



mainroads
WESTERN AUSTRALIA

SPECIFICATION 820

CONCRETE FOR STRUCTURES

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REVISION REGISTER			
Clause Number	Description of Revision	Authorised By	Issue Date
820.02	References added: AS 1012.5, AS 1012.9, AS 1012.21 and AS/NZS 3582.1 Reference removed: AS 1141.65	SDSE	25/07/2023
820.07.2	Fly ash has been added as part of blended cement		
820.07.3	Moved to consolidate with 820.07.1		
820.08.2	Standard reference amended		
820.08.6	Withdrawn standard removed		
Table 820.2	S35 class removed, max W/C for S40 increased, min cementitious content for S65 modified and note added for LH concrete target strength		
820.29.5	Slump requirement modified		
820.29.8	Sub-clause deleted, subsequent sub-clauses renumbered		
820.29.11	New Hold Point added for approved concrete mix		
Table 820.3	VPV testing requirements S35 class removed		
820.31	Changed heading from “concrete plant” to “General” and 820.31.1 has been reworded		
820.33.2	820.33.2 has been moved to clause 820.52 in PLACING		
820.35.2	Sub-clause added/moved from contract specific requirements		
820.52.5	820.52.5 has been moved to clause 820.33 in TRANSPORT		
820.56.5	Clause modified to suit the deck curing requirement		
820.56.8	Clause modified to suit the durability requirement		
820.56.11	Steam curing refence added		
820.58.3	New crack width specified for precast prestressed and post-tensioned elements		
820.71	Steam curing clause 820.91 has been renumbered, steam curing control plan requirements added		
820.72	Maturity testing clause 820.92 has been renumbered		
820.02	References added: AS 1012.1, AS 1012.3.1, AS 1012.3.5, AS 1012.13, AS 1012.20.1, AS 1141.65, AS 1478.1, AS 1478.2, AS 3582.1, AS 3582.3, AS 5100, ASTM C295 and BS 1881-204	SDSE	12/06/2018
820.08	Petrographic requirements added		
820.10	AS 1478.1 and AS 1478.2 added		

820.11	Proportion of amorphous silica updated Aggregate compliance note moved to Clause 5 Maximum amount of manufactured sand updated		
820.27	Durability requirement added		
820.28	General bridge elements removed 10 mm aggregate grading envelope graph updated Binder replaced with cement in Table 820.2 (w/c) added in Table 820.02		
820.29	Slump flow removed from Clause 3 Self-compacting concrete in accordance with AS 1012.3.5 added Slump flow and passing ability requirements added S35/10 changed to S35 in Table 820.3 VPV for test cores added to Table 820.3		
820.30	Clause heading changed		
820.52	Excessive bleeding added Clause added for construction during rain		
820.56	Exposure classification C1 or above added Clause 8, 9 10 added for additional curing requirements		
820.58	Clause added for quality assurance during construction requirements		
820.59	Clause added for non-compliance requirements		
820.92	Maturity testing limited to precast elements with accelerated curing Methodology validation added		
Whole Document	Deletion of Reviewers' Comments	SCO	20/10/2017

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SPECIFICATION 820

CONCRETE FOR STRUCTURES

GENERAL

820.01 SCOPE

1. The work under this Specification consists of the mix design, the supply and delivery, placing, compaction, finishing, curing and protection of high performance concrete for the following structures:
 - (a) bridges;
 - (b) pedestrian overpasses/underpasses;
 - (c) manufacture of box culverts; and
 - (d) other structural works.
2. Concrete for general non-structural works is covered in Specification 901 CONCRETE – GENERAL WORKS.

820.02 REFERENCES

1. Australian Standards, MAIN ROADS Western Australia Standards and MAIN ROADS Western Australia Test Methods are referred to in abbreviated form (e.g. AS 1234, MRS 67-08-43 or WA 123). For convenience, the full titles are given below:

Australian Standards

AS 1012	Methods of testing concrete
AS 1012.1	Methods of testing concrete – Sampling of concrete
AS 1012.3.1	Methods of testing concrete – Determination of properties related to the consistency of concrete – Slump test
AS 1012.3.5	Methods of testing concrete – Determination of properties related to the consistency of concrete – Slump flow, T500 and J-ring test
AS 1012.5	Methods of testing concrete – Determination of mass per unit volume of freshly mixed concrete
AS 1012.9	Methods of testing concrete – Method 9: Compressive strength tests – Concrete, mortar and grout specimens
AS 1012.13	Methods of testing concrete – Determination of the drying shrinkage of concrete for samples prepared in the field or in the laboratory

AS 1012.20.1	Methods of testing concrete – Determination of chloride and sulphate in hardened concrete and concrete aggregates
AS 1012.21	Determination of water absorption and apparent volume of permeable voids in hardened concrete
AS 1141	Methods for sampling and testing Aggregates
AS 1141.60.1	Potential alkali-silica reactivity – Accelerated mortar bar method
AS 1141.60.2	Potential alkali-silica reactivity – Concrete prism method
AS 1379	Specification and supply of concrete
AS 1478.1	Chemical Admixtures for concrete, mortar and grout – Admixtures for concrete
AS 1478.2	Chemical Admixtures for concrete, mortar and grout – Methods of sampling and testing admixture for concrete, mortar and grout
AS 2758.1	Aggregates and rock for engineering purposes – Concrete aggregates
AS 3550.4	Determination of solids – Gravimetric method
AS 3582.2	Supplementary cementitious materials – Slag – Ground granulated blast-furnace
AS 3799	Liquid membrane-forming curing compounds for concrete
AS 3972	General purpose and blended cements
AS 5100	Bridge Design

Australian / New Zealand Standards

AS/NZS 3582.1	Supplementary cementitious materials – Fly ash
AS/NZS 3582.3	Supplementary cementitious materials – Amorphous silica

Other Standards

Cement & Concrete Association of New Zealand	Report No. TR3, Alkali Silica Reaction
Australian Technical Infrastructure Committee (ATIC)	Specification SP43 – Cementitious Materials for Concrete
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
BS 1881-204	Testing Concrete – Recommendations on the use of electromagnetic cover meters

MAIN ROADS Specifications

Specification 201	QUALITY MANAGEMENT
Specification 819	FALSEWORK
Specification 821	FORMWORK
Specification 822	STEEL REINFORCEMENT
Specification 901	CONCRETE – GENERAL WORKS

820.03 DEFINITIONS

820.03.01 DESIGN

1. For the purpose of this Specification the following definitions apply:
 - (a) Concrete in general shall consist of a mixture of cement, water, and coarse and fine aggregate. Where specified on the Drawings, blended cement as described at clause 820.07(2) shall be used.
 - (b) Water/cement ratio is the ratio by mass of the total water content of the mix available for hydration to the total cement in the mix.
 - (c) Aggregate/cement ratio is the ratio by mass of the total aggregate in the mix (measured in the saturated surface dry state) to the total cement in the mix.
 - (d) The compressive strength of concrete shall be defined as the average 28-day crushing strength of a minimum of three standard 100 mm diameter by 200 mm long cylinders taken from the same sample and made, cured and tested in accordance with AS 1012.

820.03.02 SPECIAL PROCESSES

1. The placing, compacting, finishing and curing of concrete are identified as processes that require detailed Process Control Plans in accordance with Specification 201 QUALITY MANAGEMENT.

***Special
Processes***

820.03.03 ADDITIONAL QUALITY SYSTEM REQUIREMENTS

1. The information to be submitted by the Contractor as part of their Quality Management Plan prepared in accordance with Specification 201 QUALITY MANAGEMENT shall include, but not be limited to, the following:
 - (a) Details of the methods to be used in maintaining evidence generated during each process requiring a Process Control Plan. The number of personnel required together with proof of any relevant training and experience shall be included.
 - (b) Verification of the compliance of any proposed heat accelerated curing method (such as steam curing) with the Specification requirements.

***Quality
Management
Plan***

820.04 – 820.05 NOT USED

PRODUCTS AND MATERIALS

820.06 GENERAL

1. Structural concrete utilised under this Contract shall be supplied from either an approved off-site batching plant and delivered by truck agitator or an on-site batching plant.
2. In its finished state concrete shall be sound and dense and durable and free from honeycombing and shall have the strength and other properties specified.
3. Concrete shall comply with AS 1379, except as varied by this Specification.

820.07 CEMENT

1. Unless specified otherwise, all cement used in the work under the Contract shall comply with the requirements of General Purpose Cement (Type GP), Blended Cement (Type GB) or Low Heat Cement (Type LH) as specified in AS 3972 and Australian Technical Infrastructure Committee (ATIC) Specification SP43. The Contractor shall provide manufacturer's test certificates showing all cement has been sampled, tested and conforms in all respects with the AS 3972 and ATIC – Specification SP43. The Cementitious Material Registration Scheme (CMRS) shall be used to confirm that the cement complies with ATIC – Specification SP43.
2. Blended cement shall be a combination of Type GP cement and ground granulated iron blast-furnace slag complying with AS 3582.2 and ATIC – Specification SP43 or fly ash complying with AS/NZS 3582.1 and ATIC – Specification SP43. The silica fume to be added to the blended cement shall be finely divided and comply with AS/NZS 3582.3 and ATIC – Specification SP43.
3. **Prior to manufacturing of concrete the Contractor shall confirm that the cement complies with ATIC – Specification SP43 and shall provide the CMRS registration number for the cement to the Superintendent for approval of the cement.**
4. The Contractor shall use cement in approximately the chronological order in which it is manufactured. Transportation units for bulk cement shall be weatherproof and shall be constructed so that there is no dead storage.
5. Storage bins for bulk cement shall be weatherproof and:
 - (a) not have any dead storage; or
 - (b) if dead storage exists, shall be emptied completely at least once every three months.
6. Cement delivered in bags shall be stored in weatherproof structures having floors raised above the ground. Cement that is more than three months old shall not be used.

Testing and Certification

Blended Cement

HOLD POINT

7. Concrete manufactured from cement not conforming to this Specification or from cement that has deteriorated and become unsuitable for use shall be rejected.
8. Only that brand of cement used in successful Trial Mixes will be used for the production of concrete unless otherwise approved by the Superintendent.

820.08 AGGREGATE

Testing

1. Fine aggregates for concrete shall be natural sand or a combination of natural and manufactured sand and shall comply with the requirements of AS 2758.1. The maximum amount of water absorption for natural fine aggregates and manufactured fine aggregates shall not exceed 1.5 and 2.5 percent respectively.
2. The durability of fine aggregates shall be assessed according to test methods nominated in clause 9.2 of AS 2758.1. The acceptance criteria for these tests shall be that for a concrete exposure classification C unless otherwise specified.
3. Coarse aggregates for concrete shall be crushed igneous rock or screened river gravel conforming to the requirements of AS 2758.1. The maximum amount of water absorption for coarse aggregates shall not exceed 2.5 percent.
4. The durability of coarse aggregates shall be assessed according to test methods of AS 2758.1. The acceptance criteria for these tests shall be that for a concrete exposure classification C unless otherwise specified.
5. All aggregates proposed for use in the work under the Contract shall comply with the requirements of the "Alkali-Reactive Materials" clause of AS 2758.1.
6. A petrographic report for all the aggregates proposed for use in the work under the Contract shall be provided in accordance with ASTM Test Method C295. The petrographic report shall include thin section microscopic examination of the proposed aggregate giving its mineralogical composition. It shall also include comments and interpretations related to alkali silica reactivity and suitability of aggregate for use in concrete.
7. The Contractor shall provide proper means of storing the aggregates. Each nominal size of coarse aggregate and fine aggregate shall be kept separated and suitable precautions shall be taken to prevent the aggregates from being contaminated by the ground or by wind-blown dust or other foreign matter.
8. Only that aggregate source used in the successful Trial Mixes will be used for the production of concrete, unless otherwise approved by the Superintendent.

820.09 WATER

1. Water used in concrete manufacture and curing shall comply with the requirements of clause 2.4 of AS 1379. The total alkali content of a representative sample of water being a mix of recycled and bore water

shall be measured and the result obtained included in the calculation of total alkali content as required by clause 820.11.

2. Water for concrete shall have a total dissolved solids content of not greater than 1,500 mg/L when tested in accordance with AS 3550.4. The amount of chloride in the water shall not be greater than 300 mg/L.
3. The Contractor shall arrange that a suitable supply of water is available at the batching plant.

Testing

Contractor to Supply

820.10 ADMIXTURES

1. Admixtures may be used in concrete to modify workability but will not be permitted for the purpose of reducing cement content. However, the admixture shall have no harmful effect whatsoever upon the quality of the concrete or upon any reinforcement or prestressing system or other fixture embedded therein.
2. Any admixture when tested in accordance with AS 1478.2, shall comply with the requirements of and be used in accordance with AS 1478.1.
3. Calcium chloride and other chloride-bearing admixtures shall not be used in concrete containing any type of steelwork or steel reinforcement.
4. Where two or more admixtures are proposed for incorporation into a concrete mix, their compatibility shall be certified by the manufacturers and the certificates shall be provided to the Superintendent before use of the admixtures.

820.11 ACTION REQUIRED FOR THE CONTROL OF ALKALI AGGREGATE REACTIVITY (AAR)

1. The total mass of reactive alkali in the concrete, including any admixtures shall not exceed 2.8 kg/m³. The method of determining the alkali content shall be in accordance with Appendix C of Report 3 (TR3) by the Cement & Concrete Association of New Zealand.
2. All aggregates for use in concrete shall be tested for their susceptibility to AAR in accordance with AS 1141.60.1.
3. Where the aggregate source has previously been classed as acceptable in accordance with AS 1141.60.1, may be exempt from re-testing at the discretion of the Superintendent.
4. Aggregates and manufactured fine sand shall be classified in accordance with Table 820.1.
 - (a) For aggregates classified as non-reactive by AS 1141.60.1 no action for control is required.
 - (b) For aggregates classified as slowly reactive by AS 1141.60.1 as shown in Table 820.1, concrete mix shall either:
 - (i) incorporate a proportion of fly ash that is 25% by mass of the total cementitious materials; or

Testing

- (ii) be a blended cement (65% Ground Granulated Iron Blast-Furnace Slag + 35% Type GP cement); or
 - (iii) incorporate a proportion of amorphous silica that is 8% to 10% by mass of the total cementitious material.
- (c) Aggregates classified by AS 1141.60.1 or AS 1141.60.2 as reactive shall not be used.
5. Fly ash, ground granulated iron blast-furnace slag and amorphous silica shall comply with the requirements of AS 3582.1, AS 3582.2 and AS 3582.3 respectively.
 6. The Contractor may submit test results for concrete prism testing in accordance with AS 1141.60.2 as an alternative to testing described above provided test certificates are less than 12 months old and show the aggregate to be non-reactive.
 7. **The manufacture of concrete shall not occur before the aggregate source to be used has met the test requirements with respect to AAR and approved by the Superintendent.**
 8. The Contractor shall provide the Superintendent with certified test results for both the coarse and fine aggregates for each aggregate source to be used for the manufacture of concrete. The Contractor shall not change the aggregate source without the approval of the Superintendent.
 9. Manufactured sand shall be permitted in the mix of up to a maximum 15% by weight of the total aggregates in the mix, from a source approved by the Superintendent.

HOLD POINT

Note: some glassy basalt aggregates are non-reactive in the coarse aggregate form, but can become reactive in crushed fine aggregate form. The incorporation of basalt dust may significantly increase the alkali content of the concrete, and cause deleterious AAR expansion in the presence of a reactive aggregate, in an otherwise non expansive concrete.

TABLE 820.1 AGGREGATE REACTIVITY CLASSIFICATION

Mean Mortar Bar Expansion (E) %		AS 1141.60.1 Aggregate Reactivity Classification
10 days	21 days	
-	$E < 0.10^*$	Non-reactive
$E < 0.10^*$	$0.10^* \leq E < 0.30$	Slowly reactive
$0.10^* \leq E$	$0.30 \leq E$	Reactive

Note: *The value for natural fine aggregates is 0.15%.

820.12 SOLUBLE SALTS

1. Sulphate and chloride ion contents shall be determined by testing of hardened concrete in accordance with AS 1012.20.1.

2. The sulphate content of concrete as placed expressed as the percentage by mass of acid-soluble SO_3 of cement shall not be greater than 5%.
3. The mass of acid-soluble chloride ion per unit volume of concrete as placed shall not exceed 0.4 kg/m^3 .

820.13 LIMITATIONS ON SHRINKAGE

1. Concrete specimens shall be prepared from the nominated mix in accordance with AS 1012.13 for the purpose of shrinkage testing. The shrinkage of the specimens shall be measured in accordance with AS 1012.13. The shrinkage strain of the concrete specimens after 56 days of drying shall not exceed 600×10^{-6} . The maximum shrinkage strain for self-compacting concrete used in piling construction shall not exceed 700×10^{-6} .

820.14 – 820.25 NOT USED

DESIGN OF CONCRETE MIXES

820.26 GENERAL

1. The Contractor shall design a mix for each class of concrete specified and shown on the Drawings. The locations for these classes are summarised in Annexure 820A.
2. The Contractor shall not change the source and/or the formulation of the binder and the mix proportions of the concrete, unless they have been tested and approved by the Superintendent.

820.27 DURABILITY

1. All concrete utilised in the work under the Contract is intended to be durable for the life of the relevant structural element.
2. Concrete durability requirements shall comply with AS 5100.5 unless noted otherwise in this Specification.

820.28 CLASS OF CONCRETE FOR MIX DESIGN

1. All concrete for the work under the Contract shall be as specified in Table 820.2 except that blinding concrete and make-up concrete shall be Class N20 in accordance with Specification 901 CONCRETE – GENERAL WORKS.
2. **Type GP or GB cement shall be used in all classes of concrete except for class S50M. Type LH cement may be used for elements greater than 500 mm thick, providing the Contractor demonstrates to the Superintendent prior to its use through the completion of thermal modelling by an appropriately qualified and experienced person that the relevant requirements of the Contract will be met.**
3. Class S50M concrete shall use blended cement consisting of 32% Type GP cement, 60% ground granulated iron blast-furnace slag and 8% silica fume.

HOLD POINT

4. The combined grading shall be within the limits given in Figures 820.1, 820.2 or 820.3 after making allowance for the permissible tolerances on individual aggregate grading specified in clause 820.08.
5. Subject to the Superintendent's approval, the Contractor may submit a combined grading curve for mixes supplied in remote locations in lieu of the grading limits shown in Figures 820.1 and 820.2. The percentage passing of 0.075 mm and 0.15 mm sieves shall not exceed 2% and 3% respectively. The grading of material can vary from coarse to fine in a uniform and consistent manner.

**Concrete
Supply in
Remote
Locations**

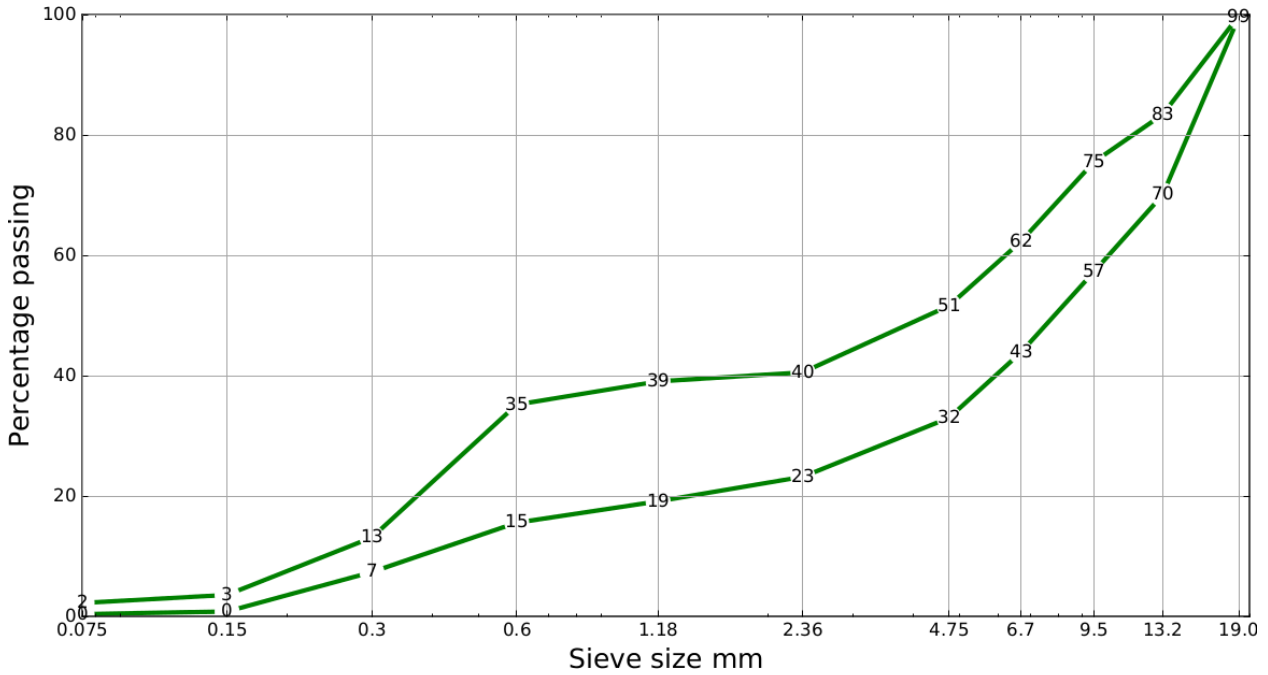


FIGURE 820.1 AGGREGATE GRADING ENVELOPE 20mm

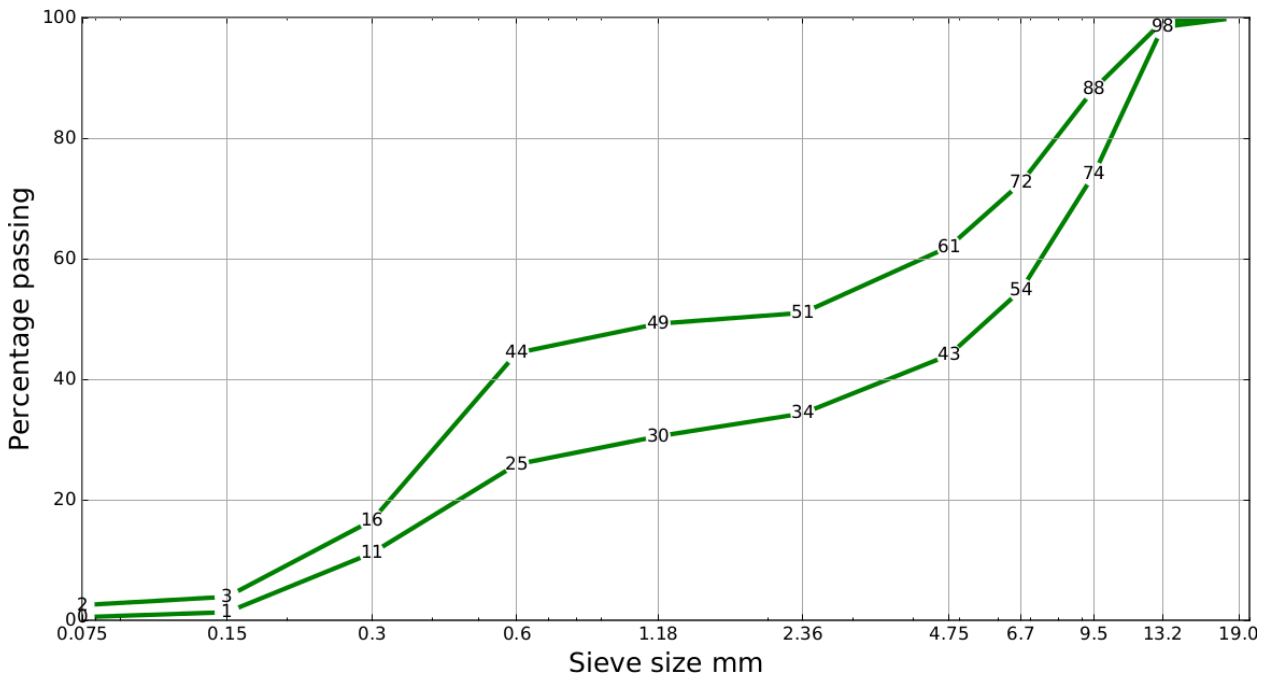


FIGURE 820.2 AGGREGATE GRADING ENVELOPE 14mm

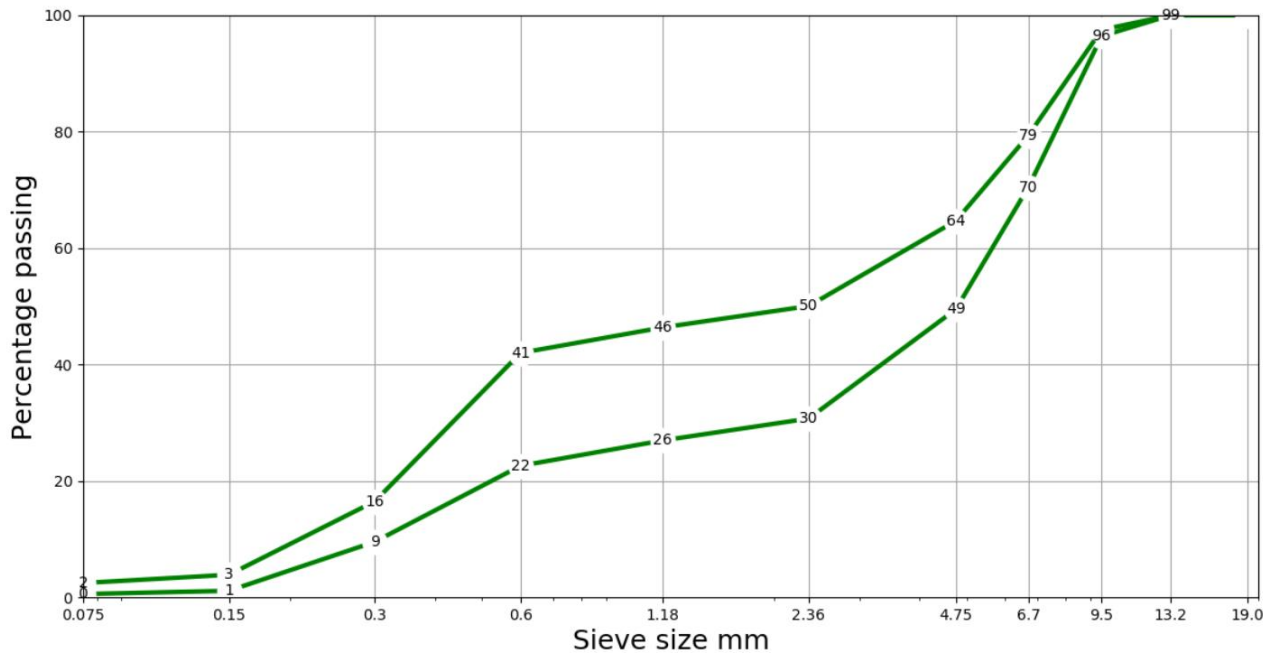


FIGURE 820.3 AGGREGATE GRADING ENVELOPE 10mm

TABLE 820.2

Concrete Class	S40	S50	S65
Nominated strength (MPa)	40	50	65
Target strength (MPa)*	48	58	73
Max aggregate size (mm)	20	20	20
Max water/cement ratio (w/c)	0.45	0.40	0.38
Min Cementitious Content (kg/m ³)	400	420	450

Note: *Target Strength for LH concrete shall be reported at 56 days.

820.29 TRIAL MIXES

1. The Contractor shall prepare a trial mix for each class of concrete to be used in the work under the Contract. Each mix shall use such aggregates that have been tested and approved by the Superintendent. The mixes shall be made using the plant and degree of quality control proposed for the work under the Contract.
2. Where the concrete is supplied by an off-Site batching plant the Contractor shall arrange for the trial mix to be delivered to the Site in a truck agitator or mixer truck of the type to be used for the supply of concrete to the work under the Contract. Surplus trial mix concrete may be placed as blinding or make-up concrete.
3. The Contractor shall measure the slump of the trial mix in accordance with AS 1012.3.1 and the value of the slump shall be agreed by the Superintendent.

4. Once a mix design for a specific class of concrete is adopted, the slump of the trial mix shall be deemed to be the slump for that class of concrete and all concrete of this class supplied to the Works shall have the same slump, within a tolerance as detailed in AS 1379.
5. The maximum slump of any concrete mix shall not exceed 200 ± 40 mm unless it is a self-compacting concrete as detailed at clause 820.29(6).
6. Self-compacting concrete shall be tested in accordance with AS 1012.3.5 and have a slump flow value of not less than 650 ± 100 mm immediately after batching and a minimum of 400 mm 3.5 hours after batching.

The slump flow shall achieve a spread of 500 mm within 2 to 5 seconds (i.e. T500 time = 2 to 5 seconds), however the final spread shall not exceed 750 mm in diameter.

The passing ability shall measure ≤ 10 mm and be free of segregation.

7. Self-compacting concrete shall be used for bored piles or tremie concrete works only.
8. The Contractor shall cast not less than 9 and not more than 21 compressive strength test specimens from the trial mix which shall be tested to determine that the strength requirements of this Specification are met.
9. The average 28 day compressive strength of all specimens made from a trial mix shall be not less than the target strength and 70% of all test results shall have compressive strengths within 3 MPa of the mean.
10. Subject to the Superintendent's approval, concrete mixes with a proven history of compliance to the Specification of no more than 12 months may be exempted from the trial mix requirements.
11. **The Contractor shall provide proof to the Superintendent that the concrete mix design has been approved in accordance with this Specification before any concrete is manufactured and placed in the work under the Contract.**

HOLD POINT

820.30 VOLUME OF PERMEABLE VOIDS

1. The maximum volume of permeable voids (VPV) values, as determined according to AS 1012.21, shall not exceed the values given in Table 820.3.
2. Unless otherwise specified, test cylinders shall be cured in accordance with AS 1012. A minimum of 2 cylinders per sample per trial mix shall be taken. Each cylinder shall be tested for VPV at 28 days in accordance with test method AS 1012.21. The average value of the test cylinders shall not exceed the values given in Table 820.3.
3. Should the VPV value exceed as shown in Table 820.3, the Contractor shall take steps to modify the concrete mix design and re-test to ensure that the maximum specified VPV value is not exceeded.

TABLE 820.3 VPV LIMITS FOR VARIOUS CONCRETE CLASSES

Concrete Class	Maximum VPV at 28 days (%)		Test Cores
	Test Cylinders compacted by		
	Vibration	Rodding	
S40	13	14	16
S50, S65	12	13	15

SUPPLY AND DELIVERY OF CONCRETE

820.31 GENERAL

1. The concrete mixes used in the work under the Contract shall be an approved concrete mix in accordance with 829.29(13).

820.32 BATCHING AND MIXING

1. The batching plant shall be capable of producing the quantities of concrete at the rates necessary for the efficient and proper placement of concrete in the work under the Contract.
2. The Contractor shall provide, maintain and operate the batching equipment so as to accurately determine and control the amount of each separate ingredient entering the concrete to the tolerances specified in AS 1379. The amounts of cement, sand and each size of aggregate entering each batch of concrete shall be determined by weighing and the amount of water shall be determined by weighing or by volumetric measurement.
3. Mixing of concrete shall comply with the requirements of AS 1379.

820.33 TRANSPORT

1. Concrete shall be transported to the Site in a manner preventing contamination, segregation or loss of ingredients. Containers for transporting concrete shall be cleaned at the end of each shift and whenever concreting work is interrupted for more than 40 minutes.
2. Unless trial mixes show a longer open time, all concrete in a batch shall be placed in its final position and compacted within 90 minutes of adding water to the mix.

Trial mixes may be undertaken to demonstrate a longer open time for a particular mix. Open time shall be judged by keeping concrete in a truck and measuring the slump at 20 minute intervals.

Retempering a batch of concrete using admixtures or water is not permitted under any circumstances. Concrete shall not be incorporated into the work under the Contract if the consistency of measured slump is not within the limits specified in AS 1379.

3. Concrete shall be continuously agitated from the time of adding water to the mix until discharge is completed. The use of non-agitating equipment to transport concrete will not be permitted.

820.34 TEMPERATURE AT POINT OF DELIVERY

1. Placement of concrete will only be permitted providing:
 - (a) the concrete mix temperature during placement shall at no time exceed 32°C; and either
 - (b) the ambient shade temperature is less than 38°C and falling; or
 - (c) the ambient shade temperature is less than 38°C and rising, but placement can be completed before the ambient temperature exceeds 38°C.
2. The Contractor must undertake measures to keep the concrete maximum temperature below 32°C including shielding and/or wetting the aggregate stockpiles, chilling the mixing water and/or scheduling concrete placement at night.
3. When the ambient shade temperature is greater than 32°C suitable means shall be provided by the Contractor to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces against which concrete is to be placed including reinforcement and formwork shall be sprayed with water to prevent excessive absorption of water from the fresh concrete.

***Hot Weather
Concreting***

820.35 MIX CONSISTENCY

1. The Contractor shall check the consistency of all concrete by measurement of the slump in accordance with AS 1012.3.1. The Contractor shall supply a minimum of one full set of Slump Testing equipment for this purpose for the period of the Contract that concreting work occurs. Slump tests shall be carried out on Site close to the concrete discharge point prior to commencement of concrete placement. The tolerances for the specified slump shall be in accordance with AS 1379.
2. For rural Contracts where mobile concrete batch plant facilities are used, one (1) slump test must be carried out on each truck delivered to Site.

Slump Test

820.36 ADDITION OF WATER TO THE MIX AFTER MIXING

1. Excessive over-mixing shall not be permitted and any concrete which has been retained in the mixer as noted in clause 820.33.2 that it requires additional water to permit satisfactory placing, shall be rejected.
2. Notwithstanding any batching variations to the design mix, water shall not be added to the concrete after the concrete leaves the batching plant.

820.37 SAMPLING OF CONCRETE FOR STRENGTH

1. Sampling procedures for concrete shall conform to AS 1012.1 and from each sample of concrete taken for the purpose of checking the 28 day compressive strength not less than 3 test specimens shall be cast.

2. The Contractor shall have available not less than 15 steel moulds for making concrete compression test specimens. For the period of large concrete pours the Contractor shall supply adequate extra moulds to meet the increased frequency of sampling required.
3. Where it is required to determine the compressive strength of concrete prior to 28 days (e.g. to determine stripping times for formwork or to assess when prestressing force may be applied), the Contractor shall cast additional test specimens and they shall be cured under similar conditions to the concrete they represent.

820.38 STRENGTH OF CONCRETE DELIVERED

1. Concrete from any class shall be deemed to conform with the strength requirements of this Specification if:
 - (a) every concrete sample has a 28 day compressive strength greater than 95% of the nominated strength; and
 - (b) the average 28 day compressive strength for any group of four consecutive samples is equal to or greater than the nominated strength.
2. Consecutive samples for the same class of concrete are not restricted to a single pour.
3. For a group of samples failing to comply with clause 820.38(1)(b), that concrete represented by the lowest strength sample shall be rejected.
4. If at any time during the progress of the work under the Contract any mix is found to be non-conforming or it becomes necessary to use materials differing from those originally approved, then the Contractor shall prepare revised mix designs and prepare trial mixes for testing in accordance with clause 820.29 prior to its use being approved. Otherwise, for any particular class of concrete, the Contractor shall not vary the properties of the materials used or their relative proportions from those of the approved trial mix.

820.39 CURING AND TESTING OF SPECIMENS FOR DETERMINATION OF COMPRESSIVE STRENGTH

1. Within 36 hours of test specimens being taken for the purpose of checking compressive strength, the test specimens shall be placed under standard moist-curing conditions as defined in AS 1012. Continuous standard moist-curing conditions shall be maintained on the test specimens, until the required curing period has elapsed and the test specimens are removed for the purpose of compressive strength testing.
2. If the requirements of clause 820.39(1) cannot be satisfied through the utilisation of off-site testing facilities then the Contractor shall be required to establish on-site curing and testing facilities.

Curing

***On-site
Facilities***

820.40 – 820.50 NOT USED

OPERATIONS

820.51 GENERAL

1. Requirements for falsework shall be in accordance with Specification 819 **FALSEWORK**. *Falsework*
2. Requirements for formwork shall be in accordance with Specification 821 **FORMWORK**. *Formwork*
3. Requirements for steel reinforcement shall be in accordance with Specification 822 **STEEL REINFORCEMENT**. *Reinforcement*

820.52 PLACING CONCRETE

1. Concrete shall be deposited as near as possible in its final position and shall be placed in a manner which will prevent segregation and excessive bleeding. It shall be spread in horizontal layers with the first layer not exceeding 350 mm in compacted thickness and the thickness of subsequent layers limited to 75% of the length of the immersion vibrators being used. Placing shall be continuous between specified or approved construction joints.
2. Where chutes are used to convey concrete their slopes shall be such as to avoid segregation. Concrete shall not be allowed to fall freely more than 2.0 m unless suitable chutes, baffles or other devices are provided to prevent segregation. The Contractor shall rectify any temporary gaps that are introduced between reinforcement during concrete placement.
3. Screeding of the deck or top surface of the structure shall progress in a longitudinal direction with the screed boards operated at right angles to the centreline of the deck or top surface. Screed guides shall be accurately set and rigidly fixed in position. Guides shall be of robust construction and shall be capable of sustaining construction loadings without undue or permanent deflection.
4. Concrete shall not be placed in standing water.
5. **Prior to the placement of any concrete, the Contractor shall certify to the Superintendent that all falsework, formwork, reinforcement and other embedded items, levels, placement, testing and curing procedures to be employed comply with the requirements of the Specifications.** *HOLD POINT*
6. In continuous pours the maximum time lag between successive layers of concrete on site shall not exceed 20 minutes.
7. Concrete shall not be placed during rain unless approved by the Superintendent, and that sufficient protection against rain is provided.

820.53 CONSTRUCTION JOINTS

1. The location of all construction joints shall be as indicated on the Drawings. Construction joints shall be made on true vertical and horizontal planes, or as otherwise shown on the Drawings. The surface of the hardened concrete shall be treated to remove all laitance and expose the aggregate

so as to provide a thorough bond with concrete cast subsequently. The roughened surface shall be thoroughly cleaned to remove loose chips and any foreign matter.

2. Immediately before fresh concrete is cast against the joint the hardened concrete surface shall be thoroughly wetted.

820.54 COMPACTION

820.54.01 MINIMUM EQUIPMENT

1. **Before commencement of each concrete pour, sufficient vibrators and spares shall be available and tested. The number of working vibrators required shall be not less than one for each 4 cubic metres of concrete placed per hour. The number of standby vibrators shall be not less than 25% of the number of working vibrators with a minimum of 1.** ***HOLD POINT***
2. The required number of vibrators for a given rate of placing concrete shall be continuously used during the pour.
3. Immersion vibrators shall be of the rotary out of balance type with a frequency of not less than 150 Hertz and, where the specified concrete finish is Class 2 or 3, shall be fitted with approved rubber caps. The largest practical size of vibrator should be used.

820.54.02 OPERATION

1. The concrete shall be properly compacted throughout the full extent of each layer so as to produce a concrete that is uniformly plastic, dense, free of all entrapped air and the finished work shall be a dense and uniform mass free of voids, segregation, honeycombing and showing a uniform face as specified when the forms are removed. Layers of concrete shall not be placed until layers placed previously have been thoroughly compacted.
2. Compaction of concrete shall be carried out by approved power-driven immersion vibrators applied in such a manner as will ensure the concrete is satisfactorily and uniformly compacted. Immersion vibrators shall penetrate the full depth of the layer and where the underlying layer is of fresh concrete, shall penetrate that layer a minimum of 100mm to ensure that successive layers are well knitted together. Immersion vibrators shall be withdrawn slowly to prevent the formation of voids. Vibrators shall not be used to work the concrete along the forms or in such a way as to damage formwork.

820.54.03 ADDITIONAL REQUIREMENTS FOR BRIDGE DECK CONCRETE

1. Compaction of deck concrete shall be carried out using approved vibrating screeds in addition to immersion vibrators followed by screeding with a "bull float" and finishing with a mechanical trowelling machine.
2. Concrete at the top surface of bridge decks must be a rough-textured surface suitable for bituminous surfacing. This surface can be produced with a rough mechanical trowelling or any method that is approved by the Superintendent. A smooth finish will not be permitted except at the locations to be covered with a preformed waterproof membrane.

820.55 FINISHING OF UNFORMED SURFACES**820.55.01 GENERAL**

1. The type of finish and surface texture required in each part of the work under the Contract shall be as shown on the Drawings.

TABLE 820.4 UNFORMED SURFACE FINISHES FOR CONCRETE

Designated Finish	Type of Concrete Finish	Maximum Allowable Surface Irregularities
U1	A wood floated finish to produce a uniform surface without surface pitting or cavities	5mm abrupt or 15mm in a 3m template
U2	A high quality steel trowelled finish having a dense smooth impervious finish without surface pitting or cavities	Nil abrupt or 5mm in a 3m template
U3	A high quality mechanical steel trowelled finish having a dense impervious finish without surface pitting or cavities	2mm abrupt or 5mm in a 3m template
U4	A wood floated surface with a broomed finish	3mm abrupt or 5mm in a 3m template

820.55.02 ALLOWABLE TOLERANCES

1. Unformed concrete surface finishes shall be as designated on the Drawings with reference to the classifications given in Table 820.4.

820.55.03 BROOMED FINISH

1. Broomed surfaces shall be obtained by finishing with a wood float followed by brooming transversely to the principal slope direction, or perpendicular to the edges. The broomed finish shall contain grooves between 1mm and 3mm deep spaced between 2mm and 6mm apart so as to provide a non-slip surface.

820.56 CURING OF CONCRETE

1. Freshly placed concrete shall be protected from the sun, wind and rain and prevented from drying out too quickly.
2. Curing shall commence immediately after the completion of final finishing operations.
3. The minimum curing period for structural concrete shall be 7 days. The minimum curing period for concrete Class S50M and any other concrete incorporating ground granulated blast furnace slag, fly ash or used in exposure classification C1 and above shall be 14 days.
4. All concrete surfaces shall be cured by one of the following methods:
 - (a) covering with sand or hessian or foam which is kept permanently wet;

- (b) wrapping with polythene or similar film to provide an airtight cover;
 - (c) maintaining the formwork in position for the required curing period; or
 - (d) spraying with an approved curing compound complying with the requirements of AS 3799, providing that the curing compound is applied in accordance with the manufacturer's published recommendations.
5. If the Contractor proposes to use a spray-on curing membrane on the top surface of a bridge deck the Contractor shall remove it by an approved means immediately before application of the surfacing unless otherwise approved.
 6. Concrete deck slabs shall also be treated with an approved aliphatic-alcohol based evaporation retardant coating applied according to the manufacturer's published recommendations immediately after the surface has been initially screeded.
 7. The Contractor shall ensure that the method of curing does not result in any staining of exposed surfaces of concrete.
 8. The maximum internal temperature of concrete after placement shall not exceed 70°C.
 9. At no point during the curing period shall the cross-section of large and restrained concrete members exceed a temperature differential of 20°C.
 10. Curing compounds shall not be used on surfaces against which fresh concrete is required to bond.
 11. For Steam Curing refer to clause 820.71.

820.57 PROTECTION OF CONCRETE SURFACES

1. The Contractor shall protect all completed surfaces from:
 - (a) damage and staining from any source including rain water, concrete spillage and grout spillage; and
 - (b) contact with hardwoods and ferrous metals.
2. Where a delay is likely prior to casting the next concrete pour such that reinforcement bars protruding from completed sections may cause staining to exposed parts of the finished Works, then the bars shall be suitably treated to prevent rusting.
3. Where any damage or staining has occurred to completed concrete surfaces the affected section shall be deemed to be non-conforming. The method of repair or removal shall in no way harm or damage any other part of the Works.

820.58 QUALITY ASSURANCE DURING CONSTRUCTION

1. Early age thermal crack of large and restrained concrete members shall be controlled in accordance with AS5100.5 clause 4.12.

2. Visual inspection for cracks of all concrete surfaces shall be carried out and any cracking found shall be recorded. Width and formation of cracks shall be recorded. Crack width gauges (meters) are sufficient to measure crack widths.
3. **Crack widths greater than 0.2 mm for precast-prestressed or post-tensioned elements and 0.3 mm for all other elements shall immediately be reported to the Superintendent which shall be subjected for approval of remedial works or replacement.**
4. After completed construction of concrete works, concrete cover measurements shall be taken on representative areas of each element as directed by the Superintendent. Suitable electromagnetic covermeters shall be used in accordance with BS 1881-204.

HOLD POINT

820.59 NON-COMPLIANCES

1. Any non-compliances identified during the work under the Contract shall be recorded and immediately reported to the Superintendent. The record shall indicate the non-compliance item(s), cause and location.

The Contractor shall carry out remedial works to rectify non-compliances in accordance with Specification 201 QUALITY MANAGEMENT and as directed by the Superintendent.

820.60 – 820.70 NOT USED

820.71 STEAM CURING

820.71.01 GENERAL

1. This clause 820.71 covers the curing of precast concrete units in an atmosphere saturated with water vapour at a pressure not exceeding atmospheric pressure.
2. The method of control and the proposed curing cycle to achieve the specified concrete compressive strength and durability properties are the responsibility of the Contractor, but shall be in accordance with this Specification.
3. The Contractor shall take measures to allow for the potential lower 28-day compressive strength obtained from test cylinders cured initially under in-situ conditions, as compared to those cured in accordance with the requirements of AS 1012.
4. The Contractor must submit a Curing Control Plan to the Superintendent for approval no less than two weeks prior to the intended start date of steam curing of precast units.
5. The Curing Control Plan must detail how the moisture and temperature will be controlled and monitored through all phases of the initial cement hydration reactions (until the steady state phase) to achieve concrete strength and durability.
6. **No steam curing works shall commence until the submitted Curing Control Plan has been approved by the Superintendent.**

HOLD POINT

7. The Contractor must comply with the approved Curing Control Plan during the execution of precast concrete works.

820.71.02 STEAM COVERS

1. To prevent drying out, steam covers shall be placed over the units immediately following the casting and screeding operations in such a manner as to ensure free circulation of the steam around the concrete mass.

820.71.03 CURING CYCLE

1. After an initial “maturity” of 40°C hours, but not less than 2 hours after batching the last batch of concrete for the units, steam shall be admitted to the steam covers at such a controlled rate that the maximum average temperature rise shall not exceed 24°C per hour and the temperature rise in any one 15 minute period shall not exceed 6°C. (Note: The initial “maturity” period is calculated by dividing 40°C hours by the concrete temperature of the last batch of concrete placed in the unit. The concrete temperature is as measured on an indicating thermometer).
2. If the admission of steam to the steam covers is delayed by more than the initial specified “maturity” of 40°C hours after the completion of placing of concrete, water curing, shall be applied until steaming commences.
3. Steaming shall continue at a rate such that the temperature rise shall not exceed 24°C per hour, until a temperature under the steam covers of not greater than 70°C has been reached. The steam supply shall then be maintained at a temperature no greater than $65 \pm 5^\circ\text{C}$.
4. After the elapse of sufficient time at the maximum temperature for the required concrete properties to have been reached, steam shall be completely shut down. Steam covers shall not be removed nor any part of the concrete units and test cylinders disturbed in any way until the temperature under the steam covers has fallen to within 30°C of the ambient temperature. The rate of loss of temperature under the steam covers after shutting off steam shall not exceed 24°C per hour.

820.71.04 TEMPERATURE CONTROLS

1. Temperature shall be recorded by means of recording thermometers. The temperature sensitive parts of the thermometers shall be so positioned under the steam covers as to record the minimum temperature under the covers. One recording thermometer shall be used for each unit or group of units in line up to a total length of 25m. For greater lengths, additional recording thermometers shall be used and the distance between the temperature sensitive parts of the thermometers shall not exceed 25m.
2. The recording thermometers shall be set in operation immediately upon completion of casting and screeding.
3. Temperature charts or records shall not be removed from any recording thermometers, nor the recording thermometers disturbed or moved in any way until after the removal of the steam covers, and until after the

completion of the full curing requirements through to the steady state phase of initial hydration reactions.

4. Charts or records from temperature recording thermometers shall be retained.
5. The following information shall be recorded on the chart:
 - (a) date on which steaming commenced;
 - (b) unique identification and description of concrete unit;
 - (c) temperature correction, if any;
 - (d) time correction, if any;
 - (e) batching of concrete;
 - (f) temperature of concrete when placed;
 - (g) ambient temperature at time of removal of steam covers; and
 - (h) name of Contractor and manufacturer.

820.71.05 STEAM DELIVERY

1. Under no circumstances shall steam jets be allowed to impinge upon any part of the concrete units or of a test specimen, or of their formwork or moulds. Steam delivery pipes must not be attached directly to any formwork or moulds in such a manner as may cause localised overheating of the concrete.
2. Sufficient steam jets or steam entry points shall be provided to ensure that a substantially uniform temperature is maintained under the steam covers such that the difference in temperature between any two points adjacent to the concrete units is not more than 10°C.

820.71.06 FULL STEAM CURING

1. Unless otherwise specified, steam curing shall be continuously applied until the concrete achieves a compressive strength that is equal to or greater than the 7 day compressive strength detailed in the relevant concrete mix design.
2. Curing must be continued until at least the core temperature of the concrete reaches the steady state phase of the initial hydration reactions.

820.71.07 PARTIAL STEAM CURING

1. Where steam curing is used only to obtain sufficient compressive strength for removal of forms or for lifting, or where elevated temperature curing is discontinued prior to the core temperature reaching the steady state phase of the initial hydration reactions, curing shall be continued by one or a combination of the methods specified in clause 820.56, for a minimum period of 7 days.

2. A reduction in the duration of curing to that specified at clause 820.71.07(1) is only permissible if the Contractor complies with a Curing Control Plan approved by the Superintendent.

820.72 MATURITY TESTING

820.72.01 GENERAL

1. Subject to the Superintendent's approval, the Contractor may be permitted to undertake Maturity Testing to determine the strength development of the concrete subjected to accelerated curing, for the purpose of facilitating early lifting of precast units or early application of loading.
2. The Contractor shall submit the following for review to the Superintendent at least 10 Business Days prior to concreting work commencing:
 - (a) purpose for test and strength(s) required for the application;
 - (b) the proposed procedure to develop the Strength-Maturity Relationship Curve with the corresponding strength required;
 - (c) the methodology of maturity testing and documenting procedures;
 - (d) the proposed temperature recording device to be used to monitor the concrete temperature and the locations where the sensors (a minimum of two sensors) will be placed;
 - (e) the proposed equipment and controls used for Maturity Testing of specimens to develop the relationship;
 - (f) the period of testing;
 - (g) the methodology for validation testing; and
 - (h) any documented evidence of previous performance of tested samples, including accuracy and deviations.
3. The constituents of the concrete test samples shall be the same used in construction; this includes the mix proportions, preparation and production of the concrete. Any deviations in manufacturing the concrete may reduce the accuracy of the Strength-Maturity Curve.
4. Strength-Maturity Relationship Curves shall be created for each project specific application and mix designs.

820.72.02 DEVELOPING THE STRENGTH-MATURITY FUNCTION

1. A minimum of 20 specimens for either cylindrical or flexural beam test specimens shall be cast from the same concrete mixture used for construction.
2. Thermocouples or any approved maturity recording device shall be embedded within ± 15 mm centrally of at least two specimens.
3. Compressive strength testing shall be taken at maturity ages of 1, 3, 7, and 28 days.

4. Unless otherwise determined from laboratory testing, the datum temperature, T_0 , may be taken as 0°C.
5. If results of one specimen has a difference of $\pm 10\%$ or greater, the specimen shall be discarded and the average of the two other specimens shall be used. However, a new Strength-Maturity Relationship shall be created if the difference of two or more specimens varies by more than $\pm 10\%$.
6. Once the Strength-Maturity Relationship has been determined, it shall be reduced by 5%.

820.72.03 ESTIMATING THE IN-PLACE STRENGTH

1. The Contractor shall nominate a suitable inspector with experience in Maturity Testing who shall be present at the concrete batch plant to monitor the batching process.
2. A minimum of two temperature sensors per element shall be installed at the locations approved by the Superintendent. It is recommended that one temperature sensor be located centrally of the concrete member and the other within the concrete cover. Installation of additional sensors at alternative locations may be required to increase the accuracy of strength estimation.
3. Temperature sensors shall not be in direct contact with any steel that may affect the temperature recorded by the sensor.
4. The maturity recording device shall immediately start recording after the concrete placement. Temperatures shall be recorded every 0.5 hours for the first 48 hours and every hour thereafter up until the strength required has been achieved.
5. The concrete shall have reached its required design strength once results indicate the strength is equal to or greater than the Strength-Maturity Relationship at the same maturity index.

820.72.04 VERIFICATION OF THE STRENGTH-MATURITY RELATIONSHIP

1. Strength verification testing shall be required for the determination of the maturity index of the specified application. A minimum of three specimens shall be cast from the concrete that is used in the structure and shall be cured in the same conditions.
2. If the percent error of the measured verification strength is equal to or less than 5% of the estimated strength, then the Strength-Maturity Relationship shall be considered valid. Similarly, the Strength-Maturity Relationship shall be considered invalid if the percent error is greater than 5%. A new Strength-Maturity Relationship shall then be created. Until a new relationship has been developed, standard compressive strength testing shall be required for determining early age concrete strength required.
3. If the volume of concrete exceeds 500m³ for the specified application, the Strength-Maturity Relationship Curve shall be monitored periodically for the duration that concreting work is being undertaken by means of taking compressive test specimens during construction. A minimum of 8 test

specimens for every 500 m³ shall be cast for the purpose of embedding sensors and testing at 6, 12 and 24 hours and 3, 7, and 28 days.

820.73 – 820.80 NOT USED

AS BUILT AND HANDOVER REQUIREMENTS

820.81 – 820.90 NOT USED

CONTRACT SPECIFIC REQUIREMENTS

820.91 – 820.99 NOT USED

ANNEXURE 820A

CLASS OF CONCRETE

Class of Concrete	Works Component
S40	Precast parapet panels Normal superstructures and substructures in non-marine environments Approach slabs End treatments and base slabs for major box culverts
S50, S65	Precast prestressed beams (as specified in the Drawings)
S50M	Reinforced concrete substructures in marine environments

GUIDANCE NOTES

FOR REFERENCE ONLY – DELETE GUIDANCE NOTES FROM FINAL DOCUMENT

1. All edits to downloaded Specifications shall be made using *Track Changes*, to clearly show added/deleted text.
2. If **all** information relating to a clause is deleted, the clause number should be retained and the words “**NOT USED**” should be inserted.
3. The proposed documents with tracked changes shall be submitted to the Project Manager for review, prior to printing the final batch of documents. When this final printing is carried out, the tracked changes option is to be turned off.
4. Before printing accept all changes in the document, turn off *Track Changes* and refresh the Table of Contents.
5. The Custodian of this Specification is Structures Design and Standards Engineer.

1. CLASS OF CONCRETE

- 1.1 The description in Annexure 820A may need to be modified to clarify where each class of concrete applies. Class S50M concrete is a class that has been used for marine environments. Its performance is being monitored. Where this does not apply, the words, “. except for class S50M (through to and including) material with silica fume” in clause 820.28.2 should be deleted.

CONTRACT SPECIFIC REQUIREMENTS

The following clauses are to be placed under the CONTRACT SPECIFIC REQUIREMENTS, as required. After inserting the clause, change the clause number and heading to style “H2 SP” so it appears in the Table of Contents.

AMENDMENT CHECKLIST

Specification No. **820** Title: **CONCRETE FOR STRUCTURES** Revision No: _____

Project Manager: _____ Signature: _____ Date: _____

Checked by: _____ Signature: _____ Date: _____

Contract No: _____ Contract Description: _____

ITEM	DESCRIPTION	SIGN OFF
<i>Note: All changes/amendments must be shown in Tracked Changes mode until approved.</i>		
1.	Project Manager has reviewed Specification and identified Additions and Amendments.	
2.	CONTRACT SPECIFIC REQUIREMENTS addressed? Contract specific materials, products, clauses added? (Refer Specification Guidance Notes for guidance).	
3.	Any unlisted materials/products proposed and approved by the Project Manager? If “Yes” provide details at 16.	
4.	Standard clauses amended? MUST SEEK approval from Manager Commercial.	
5.	Clause deletes shows as “ NOT USED ”.	
6.	Appropriate INSPECTION AND TESTING parameters included in Spec 201 (Text Methods, Minimum Testing Frequencies verified).	
7.	ANNEXURES completed (refer Specification Guidance Notes).	
8.	HANDOVER and AS BUILT requirements addressed.	
9.	Main Roads QS has approved changes to SMM .	
10.	Project Manager certifies completed Specification reflects intent of the design.	
11.	Completed Specification – independent verification arranged by Project Manager.	
12.	Project Manager’s review completed.	
13.	SPECIFICATION GUIDANCE NOTES deleted.	
14.	TABLE OF CONTENTS updated.	
15.	FOOTER updated with Document No., Contract No. and Contract Name.	
16.	Supporting information prepared and submitted to Project Manager.	
Further action necessary:		

Signed: _____ (*Project Manager*) Date: _____