3 CLASS 3 FINISH (in part)

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(b) Scale 1:1

FIGURE A3 CLASS 3 FINISH (in part)

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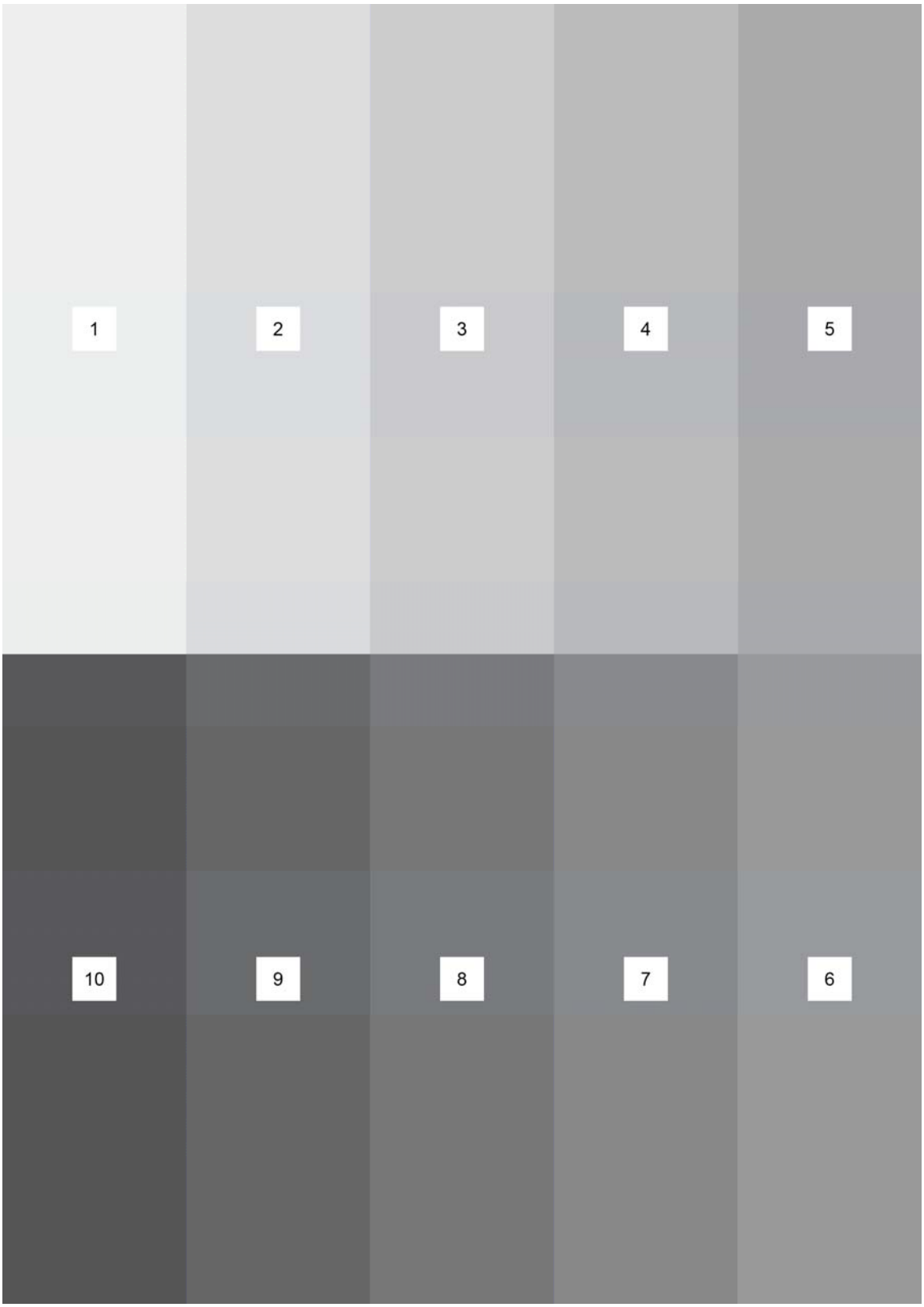

FIGURE A4 TYPICAL GREY SCALE

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APPENDIX B

MINIMUM FORMWORK STRIPPING TIMES—IN SITU CONCRETE

(Informative)

B1 SCOPE

This Appendix may be used as a guide for the documentation of stripping times for the following formwork:

(a) Side forms of vertical faces—stripped in accordance with Paragraph B2.

(b) Soffit forms spanning between undisturbed supports—stripped in accordance with Paragraph B3, provided the supports remain undisturbed.

(c) Soffit formwork (forms and supports)—stripped in accordance with Paragraph B4.

NOTES:

1 Guidance is not provided for stripping times for formwork and supports under slabs supporting structures above or post-tensioned concrete slabs.

2 The stripping times set out in this Appendix may be less than those specified in AS 3600.

3 The early stripping of formwork could be detrimental to the strength and durability of the concrete.

B2 VERTICAL FACE FORMWORK

Table B1 may be used in the case of stripping forms from vertical faces.

TABLE B1

VERTICAL FACE FORMWORK STRIPPING TIMES

Classification	Average temperature		
	Greater than 20°C	Between 12°C and 20°C	Between 5°C and 12°C
Class 1, Class 2 or Class 3 (see Note 1)	1 d	2 d	3 d
Class 4 or Class 5	9 h	12 h	18 h
All	A minimum of 1 d applies to the stripping of vertical faces where frost damage is likely		

NOTES:

1 Where colour control is specified, it is advisable to strip forms early, subject to the limitations given.

2 In the absence of site recording, local temperatures are usually available from the Australian Bureau of Meteorology.

B3 SLAB OR BEAM SOFFIT FORMS BETWEEN UNDISTURBED SUPPORTS

Slab and beam soffit forms may be removed provided—

(a) the elapsed time between the casting of the concrete and the commencement of stripping is greater than 3 d (72 h); and

(b) the spans between the remaining undisturbed supports are such that the member will remain uncracked under the bending effects arising from construction activity.

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B4 REMOVAL OF FORMWORK FROM UNDER-SLABS NOT SUPPORTING STRUCTURES ABOVE

Formwork and supports under-slabs not supporting structures above may be removed, provided the following inequalities are satisfied:

$$\left(\frac{w_c}{w_s}\right) \leq 1.0 \qquad \ldots \text{B4(1)}$$

and

$$\left(\frac{w_c}{w_s}\right) \leq \left(\frac{f'_{ce}}{f'_c}\right)^{0.6} \qquad \ldots \text{B4(2)}$$

where

w_c = most severe combination of unfactored design action due to construction activity on the slab at time of stripping, in kilopascals

w_s = unfactored in-service design action for the permanent structure, in kilopascals

= sum of permanent and imposed actions (specified in the project and construction documentation) on the permanent structure

f'_{ce} = minimum early age characteristic compressive strength of the concrete required before stripping, in megapascals

f'_c = 28 day characteristic compressive strength of the concrete, in megapascals

At the time of stripping (less than 28 d), usually only the mean grade compressive strength (f_{cm}) is known. Typically, the mean grade compressive strength (f_{cm}) is determined from testing cylinder specimens, but may be converted to a characteristic strength by the following criterion:

$$f'_{ce} = f'_{cm} - k_c\, s \qquad \ldots \text{B4(3)}$$

where

k_c = an assessment factor determined on the basis of the number of samples

s = standard deviation of the specimens tested

Appropriate values for k_c and methods for determining s are set out in AS 1379.

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ISBN 0 7337 9358 4

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