AS 3610 Supp 2—1996
(Incorporating Amendment No. 1)

AS 3610 Supp 2

AS 3610 Supplement 2—1996

Formwork for concrete—Commentary (Supplement No. 2 AS 3610—1995)

Standards Australia

This Australian Standard supplement was prepared by Committee BD-043, Formwork. It was approved on behalf of the Council of Standards Australia on 18 October 1996 and published on 5 December 1996..

The following are represented on Committee BD-043:

Association of Consulting Engineers Australia

Australian Aluminium Council

AUSTROADS

Cement and Concrete Association of Australia

Department of Training and Industrial Relations (Qld)

Formwork Contractors of W.A.

Housing Industry Association

Metal Trades Industry Association of Australia

National Precast Concrete Association Australia

Plywood Association of Australia

Queenland University of Technology

WorkCover New South Wales

WorkSafe Western Australia

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about Standards can be found by visiting the Standards Australia web site at www.standards.com.au and looking up the relevant Standard in the on-line catalogue.

Alternatively, the printed Catalogue provides information current at 1 January each year, and the monthly magazine, *The Australian Standard*, has a full listing of revisions and amendments published each month.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at mail@standards.com.au, or write to the Chief Executive, Standards Australia International Ltd, GPO Box 5420, Sydney, NSW 2001.

AS 3610 Supplement 2—1996

Formwork for concrete—Commentary (Supplement No. 2 AS 3610—1995)

Originated as AS 3610 Supplement 2—1990.
Second edition 1996.
Reissued incorporating Amendment No. 1 (March 2003).

Published by Standards Australia International Ltd
GPO Box 5420, Sydney, NSW 2001, Australia

PREFACE

This Supplement was prepared by the Standards Australia Committee BD-043 on Formwork as a commentary on AS 3610—1995, *Formwork for concrete*.

This new edition of this supplement incorporates several corrections and amendments to the previous edition. These include changes to Clauses C2.3, C3.2, C3.3.1, C3.5.1, C3.5.2, C4.4.3, C4.4.5.1, C4.4.5.2, C4.4.5.3, C4.4.5.7, C4.4.6, C4.4.7, C4.5.4.1, C4.5.5.1, C4.6.3, C4.7.1, C5.4.1.4, C5.4.1.7, C5.4.2, C5.6.2.2 and CA3.1; Paragraph CA4.4.4; Figures C4.1, C4.4.4, C4.4.5, C4.4.7, C4.4.8, C4.4.9, C4.4.10, C4.4.11, C5.4.1, C5.4.5, C5.4.7, C5.4.12, C5.4.15, CA1 and Addendum. The changes required by this Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure, or part thereof affected.

This Standard incorporates Amendment No. 1 (March 2003). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The Supplement includes background information on the Standard, guidance on its use and suggestions on good practice.

The Paragraphs in this Commentary refer directly to the respective Clauses in the Standard, e.g. Paragraph C5.3.1 refers to Clause 5.3.1, and Appendix CA refers to Appendix A. Gaps in the numerical sequence of this Commentary's Paragraph numbering means that no explanation of or background to the relevant Clauses is necessary.

Details on references and documents referred to in this Supplement are provided in the Addendum at the end of the document.

CONTENTS

FOREWORD

In this Commentary the terms 'project designer' and 'formwork designer' are used. Neither term should be taken as referring to a single individual, as each may comprise several organizations or individuals of varying qualifications.

Consider the following examples:

(a) Within the term 'formwork designer'—

  (i) proprietary items used in the formwork assembly could be designed by the manufacturer;

  (ii) forms, bearers and joists could be designed by personnel engaged by the formwork contractor; and

  (iii) footings (if necessary) could be designed by personnel engaged by the building contractor.

(b) Within the term 'project designer', a structural engineer could be responsible for the concrete structure, and an architect could be responsible for the surface finish.

STANDARDS AUSTRALIA

Australian Standard

Formwork for concrete—Commentary
(Supplement No. 2 AS 3610—1995)

SECTION C2 THE PROJECT DOCUMENTATION

C2.3 INFORMATION TO BE PROVIDED IN THE PROJECT DOCUMENTATION

It is necessary for the project designer, through the project documentation, to communicate specific requirements. The list given in Clause 2.3 is only a general list. For particular projects many other aspects may require attention, with appropriate limitations on the formworker's actions being specified. This Clause covers only those matters affecting the structural aspects of the concrete. The quality of the surface finish is discussed in the commentary to Section 3: Surface finish.

(a) *Minimum formwork stripping times* This is primarily directed towards in situ concrete, although much of it can apply to precast concrete. The stripping times provided in the formwork documentation should be in accordance with AS 3600 (see also Clause 5.4.3.2).

Three criteria apply generally to the removal of all forms and their supports, as follows:

(i) *Structural* As a structure, the member needs to remain secure from collapse, and from damage that may affect its performance in later service, e.g. cracking or deformation in excess of that anticipated by the project designer.

(ii) *Surface finish* Premature stripping may adversely affect the surface condition through scaling, spalling of edges or corners, or cause non-uniformity of colour.

(iii) *Durability* An important factor in the achievement of optimum durability is adequate hydration. As economic considerations often call for early stripping, attention to curing is vital.

A controlling factor in these three matters is the strength development of the concrete at early ages, which is in turn related to the rate of hydration of the cement.

Although strength development is influenced by the ambient humidity, most recognized models for strength gain are related only to time and temperature. Figure C2.1 (see Ref. 1) shows the variations of strength growth with temperature.

It is recommended that the specification should state the minimum strength of the concrete to be attained before removal of the forms or shores. An effective method of strength determination is the testing of cylinders, stored and cured under the same conditions as the permanent structure, or non-destructive tests of the in-place concrete. In this way the effect of the actual temperature regime is reflected in the test results.

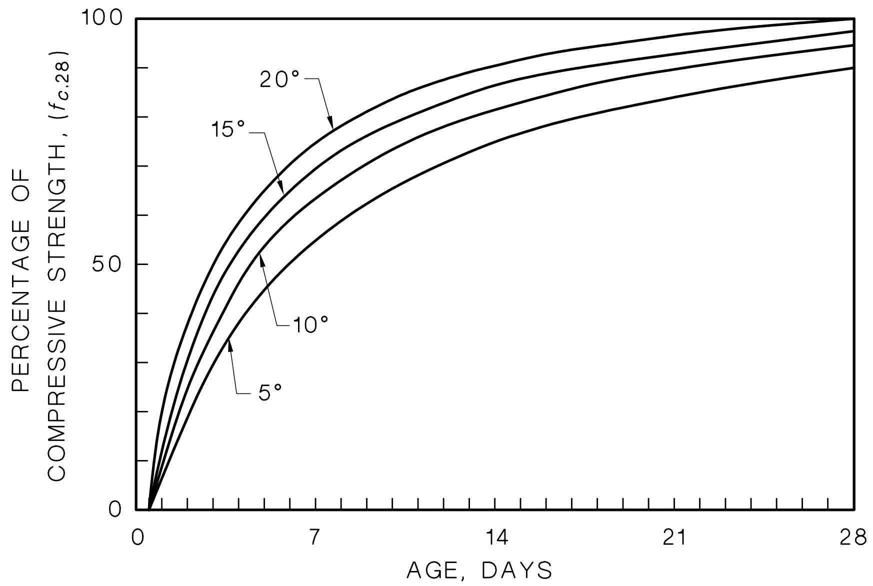

FIGURE C2.1 TYPICAL COMPRESSIVE STRENGTH DEVELOPMENT OF PORTLAND CEMENT CONCRETE UNDER DIFFERENT AVERAGE AMBIENT TEMPERATURES

If the maturity equation parameters for the particular concrete are known, then this may be used to predict the strength from the temperature history. Otherwise the Sadgrove equation (see Ref. 2) can be used to give an approximation of the strength. This uses the equivalent age concept as follows:

$$F = \left(\frac{\theta + 16}{36}\right)^2$$

where

θ = the average curing temperature in degrees Celsius

F = an equivalent age factor.

It is assumed in the maturity concept (see Ref. 2) underlying this equation that the temperatures sustained do not vary greatly in relation to the average. Research has indicated that the temperature sustained during the first 12 h after casting has a pronounced effect upon the development of strength at later ages. Very cold (around 0°C) initial temperature retards strength development at first, but results in higher strength after a few days if the temperature returns to normal (around 20°C) compared with concrete cured overall at a normal temperature. Very hot (40°C) temperatures initially have the opposite effect, but the reduction does not appear to be critical in the short term.

Also the age at stripping and the temperature regime can affect the surface quality. Uneven drying can be caused by loosening of the forms or variable form absorption, and causes variations in colour as well as durability. Rapid surface drying causes low surface strength and dusting. If the surface concrete strength is less than 2 MPa there is the potential for frost damage (see Ref. 3).

Particular attention should be paid to the following:

(A) *Vertical surfaces* Ideally, formwork should be stripped from vertical surface normal to the surface. For large forms this is impractical and a ‘peeling’ action should be adopted. The minimum strengths are given in Table C2.1.

TABLE C2.1

MINIMUM COMPRESSIVE STRENGTH ON CONCRETE FOR STRIPPING VERTICAL FORMS

Surface finishes	Compressive strength MPa
Classes 1, 2, 3	5.0
Classes 4, 5	2.0
Frost damage possible	2.0

If the strength cannot be accurately assessed and there are no specified minimum times, the times given in Clause 5.4.3.2 should be used.

(B) *Beams and slabs* Economic considerations usually determine that it is necessary to remove the formwork soffit as early as possible. This is usually achieved by a two stage process such as undisturbed supports, backpropping or reshores. These processes are defined in Section 1. The safe ages for both the initial soffit stripping and the later support removal must be determined.

For the first stage, AS 3600 gives an equation that is based on the uncracked Section where the determining factor is the growth of the tensile strength. This equation is based on the superimposed slab load not exceeding 2 kPa and the value of the tensile strength equalling 0.6 times the square root of the compressive strength. It is recommended that consideration be given to performing flexural tensile tests as set out in AS 3600 to confirm the factor of 0.6 (see AS 1012, Parts 8 to 11). For cases where the ratio of the span between supports to the overall member depth is less than that given by the AS 3600 equation, the times given in Clause 5.4.3.2 apply if there are no specified minimum times.

Clause 5.4.3.2 ensures that the concrete will have achieved at least 40% of its design compressive strength at the time of stripping, or about 65% of the flexural tensile strength. It is assumed that design load will be in excess of 1.75 times the load to be supported.

At the second stage, the structure supports all its own weight and the superimposed loads (maximum 2 kPa). Clause 5.4.3.2 also gives these times for cases within the restrictions given above.

For cases where stacked material loads occur, or where there is increased loading on the slabs due to multistorey formwork activity, Clause 5.4.3.2 does not apply and an analysis should be done (McAdam and Behan, Ref. 4).

(b) *Stacked materials* It has become commonplace for builders to stack materials for later activities on the surface of newly cast slabs, often before the next set of formwork is constructed. Prior to the stripping of the forms, this load is supported by the formwork, and after stripping it is carried by the concrete structure. All the considerations that are applicable to the times when slab forms should be stripped also apply to the stipulations to be provided on stacked materials. (See Section C4.)

(c) *Multistorey formwork* The problem of the high loads on the floors of a multistorey building, caused by the repetitive construction cycle, has been known for several decades. A simplified method of analysis was developed by Grundy and Kabaila (Ref. 5) in 1963. This method was based on the assumption that, due to the stiffness of the props, the action of the props could be considered as a uniformly distributed load and the effect of creep could be ignored, as it would be self-cancelling.

Methods to reduce these apparently very high loads were devised. Taylor (Ref. 6) proposed the orderly slackening of the props to reduce their loads and thus cause the lightly loaded upper slabs to carry their own mass at an earlier age. Marosszeky (Ref. 7) developed this proposal into the 'slab release' method, which has been used on a number of buildings in Australia. He also introduced the very useful concept of the Severity Factor. In principle, this is the ratio of the construction load to the service load strength. Ideally it should always be less than 1.0. If this is achieved then the construction load will always be less than service load strength as it develops towards its expected value at 28 days. The early loading that the slab release (reshoring) causes, requires knowledge of the rate of the concrete's strength growth.

The effect of the assumptions of infinite prop and base rigidity have also been examined. It can be shown that, within the confines of the other assumptions, the prop stiffness has little effect on the load distribution and reduced base stiffness makes the maximum value closer to the converged value.

However, it is obvious that other factors are at work as the high slab loads calculated by this simplified method have not usually been measured in practice. The average values that are measured range from 1.6 to 2.0. Beresford (Ref.8) undertook field measurements that showed the influence of creep on the deflection of the system and the loads on the floors. The continuing creep was seen to be accompanied by the reduction of the loads on the lower floors and the increase in the loads carried by the upper floors.

Work has been done by McAdam and Behan (Ref. 4) on quantifying redistribution of the loads and the method of design for this work. An examination of the stiffness of normal steel propping systems shows that only a small relative movement between adjacent floors is needed to cause an appreciable load transfer.

From this work on the effects of creep, the following conclusions can be drawn about its effects upon undisturbed formwork assemblies:

(i) The continuing creep movement of the system of slabs and formwork supports causes a redistribution of loads between the floors, with the newer upper slabs gradually receiving a larger share of their own mass.

(ii) The maximum value of slab loading occurs at the lowest slab in the system, but the critical slab load may occur at an upper floor, due to its lesser age and lower strength development. The critical case is often punching shear at the column in upper slabs.

(iii) Consideration needs to be given to the effect that lower temperatures have on strength development and the proportions of the creep redistribution of loads.

(iv) The time between pouring of successive floors and the number of sets of forms determines the age of the lowest floor in the system and the severity of the early loading on the upper floors.

The problem of analysis for multistorey loading from formwork loads is not a simple one. The analysis is complicated by the non-uniform effect of the prop loads on the slabs and the shrinkage of the columns. For props between the two top floors, field observations show an increase in the loads in props adjacent to the columns, from the two abovementioned causes. This results in an unacceptable increase in the punching shear.

In determining stripping times, consideration needs to be given to the fact that early loading of concrete leads to large long-term creep deflections. These serviceability problems are minimized by limiting the early loads in the floors through the use of an adequate number of sets of forms.