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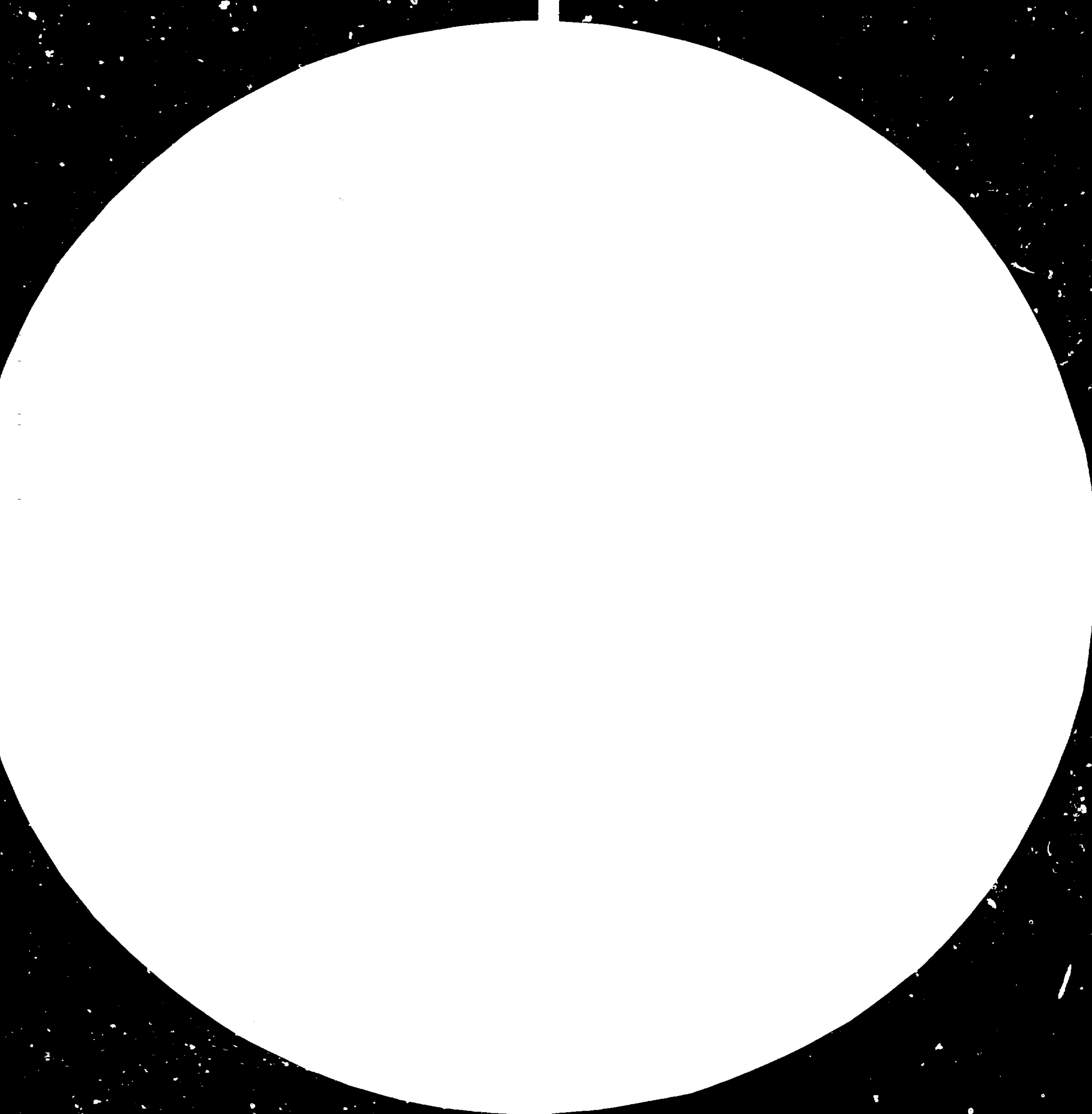

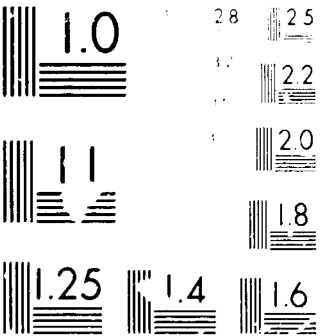
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CONCRETE ADMIXTURES - CONTROVERSIAL OR CREDIBLE*

by

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CONTENTS

Geographical - Capable of description as both a continent and an island, Australia is unique in many ways. The land mass stretches from the tropics more than half way to the Antarctic. Our climate is influenced by equatorial agencies so that we have to talk of the "wet" and "dry" seasons when we are in the northern regions. On the other side of the continent, we experience the typical rotation of four seasons - summer, autumn, winter, and spring. With the exception of our northern border, we are surrounded by oceans. Because of the weather effects associated with large land masses and the constant west to east wind streams, the southern states experience wide and often sudden extremes of weather. It is said that in some places, all four seasons can occur on a single day. When this occurs without warning, due to a lack of weather stations in the oceans, one can understand the critical attitudes we have to weather forecasts.

Australia is an essentially dry continent with only limited areas where rainfall provides sufficient water for agriculture. These areas are mainly on the coastal fringe and, as a consequence, the population is concentrated not merely on the fringe but also in a small number of capital cities of the various states. Although the population is small when the area is concerned, we do have major cities with populations of 2 - 3 million people.

Because of the low rainfall and the concentration of people in major cities, water storage and hydro electricity projects have been very significant for the community and the construction industries.

The final comment which should be made about our geography is that we are very much a remote and isolated island in an historical sense. The lack of a land link to Asia and Europe may not seem significant on the map but it has produced, together with other factors, a somewhat independent approach to many aspects of our modern life. This independence is not merely parochial or insular. It has been aggressive in many areas of the construction industry and there has fortunately been a two-way movement of experience in recent decades.

Standard Specifications and Codes of Practice - It has been said by a cynic that two early objectives of governments of developing countries are the establishment of an international airline and a national standards organization. In both respects, Australia satisfied these requirements many years ago.

The Standards Association of Australia developed from organizations mainly concerned with engineering matters. In 1977, the Golden Jubilee of SAA was celebrated by conferences held primarily in Sydney to mark the occasion. Australia uses what is best described as voluntary standardisation. Although supported by both Federal and State governments, there is no general mandatory adoption or implementation of Australian standards in either the private or public sector.

SAA has very wide support by organizations and individuals, the major focal points of this interest being in membership of the organization and participation in technical committee activity.

Our interests in standardisation are both international and parochial. Wherever possible, there is increasing awareness of the desirability of identifying our documents with pre-existing national or international standards. At the same time, our peculiar geographical and population circumstances prolong a need to maintain specific standards geared to our own needs.

The most significant example of this apparent tension was the decision by the Australian Government to adopt, as a matter of law, the metric system of measurement and in particular the SI system of units. One of the most important consequences of this decision was the obvious need to convert the many national standards in existence at the time. It was fortunate that, in conjunction with this conversion, the opportunity was taken to review the standards to ensure that local and international technologies were incorporated to satisfy the requirements of a national community which was rapidly becoming oriented to the needs of the consumer.

SAA policy has been to establish and maintain balanced committee representation, drawing upon the expertise of individuals who generally represent national organizations, whether they are consumers, designers, contractors, suppliers, academics or regulatory bodies.

In recent years the general approach has been for SAA to respond to requests from concerned groups to prepare new standards where there is an obvious need. Committee debate is an essential activity with considerable emphasis being placed on the need to obtain an early response from the community at large to the early committee proposals.

Public review comment is sought as an early guide to final committee deliberation and voting. Any individual or organization can communicate to the committee involved in any standard. Because of our relatively small and closely knit communities, although frequently far flung, appropriate credibility can be accorded to each contribution. Radical and conservative attitudes are assessed equally. Private consumer views can be outweighed by entrenched vested interests from trade associations. Any apparent imbalance can be recognised by the corporate committee membership.

One recent development which is inhibiting the processing of new or revised Australian standards is the particularly difficult question of individual or collective responsibility of committee members with respect to the documents which are ultimately published. Increased editorial vigilance is placing considerable stress on the resources of our national standards organization and it is hoped that the apparent deceleration of publishing will be seen as a necessary consequence of improving the total quality of our standards.

If industry involvement is analysed, building and construction emerge as very significant activities which have received close standardisation. Because this paper cannot hope to deal with all products and processes, the Concrete Structure Code AS 1480 is selected as a sensible primary document for study.

At this point, it must be stated that a single edition of a standard is often a deficient document because there may be no acknowledgement of the historical development of the document. Whilst the metric conversion review of Australian Standards had many advantages, it is regrettable that the previous practice of recording the history of the standard has been interrupted merely by the change in numbering system which was an essential part of the transition. For example, the 1974 edition of AS 1480 claims to be the first publishing of the Concrete Structures Code whereas the last Imperial Units version of CA2 correctly recorded that it was first published in 1934 with subsequent major revisions in 1958, 1963 and 1973.

In the Preface to the current version, recognition is given to the experience contained in other relevant national standards. There is also a list of other standards which "may be required accordingly for use in connection with the code."

The list is detailed in the attached Table 1 to demonstrate the extent to which cross referencing is necessary in this increasingly complex technological age.

Neither time nor my particular fields of interest will permit this entire list to be discussed in detail. However, a number of grouped standards will be surveyed to highlight some of the more important features of this comprehensive set of documents. The documents selected deal primarily with concrete materials, test methods and quality assessment.

Concrete Structures Code AS 1480

The first Australian version of a concrete structures code was published in 1934 and was based on specification by proportions using a very conservative approach. The first version which allowed the specification of concrete by strength appeared in 1958. The committee supported their decision by declaring that it was logical to use this approach "to achieve maximum economy in the use of the concrete and concrete materials." Over the next twentyyears, a series of different methods was used to tackle the dual problems of sampling rates and assessment of strengths. It would be an understatement to say that confusion developed over such terms as minimum, specified, average and target strengths. However, the last imperial version of CA2 appeared in 1973 and it was based on new principles from standards organizations in Europe and U.S.A. The Code was subsequently issued in metric units in 1974 as AS 1480.

Section 4 deals with the "Quality of Concrete." Three main features can be described. The term "characteristic strength" F'c is defined as the strength which is exceeded by at least 95 percent of the concrete and is effectively determined by the formula

$F'_c = \bar{x} - 1.65$ S.D. provided that the statistical analysis is based on a significant group for a given mix design i.e. containing not less than 30 and not more than 100 samples.

This approach rejects the traditional concepts of average or minimum strengths and introduces the desirable objective of achieving not only an adequate but a uniform product. The incentive to the supplier to reduce variability is compatible with the designer's wish for predictability of performance in a total sense. Whilst the assessment of quality is primarily geared to the testing of compressive, flexural or indirect tensile strength, the tacit assumption is that other desirable properties of concrete can be monitored indirectly by these procedures.

A novel concept of two approaches to accumulating sufficient samples is based on Project Control where the designer only uses data from a particular project or Plant Control where data from various projects supplied by the one plant can be used to reduce the sampling frequency on individual sites whilst still maintaining an adequate level of control and confidence.

Designers are required to consider service conditions in addition to mere structural matters and limits have been set on water-cement ratios and air entrainment when climatic conditions are considered.

Our Code still lacks guidelines which should be used to cater for the more severe aspects of durability, namely physical and chemical attack.

Aggregates for Concrete - The original standard AS A77 has been replaced by four documents. AS 1141 deals with sampling and testing of aggregates whether they are covered by AS 1465 Dense Natural Aggregates, AS 1466 Metallurgical Furnace Slag Aggregate or AS 1467 Lightweight Aggregates.

AS 1141 includes both physical and chemical tests which deal with what might be termed both short and long term quality matters.

Certain properties, namely density, grading and shape are of major importance in the preparation of mix designs and these properties must be monitored and controlled during production.

The long term serviceability of the concrete is provided by ensuring that the aggregates are physically strong, and chemically sound.

AS 1141 is a substantial document of 24 sections and has been prepared to provide for testing of aggregates, irrespective of their end use.

The separation of the specifications into three single standards is due to the significant use of the two more special types of aggregates in certain areas. Commercial quantities of blast furnace slags are available in those areas of steel production. Although not a large market, the material requires the protection of a standard. Three separate types of lightweight aggregates have been exploited. Several plants have been built to produce expanded shale due to the availability of suitable sedimentary source rock. However, there are extensive volcanic rocks in Australia and naturally occurring scoria has replaced the shalite, mainly due to increasing cost. The third development has been the processing of flyash to produce an artificial aggregate based on the products available overseas.

Ready-mixed Concrete AS 1379 - This standard is a metric version of AS A64-1971 which was a major revision of the earlier document, drawing on the findings of the extensive investigations undertaken by N.R.M.C.A. of U.S.A. and the local experience of an industry which had seen a boom during the 1960's.

In some respects, this standard is a classic case of the need to know the history of a standard to fully understand its value. It is fundamentally an operations manual for a ready-mixed concrete producer. It is based on good practice and is not cluttered by unnecessary technology. Two procedures are described for ordering concrete which differentiate the roles and responsibilities of specifier and supplier. Performance ordering allows the specifier to nominate any properties required, leaving the responsibility for selecting the materials and proportions to the supplier who must guarantee compliance. Prescription ordering is retained for those circumstances where the specifier is not prepared to accept the expertise of the supplier in particular circumstances. Performance ordering is the more common method with some limited problems occurring when designers attempt to nominate excessive mix criteria with inadequate understanding of the practices and technology.

AS 1379 makes provision for the slump of the concrete to be assessed at an early point in the discharge from a single sample (by cross reference to the appropriate standards on sampling and testing) and this is dependent on the production being based on adequate and uniform mixing throughout the load. This procedure recognises the need to mix thoroughly and indirectly acknowledges the advances made in truck mixer design. New readers of the standard would not remember the crazy procedure originally used to assess slump compliance which involved taking two separate portions at the 1/4 and 3/4 points of discharge, doing separate slump tests to determine the average slump and its divergence from the ordered slump, by which time the whole load is in the formwork and it is too late to be realistically rejected.

The other significant historical matter is the provision for addition of water to loads on site under controlled conditions. Whilst not claiming that it is a perfect statement, the provisions are sensible and would be improved by a requirement that all truck mixers must be provided with a working water meter, a practical matter which has been omitted so far.

One final aspect worthy of comment, is the nexus which exists between AS 1379 and AS 1480 with respect to quality assessment.

In earl er days, it was possible to consider that some concrete was structural and subject to the requirements of the Structures Code whereas other concrete was not subject to the same scrutiny or quality levels.

<u>Methods of Testing Concrete AS 1012</u> - My first recollection of this group of standards is a single document which was published in 1957 and included what we called the "AS A190-110" series. Some of these tests were first standardised in 1934 and 1935. We now have the impressive, if not frightening, array of 18 parts which is detailed in the attached Table 2.

During the revision, an attempt was made to re-group the various parts into a logical sequence proceeding from the sampling of concrete in the plastic state to the various properties of hardened concrete. Our human frailty is apparent when it can be seen that we have no Pt. 7 whereas that test method which is obviously the procedure for monitoring the change from the plastic to the hardened state is numbered 18 at the end of the list.

It is of interest to note that in the original version of 1957, there was provision for the determination of air contents. At that early stage, air entrainment was probably the only legitimate admixture recognised in Australia. However, it is fair to say that the inclusion of the setting time and bleeding tests in the present version is at least a partial result of the increased significance of the use of admixtures in the Australian scene.

The table indicates that the publishing of the revised metric series started in 1971 and apparently concluded in 1979. The approach being adopted by the Committee BD/42 is that it is now time to initiate a review of those conversions which were commenced a decade ago.

Cements - AS A2 Portland Cement has been replaced and expanded by three separate standards AS 1315 Portland Cement, AS 1316 Masonry Cement and AS 1317 Blended Cement.

At first sight, this appears to be a progressive attitude in that there has been recognition of the need to cater for special types of binder, whether for technical or economic reasons. However, users of cement are critical of the fact that the sampling and assessment procedures for compliance with these standards are far less onerous than those imposed in the Concrete Structures Code. For example, there are no barriers to one source of cement complying with each of the three common types - A Normal, B High Early and D Sulphate Resisting. The minimum strength limits are such that there can be a significant drop in strength producing characteristics, either physical or chemical, and yet the cement will still exceed these minimum values. The values in the standard are simply not realistic.

There have been two interesting consequences to this situation. One engineering association has set its own limits on additional physical and chemical properties so that they can be reasonably certain of obtaining a true "Normal" or "Ordinary" cement rather than the more commonly available "High Early" cements which are produced. To add to this concern, a colleague regularly specifies Type C cement for two reasons, namely that it will be a slower strength gain cement and it must be tested more stringently than the other types to require the publishing of a report which indicates compliance with a larger range of physical and chemical requirements.

These comments are not intended to suggest that there are any bad cements produced under the banner of AS 1315. The intent of these comments is to draw attention to the problem which faces a cement user who has to aim for acceptable product quality levels with low variability, whilst he must accept the fact that one of the most significant raw materials can vary widely and still satisfy the present requirements of the standards.

Admixtures - Standards for admixtures in concrete are very recent developments in the history of Australian construction practices. As a result of considerable controversy and public debate, SAA Committee BD/33 was constituted in 1965 to prepare the first Australian Standards on Concrete Admixtures.

The first documents were produced in 1970 and were based on ASTM standards with some significant advances. The two broad product groups of Water Reducing Set Controlling Admixtures and Air Entraining Agents are now covered by AS 1478 Chemical Admixtures for Concrete and AS 1479 Code of Practice for the use of Chemical Admixtures in Concrete.

Some of the main features of our standards are:
(i) the concepts of general and specific testing which can provide for broad declarations of compliance or specific suitability on individual projects; (ii) partial disclosure of formulation details; (iii) regular quality control testing with published statements of compliance being provided to consumers on request; and (iv) the recognition that decisions as to the use of admixtures could be the responsibility of either the concrete producer or the client depending on the circumstances. The decision to deal with these responsibilities in a Code of Practice was an acknowledgement of the need to bring the use of admixtures out into the open. Prior to the existence of our own national standards on admixtures, there was considerable scepticism about the products available. Because the new standards were based not only on overseas experience but also on locally produced data, consumers were reassured that the products available, although based largely on U.S. raw materials and formulations, would perform as predicted in conjunction with local raw materials, especially cements.

Additional committee activity has produced documents which deal with flyash in a similar way. There is a specification AS 1129 and a Code of Practice AS 1130.

A series of documents AS 2072, 2073 and MP20 Pt3 cover the Sampling and Testing of Expanding Admixtures for Concrete, Mortar and Grout. This group of standards is quite unusual in that, whilst there is a wide range of relevant tests, there are no specification or performance limits due to the very wide range of products and applications which have been developed.

Other committee activity has produced a document on Permeability Reducing Substances which deals with all the important aspects of producing waterproof concrete.

Tasks still not complete include dealing with the still controversial material, calcium chloride. The major dilemma facing the committee is to strike a balance between the reluctance to permit any use of the material and the commercial and technical fact that there is no other accelerator which provides the same cost benefit where it is needed.

The same committee has made a serious attempt to prepare a local equivalent to the ASTM standards on curing compounds. There is an obvious need to depart from the simple step of adopting the U.S. document when one considers the logistics involved in importing sand from overseas in relatively small quantities and at the same time having to deal with customs and quarantine matters.

The most recent topic which has required committee activity is the provision of separate statements about the use of superplasticizers. The principle problem is that the existing document is written in terms of addition of the normal water reducers at the concrete plant with all other ingredients. With superplasticizer use being maximised by addition at the job site, procedures must be set to ensure that proper control is maintained.

The Total Scene - Specifications and Practice

This broad survey has considered a series of Australian Standards as they exist today together with some historical background to provide a proper perspective. It is, in my opinion, a fact that concrete admixtures are regarded as a proper topic to receive the attention of our standardisation procedures and the place of admixtures is now clearly established in the total framework of our standards. This is not to say that our standards are perfect. We still need to resolve a few anomalies which exist because the benefits of admixtures are used in practice to overcome some traditional production problems.

AS 1480 Concrete Structure Code and AS 1379 Ready-mixed Concrete both have statements regarding temperature limits and mixing times. We still have the traditional figures of a maximum of 32°C and 1 ½ hours. It is of interest that this same problem was discussed by H lstead at the 1979 Conference. With the recent developments in Northern Australia, it is common practice for these limits to be exceeded without any obvious or reported cases of difficulties. The key to this extension of the use of portland cement concrete in these difficult climatic conditions has been the use of retarders as the principle means whereby setting is delayed until transport, placing and finishing are completed. It is true that the supplementary methods of attempting to reduce concrete temperatures have been used from time to time.

Because of the unusual population distribution, it is quite common practice in some areas to transport ready-mixed concrete up to 150 km, the time involved being in the order of 3 hours. Again, the answer to the problem has been the use of admixtures.

To quote these extreme cases is not to suggest that the admixtures are only used in unusual circumstances. The reverse is true. The widespread use of admixtures in the Australian ready-mixed concrete industry is a result of years of generally cautious experimenting involving a wide range of variables in both production and laboratory conditions. Local and overseas knowledge has been combined in an integrated series of standards which provide protection for all parties concerned.

The overwhelming experience is that admixtures are regarded as proper and credible ingredients in modern portland cement concrete due to their recognised benefits.

TABLE I

AS 1012	Methods of Testing Concrete
AS 1129 and 1130	Fly Ash for Use in Concrete
AS 1141	Methods for Sampling and Testing Aggregates
AS 1163	Structural Steel Hollow Sections
AS 1170	SAA Loading Code Part 1 - Dead and Live Loads Part 2 - Wind Forces
AS 1302	Steel Reinforcing Bars for Concrete
AS 1303	Hard-drawn Steel Reinforcing Wire of Concrete
AS 1304	Hard-drawn Steel Wire Reinforcing Fabric for Concrete
AS 1315	Portland Cement
AS 1317	Blended Cements
AS 1379	Ready-mixed Concrete
AS 1465	Dense Natural Aggregates for Concrete
AS 1467	Lightweight Aggregates for Structural Concrete
AS 1478	Chemical Admixtures for Use in Concrete
AS 1479	Code of Practice for the Use of Chemical Admixtures in Concrete
AS 1481	SAA Prestressed Concrete Code
AS 1509	SAA Formwork Code
AS 1510	Code of Practice for Control of Concrete Surfaces Part 1 - Formwork
AS 1530	Methods of Fire Tests on Building Materials and Structures
AS 1554	SAA Code for Welding in Building Part 3 - Welding of Reinforcing Steel
AS 1475	SAA Code for Concrete Block Masonry
AS CC1	Part 1 - SAA Wiring Rules
ACI 318-71	Building Code Requirements for Reinforced Concrete

TABLE 2

AS 1012 Methods of Testing Concrete

Part 1-1971	Method for sampling fresh concrete
Part 2-1971	Method for mixing concrete in the laboratory
Part 3-1976	Determination of properties related to the consistence of concrete (incorporating Amdt 1)
Part 4-1972	Determination of air content of freshly mixed concrete (incorporating Amdt 1)
Part 5-1971	Determination of weight per unit volume of freshly mixed concrete (incorporating Amdt 1)
Part 6-1971	Determination of bleeding of concrete
Part 8-1973	Method for making and curing concrete compression, indirect tensile and flexure test specimens in the laboratory or in the field (incorporating Amdts 1 to 30)
Part 9-1973	Determination of compressive strength of concrete specimens
Part 10-1972	Determination of indirect tensile strength of concrete cylinders ("Brazil" or splitting test)
Part 11-1972	Determination of flexural strength of concrete flexure test specimens (incorporating Amdt 1) Amdt 2, April 1977; Amdt 3, July 1977
Part 12-1971	Determination of weight per unit volume of hardened concrete (incorporating Add 1 and Amdt 1)
Part 13-1970	Determination of drying shrinkage of concrete
Part 14-1973	Method for securing and testing cores from ha[illegible]ed concrete for compressive strength or indirect tensile [illegible]ngth (incorporating Amdt 1) Amdt 2, April 1977
Part 15-1979	Method for the estimation of portland cement content of hardened concrete
Part 16-1974	Determination of creep of concrete cylinders in compression
Part 17-1976	Methods for the determination of the static chord modules of elasticity and Poisson's ratio of concrete specimens
Part 18-1975	Determination of setting time of fresh concrete, mortar and grout by penetration resistance