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AUSTROADS TECHNICAL SPECIFICATION ATS 3510
No-fines Concrete Subbase

Austroads

Contents

1. Scope

1.1 Austroads Technical Specification ATS 3510 sets out the requirements for the construction of no-fines concrete subbase (NFC). It includes the requirements for:

a) constituent materials;

b) concrete mix design;

c) production and transport of NFC;

d) NFC subbase paving;

e) survey;

f) sampling and testing; and

g) conformity criteria.

1.2 This Specification is not applicable to NFC used as a structural subbase layer in an asphalt composite pavement. Also, it is not applicable to NFC used for subsurface drainage (see ATS 5337).

2. Referenced Documents

2.1 The following documents are referenced in this Specification:

Australian/New Zealand Standards

AS 1012	Methods of testing concrete
Method 1:	Sampling of concrete
Method 5:	Determination of mass per unit volume of freshly mixed concrete
Method 9:	Compressive strength tests – Concrete, mortar and grout specimens
Method 14:	Method for reading and testing cores from hardened concrete for compressive strength
Method 20.1:	Determination of chloride and sulfate in hardened concrete and aggregates – Nitric acid extraction method
AS 1141	Methods for sampling and testing aggregates
Method 4:	Bulk density of aggregate
Method 6.1:	Particle density and water absorption of coarse aggregate – Weighing-in-water method
Method 6.2:	Particle density and water absorption of coarse aggregate – Pycnometer method
Method 11.1:	Particle size distribution – Sieving method
Method 14:	Particle shape, by proportional caliper
Method 22:	Wet/dry strength variation
Method 60.1:	Potential alkali-silica reactivity – Accelerated mortar bar method
Method 60.2:	Potential alkali-silica reactivity – Concrete prism method

AS 1289.4.2.1	Methods of testing soils for engineering purposes, Method 4.2.1: Soil chemical tests – Determination of the sulfate content of a natural soil and the sulfate content of the groundwater – Normal method
AS 1379	Specification and supply of concrete
AS 1478.1	Chemical admixtures for concrete, mortar and grout – Admixtures for concrete
AS/NZS 2350.2	Methods of testing portland, blended and masonry cements, Method 2: Chemical composition
AS 2758.1	Aggregates and rock for engineering purposes – Concrete aggregates
AS/NZS 3582.1	Supplementary cementitious materials Fly ash
AS 3972	Portland and blended cements
Austroads	
ATS 1120	Quality Management Requirements
ATS 3050	Supply of Recycled Crushed Glass Sand
ATS 3410	Asphalt Pavements
ATS 3520	Lean-mix Concrete Subbase
ATS 5335	Concrete for General Works
ATS 5337	No-fines Concrete
ATS 3530	Concrete Pavement Base
ATM-020	Random Selection of Sampling or Test Locations
ATM-453	Surface Deviation Using a Straightedge
Transport for New South Wales	
TfNSW T183	Surface Deviation Using a Straightedge
TfNSW T215	Wet/Dry Strength Variation (TS 02799.13)
TfNSW T239	Fractured Faces of Coarse Aggregate (TS 02799.36)
TfNSW T376	Moulding of No Fines Concrete Specimens (TS 02800.50)
TfNSW T377	Water Permeability of No Fines Concrete (Falling Head Laboratory Permeameter) (TS 02800.51)
TfNSW T378	Void Content of No Fines Concrete (TS 02800.52)
ASTM International	
ASTM C1064M	Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete Materials

3. Definitions

3.1 In addition to the definitions in AS 1379, the following definitions apply to this Specification.

Agitator	An item of plant or equipment which maintains the plastic concrete in the mixed state. Consistent with common usage, this term is also used (for convenience) in lieu of 'mobile mixer'.
Authorised nominated mix	A mix design which has been authorised by the Principal.
Batch	A quantity of concrete containing a fixed amount of ingredients and produced in a discrete operation.

Batching

The process of combining the concrete ingredients in fixed proportions by mass or by volume, including charging and mixing.

Completion of batching

(a) For a stationary batch mixer discharging into a storage bin or tipper truck, this will be the time at which discharge from the mixer commences.

(b) For a stationary batch mixer discharging into a mobile mixer, this will be the time at which mixing ceases at the batching plant, or 10 minutes after the completion of charging of the stationary mixer, whichever occurs first.

(c) For direct charging of a mobile mixer, this will be the time at which mixing ceases at the batching plant, or 10 minutes after the completion of charging, whichever occurs first.

(d) For a continuous mixer discharging into a tipper truck, this will be the time at which discharge into the truck commences.

(e) For a continuous mixer discharging into a storage bin, this will be the time of earliest discharge (from the mixer) of that concrete within the bin.

Edge, outer (of subbase)

An edge against which material other than subbase concrete is to be placed (such as granular backfill).

Fixed-form paving

Also referred to as ‘manual paving’ and ‘hand paving’. Paving between fixed formwork using manually operated equipment such as plate vibrators and vibrating bull-floats.

Formed joint

All joints except for induced joints. This includes mechanical paving and fixed-formed joints.

Forming time

The elapsed time measured from the completion of batching to the incorporation of the concrete into the Works, including compaction and hand finishing.

Load

A single truckload of concrete comprising one or more batches.

Lot

As defined in ATS 1120. See also ‘Sub-Lot’ and ‘transition Sub-Lot’.

Mixers

(a) **Stationary mixer**: a mixer in a fixed location adjacent to the batching equipment. This category includes stationary batch mixers and stationary continuous mixers.

Stationary batch mixer: a mixer which produces a fixed amount of concrete in a discrete operation.

Stationary continuous mixer or **through mixer**: a mixer where ingredients are continuously added to one end of the chamber while mixed concrete is continuously discharged from the other end.

(b) **Mobile mixer** (or **agitator**): a truck-mounted drum mixer which is used for mixing and delivery. Mobile mixer can be used as a mixer or as an agitator.

See AS 1379 Clauses 4.2 and 4.3 for further information.

Mixing time

As defined in Clause 7.12.

Retemper

The addition of water to a batch after ‘completion of batching’ to restore consistence. See also ‘temper’.

The addition of an admixture (such as a high range water reducer) is not considered to constitute retempering.

Sub-Lot	A Sub-Lot is defined as a continuous pour of area: • up to 500 m^2 for machine paved subbase; and • up to 300 m^2 for fixed-formed subbase. In transition zones, separate Sub-Lots are generated in accordance with Clause 14.1.
Temper	The addition of water, and mixing of concrete (or mortar), to bring it initially to the required consistency. See also 'retemper'.
Test result	The result from a single test specimen or sample.
Test value	The value calculated from single test results to represent the Lot (in accordance with relevant clauses of this specification). For example, single cylinder compressive strength results are averaged (after application of correction factors) to derive a test value.
Transition zone	Area of machine paved concrete of 3 m length, at each side of a transverse construction joint.
Transition Sub-Lot	A Sub-Lot which falls within a transition zone (as defined).
Yielded cubic metre	As per the determination of mass per unit volume in accordance with AS 1012.5.

Abbreviations

ATIC	Australian Technical Infrastructure Committee
IANZ	International Accreditation New Zealand
NATA	National Association of Testing Authorities, Australia
NFC	No-fines Concrete
SCM	Supplementary cementitious material
SF	Shape correction factor for cores (see Clause 14.15)

Symbols

$\mathbf{F_{28}}$	Actual 28-day (cylinder) compressive strength in the nominated mix.
$\mathbf{F_{28Min}}$	Specified minimum 28-day (cylinder) compressive strength in the nominated mix.
$\mathbf{f_{cMin}}$	Specified minimum 28-day (core) compressive strength in the pavement.

Note:

1. *The symbol for concrete strength shown with the leading uppercase 'F' refers to test results on moulded cylinders from the nominated mix, while that shown with the leading lowercase 'f' refers to test results on cores taken from the constructed work.*

4. Quality System Requirements

4.1 The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1.

Table 4.1: Quality Plan

Clause	Description of Document
5.21	Admixture selection
7.3	Method of handling, storing and batching materials
7.17	Admixture incorporation method
7.23	Monitoring of identification certificate
7.27	Monitoring of concrete supply for compliance with the retempering provisions
7.29	Determination of maximum forming time
8.5	Details of key personnel
8.7	Method of traceability of batches/loads of concrete placed
8.20, 8.21	Equipment, methods and parameters for placing, spreading and finishing concrete
8.28	Parameters for proposed machine paving configurations
8.42	Meteorological data and measures to restrict evaporation
11.2	Protection of work from low air temperatures
11.5	Protection of work from water damage
12.6	Method to ensure loose, foreign and deleterious material does not get carried onto the NFC subbase by the equipment wheels supplying asphalt
15.4	Method of calculating adjusted thickness from survey

HOLD POINT 1	
Process Held	Commencement of concrete production.
Submission Details	The Quality Plan must be provided to the Principal at least 10 working days prior to the commencement of work on site.

5. Materials

Coarse Aggregate

5.1 Coarse aggregates for NFC must consist of clean, durable materials sourced from natural gravel, crushed stone or air-cooled iron blast furnace slag. Basic oxygen and electric arc furnace steel slag aggregates are not acceptable.

5.2 During the Contract, all aggregate testing must be on samples taken either from dedicated stockpiles or from materials delivered to the Site.

5.3 Coarse aggregate must conform to AS 2758.1 and the supplementary requirements in Table 5.3.

Table 5.3: Coarse aggregate property requirements

Property	Test Method	Requirements
Bulk density (compacted)	AS 1141.4 Clause 7.2	Minimum 1200 kg/m^3
Particle density	AS 1141.6.1 or AS 1141.6.2	Minimum 2100 kg/m^3
Water absorption	AS 1141.6.1 or AS 1141.6.2	Maximum 2.5%
Wet strength[(2)]	TfNSW T215	Minimum 50 kN
Wet/dry strength variation	TfNSW T215	Maximum 35%
Particle size distribution	AS 1141.32	Nominated by the Contractor
Particle shape: 2:1 ratio 3:1 ratio	AS 1141.14	 Maximum 35% Maximum 10%
Crushed particles – at least 2 fractured faces (%)[(2)]	AS 1141.18	Minimum 80%
Alkali-aggregate reactivity (AAR)	AS 1141.60.1 and AS 1141.60.2	As per Clause 5.4 and 5.5

Notes:

1. *If 2 or more coarse aggregates are to be blended, the aggregate from each source must comply with these requirements.*
2. *The fraction to be tested is the particle size distribution interval in Table 1 of AS 1141.22, which represents at least 50% of the aggregate by mass.*
3. *Testing is not required for an aggregate that has been extracted from mineral rock quarries by drilling and blasting.*

Alkali-Aggregate Reactivity

5.4 Clause 5.5 does not apply if the Principal has previously approved the aggregate for use in a concrete mix and/or approved a concrete mix design utilising supplementary cementitious materials with the aggregate.

5.5 The Contractor must carry out testing on aggregates from each proposed individual supply source for potential alkali-aggregate reactivity in accordance with the Accelerated Mortar Bar Test Method AS 1141.60.1 within the 18-month period prior to the commencement of paving. From the classification obtained by the testing, the action specified in Table 5.5 applies.

Table 5.5: Action for aggregate reactivity classification

Aggregate reactivity classification in accordance with AS 1141.60.1	Action required
Non-reactive	None
Slowly reactive	Limit total alkali content in the mix to 2.1 kg/m^3[(1)] or use an approved concrete mix design containing supplementary cementitious materials.
Reactive	Use a different aggregate and repeat the test or re-test using blended cement containing supplementary cementitious materials and re-assess the alkali aggregate reactivity potential using AS 1141.60.2. Any aggregates classified as 'reactive' by AS 1141.60.2 must not be used.

Note:

1. *Total alkali content is the available alkali content of cement and other sources expressed as the Na_2O equivalent and calculated as the sum of Na_2O and 0.658 K_2O.*

Cementitious Materials

5.6 Cement types are as follows:

a) general purpose cement (Type GP);

b) blended cement (Type GB);

c) shrinkage limited cement (Type SL);

d) low heat cement (Type LH); and

e) high early strength cement (Type HE).

5.7 All cement types, whether general purpose (Type GP), special purpose (Types HE, LH and SL) or blended cement (Type GB), must conform to AS 3972.

5.8 Blended cements may comprise a mix of general or special purpose cement and one or more of the following: fly ash, ground granulated iron blast-furnace slag and amorphous silica.

5.9 The blending of cements may be carried out at the cement supplier's facilities or at the concrete batching plant. Regardless of the location of blending of cements, the individual components of the cements must conform to their respective requirements in this Specification.

5.10 Mineral additions and minor additional constituents (as defined in AS 3972) contained in cements must conform to AS 3972.

5.11 The Principal must be provided with details of any mineral addition and/or minor mineral contained in the cement.

5.12 Fly ash must:

a) be fine grade;

a) comply with ATIC-SPEC SP43 and AS 3582.1; and

b) comply with Table 5.12 (calculated using the 30 most recent successive test results).

Table 5.12: Fly ash uniformity requirements

Property	Test Method	Formula	Limit
Carbon content (LoI)	AS/NZS 2350.2	$LoI_{average}$ + 3SD	≤4%
Fineness	AS/NZS 2350.8	$Fineness_{average}$ + 3SD	≤100%
		$Fineness_{average}$ − 3SD	≥75%
		CoV	≤3%

Where:

$LoI_{average}$ = mean of loss on ignition test results.

$Fineness_{average}$ = mean of fineness test results.

SD = standard deviation expressed as a decimal.

CoV = coefficient of variation = $SD \div Fineness_{average} \times 100\%$.

5.13 Ground granulated iron blast-furnace slag must:

a) comply with ATIC-SPEC SP43 and AS 3582.2; and

b) conform to the following (calculated conformity with AS/NZS 2350.8 using the 30 most recent successive test results):

$(Fineness_{average} - 3SD) \leq Fineness_{sample} \leq (Fineness_{average} + 3SD)$

Where:

$Fineness_{sample}$ = individual fineness test result.

$Fineness_{average}$ = mean of fineness test results.

SD = standard deviation expressed as a decimal.

Water

5.14 Water used in the production of concrete must be free from materials harmful to concrete and steel reinforcement and be neither salty nor brackish. The water must conform to AS 1379 Clause 2.4 and the following:

a) chloride ion: maximum 500 mg/L determined by AS 1478.1 Appendix C; and

b) sulphate ion: maximum 400 mg/L determined by AS 1289.4.2.1.

5.15 Water that is drawn solely from a reticulated drinking water supply is deemed to conform to the above.

5.16 If the water contains a component from a source other than a reticulated drinking water supply, the combined water must conform to the requirements of Clause 5.14.

Admixtures

5.17 Chemical admixtures and their use must conform to AS 1478.1.

5.18 Admixtures must not contain calcium chloride.

5.19 For combinations of 2 or more admixtures, their compatibility with each other must be certified in writing by their manufacturers.

5.20 For mixes with less than 50 kg/m^3 of fly ash, the total alkali contribution (measured as the Na_2O equivalent in accordance with AS 1478.1) from all admixtures used in any mix must not exceed 0.20 kg/m^3.

5.21 The Quality Plan must include details of the criteria for initiating changes in admixture type with changes in season. If the same admixture is proposed for use across all seasons, also provide dosage rate charts for various temperature ranges. Additional testing in the mix design process is not required if admixture dose rate changes are based solely on ambient temperature.

Curing Membrane

5.22 The curing membrane must consist of 0.2 mm minimum thickness opaque polyethylene sheets at a minimum width of 1.2 m.

6. Design of Concrete Mixes

General

6.1 The concrete mix must be designed in accordance with this Specification, taking into consideration the anticipated conditions that will be prevailing on site so that, under those conditions, the concrete in the constructed subbase meets all the requirements of this Specification.

Water to Cementitious Material Ratio

6.2 The water to cementitious material ratio must provide for complete cementitious paste coverage of the aggregate and must be in the range of 0.30 to 0.45 by mass. The paste content must not be such as to cause the paste to flow during mixing, handling or placing.

Compressive Strength

6.3 Concrete compressive strength must comply with the requirements shown in Table 6.3.

Table 6.3: Concrete Strength

Description	Nominated mix	In situ pavement concrete(1)
Test specimen	Cylinder (150 mm diameter)	Core (refer to Clause 14.3)
Test methods	Moulding: TfNSW T376 Testing: AS 1012.9	AS 1012.14, as amended by Clause 14.12
Compressive strength	At 28 days: minimum 6.0 MPa (F_{28Min})	At 28 days: minimum 5.0 MPa (f_{cMin})

Notes:

1. *Each sample must have a minimum air void content of 25% for the concrete strength to be valid. Determine air void content using TfNSW T378.*
2. *In situ pavement core concrete strength requirements are provided in this Clause for comparison with the cylinder strength requirements of the nominated mix.*

6.4 To determine the compressive strength F_{28} for each batch of the nominated mix, test a minimum of 3 specimens at age 28 days. F_{28} is taken as the mean of all individual results from all batches that are not more than 2.0 MPa from the median value of all individual results.

Permeability

6.5 The permeability of the concrete must be determined by:

a) moulding a nominal 150 mm diameter cylinder;

b) curing the specimens in accordance with TfNSW T376; and

c) testing the permeability in accordance with TfNSW T377.

6.6 The permeability must not be less than 0.015 m/s.

Sulphate Content

6.7 The sulphate ion content must comply with Table 6.7.

Table 6.7: Sulphate ion content requirements

Attribute	Test Method	Requirement
Sulphate ion content	Refer to Clause 6.8	Maximum 5% relative to cementitious binder mass

Note:

1. *Calculate the sulphate ion content relative to the cement mass (i.e. excluding supplementary cementitious materials such as fly ash and slag).*

6.8 Testing for sulphate ion contents must be carried out by either:

a) testing of concrete constituents in accordance with Clause 6.9; or

b) testing of hardened concrete in accordance with Clause 6.10.

6.9 For testing of concrete constituents for sulphate ion contents, the sulphate content of the mix is determined by testing in accordance with:

a) AS 1012.20.1 for aggregates;

b) AS 1289.4.2.1 for water and admixtures dissolved in water; and

c) AS/NZS 2350.2 for cementitious materials,

and calculating the total sulphate content and percentage in the mix.

For water, test samples are taken from the source proposed for the Works. If the mixing water is drawn solely from a reticulated drinking water supply, test values provided by the supply authority may be used.

For admixtures, the sulphate contents may be taken as the values certified in writing by the manufacturer.

6.10 The sulphate content of the hardened concrete must be determined in accordance with AS 1012.20.1.

Trial Mixing for Mix Design

6.11 Trial mixing must be conducted in the laboratory to demonstrate that the proposed mix designs conform to this Specification.

6.12 The trial mixing must conform to the Contractor's proposals under Clause 7 for batching and mixing, including the dilution and incorporation of admixtures, and the sequence of addition of the constituent materials.

6.13 The date of testing of both the laboratory trial mix and all constituent materials must not be older than 18 months from the date on which the nominated mix is proposed to be used.

6.14 If sufficient production mix test results are available within this period in accordance with AS 1379, the Principal may reduce the scope of the laboratory trial mix or may waive it altogether.

Submission of Nominated Mixes

General

6.15 Prior to commencing production of each subbase concrete mix, the following must be submitted to the Principal:

a) details of each nominated concrete mix in accordance with Clauses 6.17 to 6.20;

b) NATA or IANZ endorsed test results for all specified tests;

c) a copy of a verification checklist covering the items listed in Clauses 6.17 to 6.20; and

d) a statement signed by the Contractor certifying that each nominated mix and its constituents meet the requirements of this Specification.

6.16 For work carried out in New South Wales, a mix that is currently listed as conforming to this Specification in the TfNSW Register of Concrete Mixes may be proposed as an alternative to the submission in Clause 6.15, available at: Register of Materials | Transport for NSW.

HOLD POINT 2	
Process Held	Production of each concrete mix.
Submission Details	At least 5 working days before production, submit one of the following: For new mixes: details and attachments as specified in Clause 6.15; or For mixes registered/approved by the Principal: a statement stating that the mix conforms to this Specification and is suitable for its intended use.

Constituent Materials

6.17 The following details of the constituent materials must be provided to the Principal:

a) cement: supplier, product name, ATIC registration number and source;

b) SCM: supplier, product name, ATIC registration number and source (for each);

c) water: source;

d) admixtures: proprietary source, type, name and dosage recommended by manufacturer;

e) aggregates: source, geological type, moisture condition on which mix design is based (oven dry, saturated surface dry or nominated moisture content).

f) relevant test results for all constituents; and

g) test results for sulphate content in accordance with Clause 6.7.

Mix Design

6.18 The following details of the mix deign must be provided to the Principal:

a) constituent quantities, including cementitious material content, per yielded cubic metre of concrete; and

b) nominated particle size distribution of aggregates.

Test Results of Nominated Mix

6.19 For each nominated mix, details and demonstrated conformity for the following must be submitted to the Principal:

a) water to cementitious material ratio;

b) compressive strength (F_{28}) and air void content at age 28 days; and

c) permeability.

6.20 Test results must certify that the specimens were prepared specifically in accordance with this Specification and using vibration as stipulated above. All test specimens must be moulded from the same homogeneous batch, and certification must be provided to the Principal that the specimens were moulded in accordance with the requirements of this Specification.

Variation to Authorised Nominated Mix

6.21 After the nominated mix has been accepted for production, it becomes the authorised nominated mix for use.

6.22 The authorised nominated mix may be varied without submitting a new nominated mix, unless the proposed variations from the current authorised nominated mix exceed the following amounts:

a) cement: −10 kg/m^3, +20 kg/m^3;

b) other cementitious material: 20 kg/m^3;

c) other solid constituents: 5% by mass;

d) admixture dosages: in accordance with Clause 7.9; and

e) water: not specified.

6.23 The Principal must be notified of such variations to an authorised nominated mix before commencing production with the varied quantities.

6.24 If it is intended to vary the quantities of the constituents in excess of the above amounts, or to change the type of admixture or the source of supply of any constituent, a new nominated mix must be submitted in accordance with Clause 6.15.

7. Production and Transport of Concrete

General

7.1 Concrete produced for the Works must be homogeneous, without segregation or loss of materials during transport. The concrete must have workability at the time of incorporation that is compatible with the capacity of the paving equipment to achieve the required compaction uniformly and a surface finish requiring only minimal manual finishing.

7.2 The handling, storing and batching of materials, and the mixing, transport and consistence of concrete, including any retempering, must comply with AS 1379 Sections 3 and 4 (using control of water to cementitious material ratio) and AS1379 Appendix A (except for determination of slump, air content and mass per unit volume of the air-free mortar), modified by the requirements of Clause 7.

7.3 The Quality Plan must include details of the proposed methods of handling, storing and batching materials, and the method of charging the mixer, including the proposed sequence of addition of ingredients. The method and sequence of charging must be consistent with the recommendations of the suppliers of mix additives.

7.4 For machine paving, the production and transport equipment must have an operational capacity that allows continuous paving at the target paving speed. The capacity must not be less than that required to maintain a continuous paving speed, with adequate allowance for mixer efficiency and control testing. Pumping must not be used to transfer NFC.

Production Mixes

7.5 For production mixes, the authorised nominated mix must be targeted. Table 7.5 lists the tolerances for constituents in individual batches from the authorised nominal mix.

Table 7.5: Production tolerances

Description	Tolerance (% by mass)
Aggregate particle size distribution (AS sieve)	
26.50 mm sieve	± 2
19.00 mm sieve	± 5
9.5 mm sieve	± 2
0.075 mm sieve	± 1
Each cementitious material	± 3.0

Note:

1. Notwithstanding these tolerances, the water to cementitious material ratio must comply with Clause 6.19.

Production Monitoring

7.6 Aggregates that have become intermixed or contaminated with foreign matter must not be used in the Works.

7.7 For all batches within a Lot, the mean content of each cementitious material must be monitored. The mean must not be less than that of the authorised nominated mix or as varied in accordance with Clause 6.22. Each cementitious material must be weighed separately.

7.8 For volumetric batching of water, a measuring device calibrated in one litre increments to an accuracy of ± 2% of the value shown on the indicating device must be used.

7.9 For liquid admixtures, the metering equipment must measure the volume, or mass, of liquid to an accuracy of ± 5% of the value shown on the indicating device.

7.10 A Batching Record, which records the actual masses of each constituent in every batch together with departures beyond the allowable tolerances, must be maintained and monitored. Nonconforming batches or loads must not be incorporated into the Works.

Mixing of Concrete

Measurement of Mixing Time

7.11 The term ‘mixing time’ is applicable to batch mixers only and comprises only that mixing carried out at the specified mixing rate (i.e. excluding agitation). It is measured as follows:

Stationary batch mixers: The mixing time is measured from the time when at least 90% of the total water content and all other ingredients are in the mixing drum, until mixing ceases, or after the completion of specified revolutions.

Mobile mixers: The mixing time is measured from the time all the ingredients, including the total added water content, are in the mixing drum until mixing ceases or after specified revolutions.

Minimum Mixing Time

7.12 For stationary batch mixers, the minimum mixing time M_{Tmin} must be the greater of that determined from mixer uniformity testing in accordance with Annexure B and the following:

Stationary twin-shaft mixers: Not be less than 30 seconds plus 5 seconds for each cubic metre (or part thereof).

All other stationary batch mixers: Not be less than 54 seconds plus 6 seconds for each cubic metre (or part thereof).

7.13 Up to 10% of the remaining total water content for the authorised nominated mix may be added after the defined mixing time, and the mixing time increased as follows:

Stationary twin-shaft mixers: A minimum of 15 seconds of mixing must be provided after the final addition of water.

All other stationary batch mixers: A minimum of 30 seconds of mixing must be provided after the final addition of water.

7.14 For mobile mixers, the minimum mixing time M_{Tmin} after charging must be the greater of that shown on the mixer identification plate and 3.0 minutes.

7.15 The full period of mixing must be provided at either the testing station or the point of placement. All other mixing and agitation must be ignored for the purpose of assessing the actual mixing time for a specific batch.

Maximum Mixing Time

7.16 The maximum mixing time is 5 minutes for twin-shaft and split-drum mixers, and 10 minutes for all other mixer types.

Admixture Addition

7.17 The Quality Plan must include details of how admixtures will be incorporated in the mix in accordance with the requirements of this Specification.

7.18 The admixtures must be incorporated in accordance with the manufacturer's instructions and by a method that ensures that no adverse interaction occurs.

7.19 Admixtures must be diluted separately and thoroughly in the mixing water prior to their introduction to other materials.

Discharge

7.20 For batch mixers, after the completion of batching, the entire batch of concrete must be discharged from the mixer before any further charging takes place, with the exception of conforming retempering.

HOLD POINT 3	
Process Held	Production of concrete for paving (including paving trial).
Submission Details	Results demonstrating conformity of mixer uniformity as per Annexure B.

Transport of Concrete

7.21 Each batch of concrete must be provided with an identification certificate (delivery docket) that is pre-numbered and issued sequentially in accordance with the order of batching. This certificate must record the details required to establish the time of completion of batching.

7.22 The identification certificate must show the quantity of water in the batch and the total allowable quantity of water. Depending on the mixer and transport types, this may require the recording of times for charging and/or mixer discharge.

7.23 The Quality Plan must include details of how the identification certificate will be monitored for compliance with the batching requirements of this Specification.

7.24 Agitators must be used to deliver concrete that will be placed manually; however, material transfer placers and tipper trucks may be used where haul lengths are such that segregation does not occur and compaction and finishing of the mix is not compromised.

Retempering

7.25 For concrete that is delivered by a means other than an agitator, water or any other ingredient must not be added to the mixed batch.

7.26 Concrete that is delivered by agitator may be retempered in accordance with the following conditions:

a) Retempering is allowed only within 40 minutes of the completion of batching, except for mixes containing hydration control admixture. For such mixes, the time nominated for retempering in the mix design is applicable.

b) Retemper only in the presence of the Contractor's representative who has been previously nominated to the Principal for this purpose.

c) Retemper only at the batch plant, the testing station or the point of placement.

d) Immediately after retempering, re-mix the batch at the designated mixing speed for no fewer than 30 revolutions or for such additional time as may be necessary to re-establish uniformity of the mix.

e) Record the quantity of added water on the identification certificate for that batch. If water is added after the commencement of discharge, record the estimated remaining quantity of concrete at that time.

f) During retempering, ensure that the maximum water cement ratio nominated in the mix design is not exceeded.

g) Mould test cylinders for compressive strength from the retempered mix, in accordance with this Specification. These cylinders are additional to the routine testing requirements.

7.27 The Quality Plan must include details of how concrete supply will be monitored for conformity with these retempering provisions.

Forming Time

7.28 The maximum forming time for each authorised nominated mix must be determined with consideration of the prevailing weather conditions and concrete temperature.

7.29 The Quality Plan must include details of the procedure to determine the maximum forming time.

7.30 The actual forming time must be monitored and recorded for any load exceeding:

a) 90 minutes for air temperatures less than 30°C;

b) 60 minutes for air temperatures greater than or equal to 30°C; or

c) the nominated forming time for mix design with hydration control admixtures, based on the laboratory trial for mix design with hydration control admixtures.

7.31 NFC subbase constructed from such loads may be accepted if the compressive strength of cores taken from the section of subbase constructed with the specific load are conforming. The specific location of the load placed in the Works must be recorded.

8. No-fines Subbase Concrete Paving

General

8.1 The Contractor must prepare a schedule of underlying surface levels and relevant nonconformity report (together with any proposed redesign of pavement levels) prior to commencing paving.

HOLD POINT 4	
Process Held	Paving of NFC subbase (including paving trial).
Submission Details	The schedule of underlying surface levels and any relevant nonconformity report (together with any proposed redesign of pavement levels) must be provided to the Principal at least one working day prior to the commencement of paving.

8.2 The concrete must be placed, spread and finished in such a manner as to:

a) avoid segregation or loss of materials;

b) avoid premature stiffening;

c) produce a homogeneous product throughout the subbase layer;

d) meet strength and permeability requirements; and

e) provide the minimum specified thickness and surface finish. Notwithstanding this, the thickness of NFC subbase must not exceed 300 mm.

8.3 Where the NFC subbase extends over subsurface drains with NFC, the placing of NFC in the drains may occur in the same shift as the NFC subbase layer.

Concrete Paving Crew Training

8.4 Personnel must be trained in paving techniques for NFC in accordance with ATS 1120.

8.5 Details of such training must be included as part of the Quality Plan.

Traceability

8.6 Records showing the location of each load of concrete in the finished work must be maintained in accordance with ATS 1120. The method of traceability must be sufficiently accurate to enable subsequent identification of specific loads for examination and/or testing.

8.7 The Quality Plan must include details of the method of traceability.

Surface Preparation Using Dental Concrete

8.8 Where the underlying surface is uneven with a risk of ponding of water under the NFC subbase layer, ‘dental concrete’ must be used to produce a smooth, even surface.

8.9 Dental concrete may be either:

a) lean mix concrete complying with ATS 3520; or

b) concrete of minimum strength Grade N20 complying with ATS 5335.

Temperature, Weather Condition and Tunnel Leakage

8.10 The concrete temperature at the point of discharge must be measured and recorded in accordance with ASTM C1064M.

8.11 Concrete must not be placed in the Works if its temperature at the point of discharge from transport vehicles is less than 10°C or more than 32°C.

8.12 The ambient air temperature outdoors in the shade at the paving site but remote from artificial influences such as machinery exhaust outlets must be measured and recorded at intervals not exceeding 30 minutes.

8.13 Concrete batching and/or placement must stop when the ambient air temperature:

a) reaches 32°C and is rising; or

b) is below 5°C or above 35°C.

8.14 Concrete must not be placed in the Works:

a) during rain or when rain appears imminent for areas outside tunnels or within 20 m from the tunnel portal inside tunnels;

b) when water is continually leaking in drops or streams from the roof of the tunnel onto the paved area, unless such water is temporarily diverted from above the area being paved; or

c) the surface has water ponding.

Machine (Mechanical) Paving

8.15 Where practicable, paving must be carried out by the machine paving method.

8.16 The unsupported longitudinal edge produced must maintain its shape and must not sag or tear.

8.17 The Contractor must plan the work and coordinate the concrete delivery, spreading and paving activities to optimise the continuous and uniform progress of the paver and to minimise discontinuities in the work. Details of any interruptions to the progress of the paver, including the reason, location, and duration, must be recorded.

8.18 The mechanical paver must spread, compact, screed and finish the freshly placed concrete so as to produce a homogeneous layer with uniform aggregate to aggregate contact, and with a uniform finish requiring minimum hand finishing.

8.19 The mechanical paver must be a self-propelled machine and must include the following features:

a) an automatic control system with a sensing device to control line and level to the specified tolerances;

b) means of spreading the mix uniformly and regulating the flow of mix to the paver and conforming plate without segregation of the components;

c) a tamping device as part of the paver for compaction of concrete – roller compaction is not permitted; and

d) capability of paving to the widths and depths shown on the Drawings.

8.20 The Quality Plan must include details of the equipment and methods to be used for placing, spreading and finishing the NFC subbase. For each of the proposed machine paving configurations, the following parameters must be nominated in the Quality Plan:

a) maximum paving speed (i.e. instantaneous, not average);

b) target (optimum) paving speed; and

c) gross operating mass per linear metre of paving width.

Fixed-Form (Manual) Paving

8.21 The Quality Plan must include details of the equipment and methods to be used for placing, spreading and finishing the concrete.

8.22 The formwork must be designed and constructed so that it is braced in a substantial and unyielding manner.

8.23 The formwork must be debonded so that it can be removed without damaging the concrete.

8.24 The formwork must be up such that the screeding surface will be within the tolerances of the specified levels of the finished surface.

8.25 The concrete must be uniformly deposited and spread, without segregation within the formwork by means other than vibration.

8.26 The concrete must be compacted by at least 2 passes of a hand-guided vibratory screed traversing the full width of the paving run on each pass. The screed's length must be consistent with the width of the paving run under construction.

Paving in Transition Zones

8.27 For transition zones, methods of placing that will ensure adequate compaction of the concrete must be used.

8.28 The Quality Plan must include the following details:

a) proposed technique for paving at transverse construction joints, for both machine and fixed-form paving, at both the start and finish of paving runs;

b) length of paving run between a transverse construction joint and the point of effective paver tamping, at both the start and finish of paving runs;

c) details of vibratory screed devices for manual paving; and

d) method of side forming to prevent edge slump;

Joints and Edges

General

8.29 The first-placed face must be compacted and visually homogenous.

8.30 Where a joint is nonconforming or its edge is damaged, it must first be reinstated or repaired and allowed to set before new concrete for the adjoining section is placed.

8.31 Unless shown otherwise on the Drawings, slabs formed by the joints (both transverse and longitudinal) must not have dimensions or corner angles less than that shown in Table 8.31.

Table 8.31: Minimum dimensions or corner angles of slab

Description	Minimum value
Slab length (m)	1.5(1)
Slab width (m)	1.0(2)
Corner angle (°)	70(3)

Notes:

1. *Measured parallel to the control line.*
2. *Measured orthogonal to the control line.*
3. *Measured in plan view.*

Transverse Construction Joints

8.32 Transverse construction joints must be provided at discontinuities in the placement of concrete as determined by the Contractor's paving operations.

8.33 Transverse joints must be:

a) continuous over the full paving width, without steps or offsets in any axis, so that along the line of the joint it does not deviate by more than 50 mm from a 3 m straightedge nor by more than 10 mm from a 0.3 m straightedge; and

b) constructed with a butt (flat) joint face which is orthogonal (± 5°) to the finished top surface of the NFC subbase.

Longitudinal Construction Joints

8.34 Where longitudinal joints are required by the placing methods, their location must be at minimum 300 mm (nominal) offset from a planned longitudinal joint in the base. The joint location must not deviate from the planned or nominated position at any point by more than 100 mm; i.e. the joint location of the NFC subbase must not be less than 200 mm offset from a planned longitudinal joint in the base.

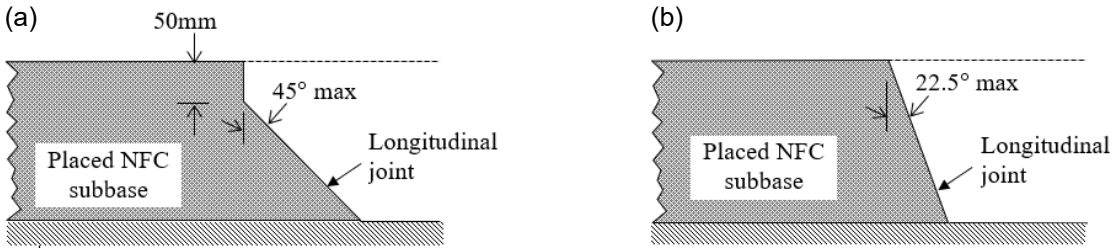
8.35 Longitudinal joints must, along the line of joint, not deviate horizontally by more than 20 mm from a 3 m straightedge placed along the joint, after due allowances for any planned curvature, nor by more than 10 mm from a 0.3 m straightedge.

8.36 The face profile of the longitudinal joint must be either one of the following:

a) the face of the joint is orthogonal to the finished top surface of the NFC subbase, with the top 50 mm at a tolerance of 10° and below this top 50 mm, at a tolerance of 45° (see Figure 8.36 (a) below); or

b) the entire face of the joint is orthogonal to the finished top surface of the NFC subbase, with a tolerance of 22.5° (see Figure 8.36 (b) below).

Figure 8.36: Face profile of longitudinal joints



Outer Edges

8.37 Unless shown otherwise on the Drawings, the NFC subbase must be constructed wider than the plan position of the overlying base by 50 mm (with a tolerance of ± 25 mm).

8.38 The face profile of outer edges must conform to that for longitudinal joints in Clause 8.36.

8.39 Outer edges must be compacted and visually homogenous.

8.40 Where the paved edge is to form a longitudinal construction joint with adjoining subbase concrete, the horizontal alignment tolerances must comply with Clause 8.35.

Inspection

8.41 Each joint and edge must be inspected within 24 hours of its construction and again before paving of the next adjoining section of the NFC subbase. If nonconformity is detected, Corrective Action must be implemented before proceeding with the paving of the adjoining section.

Prevention of Moisture Loss

8.42 The Quality Plan must include what meteorological or other data will be collected, how such data will be used and what measures will be taken to restrict the evaporation of water from the concrete surface and to limit the incidence of plastic shrinkage cracking or rapid drying of the surface leading to aggregates being dislodged from the concrete.

8.43 The use of evaporation retarders to restrict the evaporation of water is not permitted.

8.44 The plastic concrete must be regularly inspected to monitor the effectiveness of the adopted procedures.

Surface Finish

8.45 The paved surface of the NFC subbase must be uniform and without distinct ridges or recesses.

9. Curing

9.1 The NFC subbase must be cured by covering with polyethylene sheets complying with Clause 6.15.

9.2 The sheeting must be applied immediately after finishing the surface and must continue curing for a continuous period of 7 days, or until in situ concrete strength of 4 MPa is achieved, whichever occurs first. A minimum of 200 mm overlap must occur at the edges of the sheeting. Edges must be restrained to prevent exposed areas.

10. Concrete Paving Trial

General

10.1 Prior to full-scale NFC subbase paving, a trial section of NFC subbase must be constructed using the authorised nominated concrete mix, equipment and methods, and in accordance with the dimension and volume limits stated in Table 10.1.

Table 10.1: Quantity limits for paving trial

Parameter		Requirements	
		Machine paving	Fixed-form
Length of paving trial[1, 2]	Minimum	50 m	15 m
	Maximum	100 m	50 m
Concrete volume in paving trial	Minimum	Not applicable	20 m^3

Notes:

1. *The Principal may accept an extension of the paving trial to a full day of paving if the Contractor has demonstrated satisfactory paving performance in recent past projects.*
2. *Construct the trial section(s) in a continuous operation without intermediate construction joints.*

10.2 The Principal must be given at least 5 working days' written notice of the intention to commence each paving trial.

WITNESS POINT 1	
Process	Construction of section of trial pavement.
Notification Period	At least 5 working days before the commencement of the trial.

10.3 If a paving trial is conducted at a paving width of less than 70% of the maximum paving width proposed, the Principal may call for a new trial section prior to paving sections with widths equal to or greater than 70% of the maximum width proposed.

10.4 Concrete compressive strength testing for the trial must be conducted in accordance with Clause 14.6.

HOLD POINT 5	
Process Held	Commencement of NFC paving other than trial paving.
Submission Details	Report of paving trial, including test results (but excluding results for 28-day compressive strength).

Acceptance of Trial Section

10.5 The trial section will be accepted as part of the Works if it conforms to this Specification.

10.6 If the trial section is nonconforming, it must be removed, a new trial section prepared and the evaluation detailed in this Clause repeated.

New Trial Section

10.7 The Principal may direct that a new trial section be prepared and evaluated at any stage of the Works if:

a) significant changes are made to the equipment, materials, plant or rate of paving; or

b) recurring nonconformities of the NFC subbase occur.

11. Protection of Work

Temperature

11.1 If the temperature at the Site is forecast by the Bureau of Meteorology to fall below 10°C within 24 hours of paving when placing concrete in areas outside tunnels or within 100 m from the tunnel portals inside tunnels, the temperatures for the first 24 hours after paving must be measured and recorded at 2 or more locations within each day's paving, using purpose-made surface thermometers.

11.2 The Quality Plan must include details of the procedures and equipment proposed for the protection of concrete from low air temperatures.

11.3 The failure to maintain the temperature of the concrete at or above 5°C for the first 24 hours after paving is a nonconformity.

Water Damage

11.4 The Works must be protected from water damage. The protective equipment must be kept on site ready for use by experienced personnel at short notice.

11.5 The Quality Plan must include details of the procedures and equipment proposed to protect the concrete from water damage.

11.6 Concrete is nonconforming if it is exposed to water within the period from tipping to application of the curing sheeting.

11.7 Beyond this time, any water-exposed surfaces must be assessed in accordance with the finished surface acceptance criteria.

12. Asphalt Interlayer

General

12.1 Where shown on the Drawings, an asphalt interlayer must be placed over the top surface of the NFC subbase. The application of this asphalt interlayer is not considered to be a curing treatment.

12.2 Asphalt must be either AC7 or AC10 (i.e. nominal size 7 mm or 10 mm, respectively), using C450 binder, conforming to ATS 3410.

Surface Preparation Prior to Placing Asphalt Interlayer

12.3 The NFC subbase surface must be cleaned of all loose, foreign and deleterious material before applying the asphalt interlayer.

12.4 Spalled areas must be squared up and infilled with NFC.

12.5 Immediately prior to placing the asphalt, a light surface spray of bitumen must be applied uniformly over the top of the NFC subbase.

12.6 The Quality Plan must include details of the methods used to ensure loose, foreign and deleterious material does not get carried onto the NFC subbase by the vehicle wheels supplying asphalt to the paver.

Placing of Asphalt Interlayer

12.7 The asphalt interlayer must not be placed until:

a) the NFC subbase has achieved in situ compressive strength of 4.0 MPa; and

b) the NFC subbase level schedules are submitted and the disposition for any nonconformity is completed (see Clause 16.4).

12.8 The asphalt interlayer must be placed to the thickness and level tolerances shown in Table 12.8 in accordance with ATS 3410.

Table 12.8: Asphalt interlayer thickness and level tolerances

Asphalt designation	Nominal thickness (mm)	Tolerances	
		Thickness[1] (mm)	Level (mm)
AC7	25	± 5	− 20, + 0
AC10	30	± 6	− 20, + 0

Note:

1. Conformity is based on the average thickness of the Sub-Lot.

Trafficking of NFC Subbase and Asphalt Interlayer

Trafficking of NFC Subbase

12.9 Except for personnel or equipment undertaking essential inspection and testing, the NFC subbase must not be trafficked until an in situ compressive strength of 4.0 MPa has been reached.

HOLD POINT 6	
Process Held	Trafficking of the NFC subbase.
Submission Details	In situ compressive strength test results of the NFC subbase must be submitted to the Principal at least 1 working day before trafficking of the NFC subbase.

12.10 Thereafter, only foot traffic, vehicles with a gross mass of less than 1.5 tonnes, and any construction equipment necessary for the following operations are permitted to travel over the NFC subbase for any of the following reasons:

a) surface survey measurements;

b) repair, removal or replacement of the curing sheeting; and

c) construction equipment required to place the asphalt interlayer.

Trafficking of Asphalt Interlayer

12.11 After the asphalt interlayer has been placed, only the equipment required for the construction of the overlying continuously reinforced concrete pavement (CRCP) is permitted to traverse over it.

12.12 For all other traffic and where the in situ compressive strength of the NFC subbase exceeds 8 MPa, the following applies:

a) All vehicles/equipment with axle loads within the legal limits may traffic the asphalt interlayer.

b) Rubber tracked vehicles with a maximum pressure of 15 t/m^2 over the contact area may traverse over the asphalt interlayer, provided that the asphalt interlayer and NFC subbase are protected from damage.

c) For vehicles/equipment with axle loads over the legal limit, calculations in accordance with the Hold Point for trafficking of asphalt interlayer must be submitted to the Principal.

12.13 The following information must be submitted to the Principal:

For axle loads within legal limits:	In situ compressive strength test results of the NFC subbase and axle loads of proposed vehicles/equipment traversing over asphalt interlayer. For rubber tracked vehicles with maximum track pressure of 15 t/m2, details of measures to protect asphalt interlayer and NFC subbase.
For axle loads over legal limits:	In addition to the requirements above, estimated number of repetitions of axle loadings and calculations verifying that the NFC subbase in the area to be trafficked can withstand the proposed loading.

HOLD POINT 7	
Process Held	Trafficking of asphalt interlayer by vehicles/equipment other than those required for CRCP paving.
Submission Details	The information specified in Clause 12.13 must be submitted to the Principal at least 24 hours prior to the trafficking by other vehicles.

Rectification of Damage

12.14 Any damage caused to the NFC subbase and asphalt interlayer resulting from the Contractor's operations must be rectified to produce a homogeneous subbase with the specified surface finish.

13. Survey

13.1 The subbase must be surveyed in accordance with the survey requirements included in the Contract documents and this Specification. Conformity requirements for alignment, levels and surface profile are specified in Clause 16.4.

Levels

General

13.2 When determining the levels, a survey staff (or reflector) with a flat base of area between 300 mm^2 and 4000 mm^2 must be used.

13.3 The levels obtained must be reported to the nearest millimetre.

13.4 During the progress of the Works, surveys must be carried out to determine the levels at the top of:

a) the underlying surface, over which the NFC subbase is to be placed;

b) the finished surface of NFC subbase; and

c) asphalt interlayer surface levels, where applicable.

Survey Prior to NFC Subbase Paving

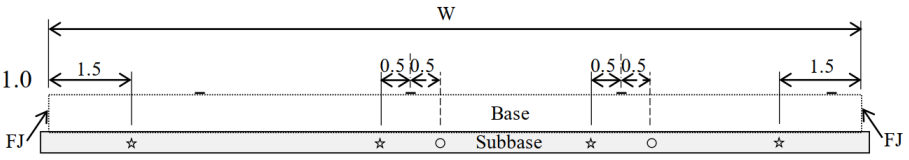
13.5 A survey of the underlying surface levels must be carried out prior to the commencement of NFC subbase paving.

13.6 Levels of the underlying surface must be taken at a spacing of 10.0 m longitudinally and at the transverse offsets shown in Figure 13.7, with a tolerance of 0.5 m.

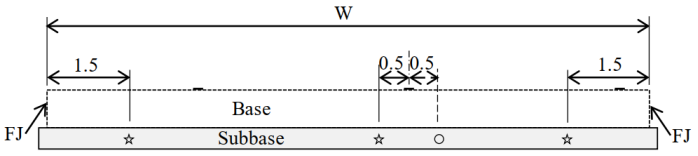
13.7 Prior to NFC subbase paving and upon completion of placing dental concrete, a Survey Report highlighting all locations where the actual levels are outside of tolerance with respect to the design levels must be submitted to the Principal.

Figure 13.7 Survey Locations

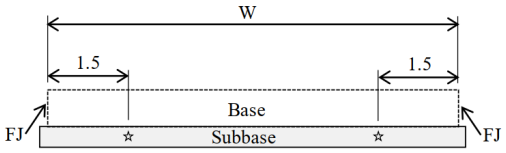
Case 1
Machine paved: W ≥ 11.0



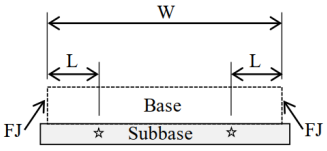
Case 2
Machine paved: W ≥ 8.0
Fixed-formed: W ≥ 6.0



Case 3
Machine paved: 4.5 ≤ W < 8.0
Fixed-formed: 4.5 ≤ W < 6.0



Case 4
W ≤ 4.5
For 3.0 < W ≤ 4.5: L = 1.0
For W ≤ 3.0: L = 0.5



Case 5
W ≤ 4.5
For 3.0 < W ≤ 4.5: L = 1.0
For W ≤ 3.0: L = 0.5

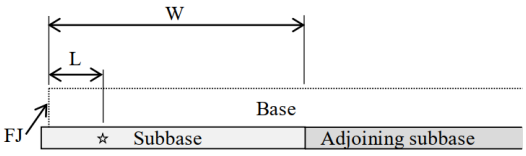


Figure R81.2 - Survey Locations

Legend:

- Location of lane line on base course
- ☆ Location of survey point (see Note (2) below)
- ○ Alternative location of survey point at other side of lane line (see Note (2) below)
- FJ Formed joint or edge

Notes:

1. *All dimensions are in metres (m).*
2. *Where an alternative location of survey point is shown (Cases 1 and 2), the Contractor can take survey levels at either side of the lane line (i.e. at either of the locations marked with '○' or with '☆').*
3. *Survey levels must be taken for both the underlying surface (see Clause 13.5) and the NFC subbase and asphalt interlayer (where applicable) finished surface (see Clause 13.8).*
4. *At locations where the distance between a formed edge and the adjacent lane line is varying (i.e. is tapered in plan view), the survey point will be at a 0.5 m offset from that lane line.*

Survey Prior to Asphalt Interlayer and Base Paving

13.8 A survey of the finished surface levels of both the NFC subbase and asphalt interlayer (where applicable) for conformity with levels and thickness must be carried out within 4 days of placing, unless agreed otherwise with the Principal.

13.9 Levels must be taken at the following locations:

a) at the same plan locations as those surveyed for the levels on the underlying layer under Clause 13.5, with a tolerance of 0.5 m; and

b) randomly selected locations at a minimum frequency of at least half the frequency required to comply with item a) above.

13.10 Schedules of levels showing the measured actual levels and their corresponding design levels, and the difference between them, must be submitted to the Principal. Highlight those levels and differences that are out of tolerance, and those locations that were specially surveyed for apparent nonconformity.

13.11 The following convention for the difference between the actual and design levels must be used:

a) where actual levels are above design levels, show the difference as positive; and

b) where actual levels are below design levels, show the difference as negative.

Alignment

13.12 A survey for conformity of the alignment of the edges and joints must be carried out within 4 days of placing a Sub-Lot of NFC subbase.

13.13 Each outer edge (see Clause 8.36) must be surveyed for alignment conformity at random locations, commencing with the trial paving and thereafter independent of the boundaries to Sub-Lots, at a frequency not less than the following:

a) one reading per 10 m of edge, until 5 conforming results are recorded; and thereafter

b) one reading per 50 m of edge.

13.14 The survey frequency reverts to the frequency in Clause 13.13 a) if nonconformity is detected.

Surface Profile

13.15 A survey of the surface profile must be carried out within 4 days of a Sub-Lot of NFC subbase or at the times agreed with the Principal.

13.16 The surface profile under a 3 m straightedge must be determined in accordance with Test Method ATM-453 or TfNSW T183. Where the surface is convex, place the straightedge so that the cantilever length does not exceed 0.75 m.

13.17 The surface profile must be surveyed for conformity at random locations, commencing with the trial paving and thereafter independent of the boundaries to Sub-Lots, at a frequency of not less than the following:

a) one reading of longitudinal and transverse surface profile per 10 m of paving run, until 5 conforming results are recorded; and thereafter

b) one reading of longitudinal and transverse surface profile per 100 m of paving run.

13.18 The survey frequency reverts to the frequency in Clause 13.17 a) if nonconformity is detected.

14. Conformity – Concrete Compressive Strength

Sub-Lot Delineation

14.1 Conformity of LCS for compressive strength must be assessed on the basis of Sub-Lots.

14.2 Transition zones must be treated as separate Sub-Lots.

Test Groups

14.3 A test group of cores is defined as a group comprising 2 cores taken from the NFC that are within a distance of 0.3 m to 1.0 m apart from each other, except if:

a) either of the cores has compressive strength of less than 4.5 MPa; or

b) the difference between the strengths is greater than 1.0 MPa,

then a third core is taken at a distance within 0.3 m to 1.0 m from the others and included in the test group.

14.4 The in situ compressive strength of the Sub-Lot is the mean (rounded to the nearest 0.1 MPa) of the corrected compressive strengths of all the cores in the particular test group.

14.5 The void content of the cores must be determined using TfNSW T378 before strength testing and the results must be submitted to the Principal.

Location and Frequency of Coring

14.6 The locations for coring must be selected at random, in accordance with ATM-020 and as set out in Clause 14.7.

14.7 One test group of cores must be taken from:

a) each Sub-Lot of machine paved concrete;

b) each Sub-Lot of fixed-formed concrete; and

c) in transition zones, commencing with the trial section, the minimum frequency of coring is as follows:

i) one group from each Sub-Lot until 3 consecutive conforming Sub-Lots are obtained; and then

ii) one group from each third Sub-Lot, selected on the basis of time sequence, until 4 consecutive Sub-Lots conform; and then

iii) one group from each fifth Sub-Lot, selected on the basis of time sequence.

14.8 If a nonconforming result in Clause 14.7 c) ii) or c) iii) above is obtained, the frequency of testing, starting from the nonconforming Sub-Lot, reverts to that specified in Clause 14.7 c) i).

14.9 Additional cores for the purpose of core compressive strength testing must not be taken without the prior approval of the Principal.

14.10 In accordance with ATM-020, further samples at specific (non-random) locations that are visually non-homogeneous and/or non-representative must be taken.

14.11 Core holes must be backfilled in accordance with Clause 18.2.

Test Specimens

14.12 The core specimens must be prepared and tested in accordance with AS 1012.14, but with the following amendments:

a) Cores must be 150 mm in diameter.

b) Concrete in the NFC subbase must have hardened enough to permit removal of the cores without the coarse aggregate coming off.

c) AS 1012.14 Clause 6.3.2 (b) is amended to read as follows: 'The diameter at any cross-section deviates from the mean diameter by more than 5 mm.'

d) AS 1012.14 Clause 6.4 (d) is amended to exclude dry conditioning. Instead, cores must be wet conditioned by submersion in water at a temperature of 23 ± 5°C for no less than 24 hours and no more than 72 hours immediately prior to testing.

e) The individual core strengths must be corrected for shape (length/diameter ratio) in accordance with Clause 14.3 of this Specification.

f) AS 1012.14 Clauses 9 (k), 9 (l), 10 (h) and 10 (i) are amended by the addition of the following words: 'except where the strength is less than 10 MPa, in which case it must be calculated to the nearest 0.1 MPa.'

14.13 Prior to testing, any asphalt found on the core must be trimmed.

Correction Factors

14.14 Age correction factors must not be applied to core compressive strength results.

14.15 The shape correction factors (SF) shown in Table 14.15 must be applied to the core compressive strengths by multiplying them by the factor SF to obtain the 'factored core strength'. Apply the shape correction factor to the unrounded core strength.

Table 14.15: Shape correction factor

Length-diameter ratio of core	Shape correction factor (SF)
2.0	1.00
1.75	0.98
1.5	0.96
1.25	0.93
1.0	0.87

Conformity for Core Compressive Strength

14.16 The NFC subbase must achieve in situ compressive strength of 5.0 MPa or greater within 28 days of placement.

14.17 Any Sub-Lot of NFC subbase which fails to achieve in situ compressive strength of 5.0 MPa must be removed and replaced within 28 days of placement.

15. Conformity – Thickness

General

15.1 The thickness of the NFC subbase and asphalt interlayer (if applicable) must be assessed within Sub-Lots, except that each transition zone must be combined with the adjacent Sub-Lot. (Refer to Table 12.11 for thickness tolerance on asphalt interlayer).

NFC Subbase and Asphalt Interlayer Thickness Determination from Survey

15.2 The LCS thickness at individual survey points selected must be calculated as the difference between the finished LCS surface level and underlying surface level in accordance with Clause 13.2.

15.3 The calculated thickness must be adjusted to allow for the design surface longitudinal and transverse slopes between the 2 surveyed points.

15.4 The Quality Plan must include details of the method of determining the thickness with adjustment.

NFC Subbase Thickness Determination from Cores

15.5 The NFC subbase thickness must be measured on cores taken for compressive strength testing.

Discrepancy Between Thickness from Survey and Cores

15.6 Wherever a core thickness result is thinner by 5 mm or more than the thickness calculated from the survey result at a location within 1.5 m of the core, or thinner by 10 mm or more at a location between 1.5 m and 2.5 m from the core, the core result will be the accepted thickness and the particular survey result disregarded.

15.7 If the frequency of such occurrences is more than 3 in any group of 10 consecutive comparisons, the NFC subbase thickness calculated from the survey results for the entire area represented will be disregarded.

15.8 In areas where the NFC subbase thickness calculated from survey results is nonconforming and no representative cores are available for comparison, the Principal may authorise the drilling of 50 mm diameter cores.

15.9 Additional cores for the purpose of thickness assessment must not be taken without the prior approval of the Principal.

Mean Thickness

15.10 The mean thickness for each Sub-Lot must be calculated using all results for the Sub-Lot (to the nearest 1 mm) that have not been disregarded. Round off the calculated mean thickness to the nearest 5 mm.

Conformity for Thickness

15.11 An NFC subbase Sub-Lot will be conforming in thickness if:

g) the rounded mean thickness is not less than the design thickness; and

h) no individual result is 15 mm or more below the design thickness.

Offsetting Subbase Thickness Deficiency With Increased Base Thickness

15.12 Where the Contract includes the construction of concrete base, any reduced NFC subbase thickness may be offset by an increase in base thickness.

15.13 Unless specified otherwise in the Contract documents, the deductions in relation to the offsetting increase in base thickness shown in Table 15.13 will apply to the applicable item in the payment schedule for NFC subbase.

Table 15.13: Deduction with increased concrete base thickness as offset for NFC subbase thickness deficiency

Deficiency in mean NFC thickness[1] (mm)	Increase in specified base thickness (mm)		
	5	10	≥15
	Deduction to payment item (%)		
10	0	0	0
15	12	0	0
20	25	12	0

Note:

1. *Thickness deficiency is the calculated difference between the rounded mean thickness and the design thickness.*

16. Conformity – Subbase Alignment, Levels and Surface Profile

Alignment

16.1 Tolerances on horizontal alignment are given in Clause 8.34 for the outer edges of the NFC subbase and for joints.

NFC Subbase and Asphalt Interlayer Surface Levels

16.2 The NFC subbase and asphalt interlayer (if applicable) surface levels must be assessed for conformity on the basis of individual survey results.

16.3 The level at any point on the top of the NFC subbase must not vary by more than 0 mm above or 20 mm below the design level.

16.4 The level at any point on top of the asphalt interlayer must comply with the tolerances shown in Table 12.11. If the levels are outside of the specified tolerance, the Contractor must take the action specified in Table 16.4.

Table 16.4: Surface levels outside of tolerance

Levels outside of tolerance	Required action
The levels are below the levels shown on the Drawings:	Submit a nonconformity report and attach the survey report and the relevant assessment of thickness.
The NFC subbase levels are above the levels shown on the Drawings:	For such Sub-Lots, submit a nonconformity report and grind the high spots down to the design levels. Remove grinding debris by suction. Re-survey the area and resubmit the survey report.
The asphalt interlayer subbase levels are above the levels shown on the Drawings:	For such Sub-Lots, mill and cover the area with a slurry seal to provide a surface consistent with the adjacent asphalt and complying with specified level requirements. Re-survey the area and resubmit the survey report.

16.5 Alternatively, for NFC subbase and asphalt interface areas that are high by 20 mm or less, the Contractor may propose a redesign of the finished levels in accordance with Clause 17.1.

HOLD POINT 8	
Process Held	Placing of overlying layer over area of NFC subbase surveyed. The overlying layer may be asphalt interlayer or concrete base if asphalt interlayer is not required. Placing of overlying concrete base over area of asphalt interlayer surveyed (if asphalt interlayer is required).
Submission Details	The schedule of measured levels and any relevant nonconformity report must be submitted to the Principal at least 5 working days prior to placing the overlying layer.

Surface Profile

16.6 Deviations under a 3 m straightedge, laid in any direction, must not exceed 10 mm where the NFC subbase is overlaid by asphalt, or 5 mm otherwise.

17. Redesign of Pavement Levels

Redesign by the Contractor

17.1 Where the NFC subbase and the underlying layer are both constructed by the Contractor, and where the pavement levels are high and nonconforming, the Contractor may locally redesign the pavement levels in accordance with the following criteria:

a) the rate of level change on any longitudinal profile string, calculated relative to the approved design, must not be greater than 0.1% (1.0 mm per metre);

b) the revised crossfall (or superelevation) at any location must not vary from the approved value by more than ± 0.3% (expressed as actual values); hence a specified crossfall of 3.0% may be varied within the range 3.0% ± 0.3%;

c) the transition from the redesigned pavement to abutting structures and pavements must be smooth; and

d) compliance with the vertical clearance requirements.

17.2 The redesigned pavement must be such that:

a) water will not pond on the carriageway;

b) drainage is not compromised in any aspect, including depth and rate of flow over the pavement, flow direction and capacity (both on the pavement and within the drainage network); and

c) the risks and associated consequences (in terms of drainage) are not increased at locations such as superelevation transitions, taking into account the likely construction deviations (within the specified level tolerances) from the finished base levels.

17.3 The redesign must be submitted to the Principal for approval. The Principal will respond within 4 working days.

17.4 The Contractor is not entitled to additional payment for redesign due to nonconformity of the underlying surface levels or the NFC subbase and asphalt interlayer finished surface levels.

Redesign by the Principal

17.5 The Principal may alter the NFC subbase and/or asphalt interlayer thickness and/or levels by up to 30 mm before the commencement of each section of work, in which case payment will be made on the basis of the actual variation to the quantities of work in accordance with the relevant items in the applicable payment schedules.

18. Restoration of NFC After Coring

18.1 All core holes in NFC subbase must be restored prior to placing of the asphalt interlayer.

18.2 All core holes taken in the NFC subbase must be cleaned and backfilled with NFC having compressive strength of not less than that in the NFC subbase. The approved NFC subbase mix may be used.

18.3 After backfilling, the finished surface of the NFC subbase at the core hole location must be flush with the surrounding surface of the NFC subbase.

18.4 The costs of backfilling all holes in the NFC subbase will be borne by the Contractor, except for any additional cores ordered by the Principal.

19. Removal and Replacement of NFC Subbase

Boundaries of Section for Removal

19.1 Where an area of the NFC subbase is nonconforming and is to be removed and replaced, the longitudinal boundaries of the section for removal must either coincide with existing longitudinal joints or edges or be parallel to the control line. Transverse boundaries must be orthogonal to the longitudinal boundaries with a 6° tolerance.

19.2 The locations of the boundaries of the section for removal must be such that the dimensions of both the replacement slab and the residual slab (i.e. slab remaining after removal), and the corner angles, comply with Table 8.31.

19.3 The location of the longitudinal construction joints created by the removal and replacement of nonconforming concrete must also conform to Clause 8.34 with respect to the location of the longitudinal joint in the overlying base.

Sawcutting

19.4 Where sawcutting is required, the sawcut must be to the full depth of the LCS in straight lines that are continuous between opposing boundaries. Waste from the sawcutting operations must be managed in accordance with the environmental management requirements included in the Contract documents.

HOLD POINT 9	
Process Held	Sawcutting for removal and replacement of NFC subbase.
Submission Details	A nonconformity report for each section of nonconforming NFC subbase to be removed must be submitted to the Principal at least 3 working days prior to the commencement of sawcutting.

19.5 Sawcuts must not be extended by more than 150 mm beyond the boundaries that define the limits of removal. Any additional internal sawcuts that are made to aid the removal of the LCS must not be over-sawn.

Replacement

19.6 The area of nonconforming NFC must be removed and replaced with conforming NFC.

Annexure A: Summary of Hold Points, Witness Points and Records

The following is a summary of the Witness Points/Hold Points that apply to this Specification and the Records that the Contractor must submit to the Principal to demonstrate compliance with this Specification.

CLAUSE	HOLD POINT	WITNESS POINT	RECORD
4.1	1. Commencement of concrete production		Quality Plan
6.15	2. Production of each concrete mix		Details of nominated mix and associated documents
6.23			Details of variations to a nominated mix before commencing production with the varied quantities
7.20	3. Production of concrete for paving		Results demonstrating conformity of mixer uniformity
8.1	4. Paving of NFC subbase		Schedule of underlying surface levels and any relevant nonconformity report
10.2		1. Construction of section of trial pavement	
10.4	5. Commencement of NFC paving other than trial paving		Report of paving trial
12.9	6. Trafficking of the NFC subbase		Compressive strength test results
12.13	7. Trafficking of asphalt interlayer by vehicles other than those required for CRCP paving		Test results and calculations
13.7			Schedule of levels on underlying layer below the NFC subbase and survey report
13.10			Schedule of levels on top of NFC subbase and any relevant nonconformity report
13.10			Schedule of levels on top of asphalt interlayer and any relevant nonconformity report
14.5			In situ strength test results of the NFC subbase
16.5	8. Placing of overlying layer over area of NFC subbase surveyed or placing of overlying concrete base over area of asphalt interlayer		Submission of measured levels and associated documents
19.4	9. Sawcutting		Nonconformity report

Annexure B: Mixer Uniformity Testing

B1 General

B1.1 Charging Mixer

For the purpose of conducting the mixer uniformity test, charge the mixer:

a) in accordance with the manufacturer's instructions;

b) in the sequence proposed to be used in the Works; and

c) to the maximum volume (or throughput) proposed to be used in the Works.

Thereafter, use the same charging sequence and do not exceed the volume (or throughput) unless another uniformity test is conducted.

B1.2 Use of Concrete from Uniformity Test

Concrete from the mixer uniformity test may be incorporated into any part of the Works on the condition that all concrete from the test conforms to the relevant specification and is placed in a discrete Sub-Lot. The entire Sub-Lot must be removed if the mixer fails to meet the criteria specified in Clause B2 or Clause B3.

B2 Stationary Mixer

B2.1 General

Where concrete is to be produced and mixed by a stationary mixer, conduct mixer uniformity tests before paving with that mix, and thereafter upon production of each 30,000 m^3 of concrete from that mixer (including all mix types and customers) or as otherwise required in accordance with AS 1379 Clause 3.5.

Carry out tests on each NFC subbase mix to be placed in the Works.

For stationary batch mixers, conduct tests on 3 consecutive batches of the same mix that conform to the requirements of this Specification.

For stationary continuous mixers, conduct tests on 3 consecutive batches, with each batch separated by an interval equivalent to at least 2 m^3 of throughput of the same mix, that conform to the requirements of this Specification. Each batch must comprise no less than 5 m^3 of mix.

For each batch, report the following:

a) mixing speed;

b) batch volume;

c) duration of charging;

d) total mixing time or, for continuous mixers, the throughput rate; and

e) mixing time after the last addition of water.

B2.2 Sampling

Discharge and sample the whole of a single batch by one of the following procedures:

a) By discharge into a tipper truck with tray length no less than 8 m. Conduct sampling from the truck before tipping. Obtain the samples by using a shovel or scoop but exclude the top 100 mm of concrete.

b) By discharge into a transport vehicle typical of that to be used in the Works, and then spread evenly over a length of between 6 m and 10 m onto ground that is either sealed or pre-dampened to prevent absorption of water from the mix. Conduct sampling from the ground.

In each case, sample the batch at 3 points approximately 15%, 50% and 85% along the discharged length of the mix, but not closer to either end than 10% of the length. Take a sample of approximately 50 litres from each point, in accordance with AS 1012.1.

B2.3 Testing

Carry out tests required for each property of the concrete in AS 1379 Table A1 on each of the 50 litre samples, in accordance with Appendix A of AS 1379 and as amended by this Specification.

B2.4 Compliance

The mixer will be deemed to have passed the uniformity test if, for each batch, the differences between the highest value and the lowest value for the corresponding properties of the 3 samples do not exceed the limiting values given in AS 1379 Table A1.

B3 Mobile Mixers

B3.1 Sampling and Testing

Over a period of 24 months (which may include a period prior to the term of this Contract), randomly test the number of mobile mixers listed in Table B3.1.

Table B3.1: Mobile mixer fleet testing

Population size	Sample size
<16	All
16-25	17
26-50	22
51-90	24
91-150	26
151-280	28
281-500	32

Take 3 samples each of approximately 50 litres at uniform interval from each of the randomly selected mobile mixers, in accordance with AS 1012.1 Clause 7. Carry out tests for the properties in AS 1379 Table A1 on each sample, in accordance with Appendix A of AS 1379 and as amended by this Specification.

This sampling program is predicated on an 8% limiting quality value.

Because of the retempering provisions of the Specification, include mobile mixers that are used to transport centrally-mixed concrete in the fleet testing.

B3.2 Compliance

The differences between the highest value and the lowest value for the corresponding properties of the 3 samples of each randomly selected mixer in accordance with Table B3.1 must be within the limiting values given in AS 1379 Table A1.

The fleet will be deemed to conform if all the randomly selected mixers satisfy the requirements of AS 1379 Appendix A.

Where a mixer fails to satisfy a mixer uniformity test, the entire fleet is deemed to have failed, until:

a) The producer immediately stands down the mixer while reasons for the failure are investigated to determine whether the failed result is a true outlier. If it is found that the failure was due to extraordinary reasons, it may be treated as a one-off event;

b) The producer immediately tests another randomly selected mixer from the same fleet, and that result will determine the continued compliance of the fleet, as follows:

   i) if it passes, the fleet will carry provisional compliance until the failed mixer is either repaired and passed or withdrawn from operational service;

   ii) if it fails, proceed in accordance with item a) above.

To satisfy the mixer uniformity and compliance program, regularly inspect all mixers to determine the extent of internal wear, internal build up and the ability to rotate at the required rate (revolutions/minute). Keep a progressive maintenance record for each mixer showing inspection frequency and details of any repair or rectification and make this available on request.

Further testing must be carried out:

a) upon evidence of non-uniformity of mixing that appears to be associated with mixer wear; or

b) where the discharge time for that mixer is more than 25% longer than the typical time for other trucks using the same mix.

All mobile mixers must display an identification plate in accordance with AS 1379 to certify conformity with mixer uniformity criteria.

Where a mixer is one of the randomly tested mixers, show the date of the latest test on its identification plate.

Annexure C: Minimum Frequency of Testing

Clause	Characteristic tested	Test Method	Minimum frequency of testing
Constituent material: coarse aggregate			
5.3	Wet strength	TfNSW T215	One per 2000 t(1)
5.3	Wet/dry strength variation	TfNSW T215	One per 2000 t(1)
5.3 and 7.5	Particle size distribution of combined aggregate – deviation from nominated: by calculation	 AS 1141.11.1	One per 800 t of aggregate
Constituent material: other materials			
5.6	Cementitious materials	See ATIC SP43	See ATIC SP43
5.14	Water	AS 1379, AS 1478.1, AS 1289.4.2.1	One per 40,000 m^3 of concrete
6.7	Sulphate ion content	As per Clause 6.7	One per 30,000 m^3 of concrete
Concrete mixer			
Annexure B	Mixer uniformity	AS 1379 and Annexure B	As per Annexure B
Placed NFC subbase			
8.33	Geometric tolerance on transverse joints	As per Clause 8.33	2 tests per joint
8.35	Geometric tolerance on longitudinal joints	As per Clause 8.35	Initially, and after each nonconformity: One per 10 lin m of joint until 5 conforming results are recorded, then one per 25 lin m
12.9	In situ compressive strength (for trafficking purposes)	Cores as per Clause 12.9	As per Clause 12.9
13.2	Surface levels	As per Clause 13.2	As per Clause 13.2
13.13	Alignment	As per Clause 13.13	As per Clause 13.13
13.15	Surface profile	As per Clause 13.15	As per Clause 13.15
14.3	Compressive strength of concrete cores at 28 days	As per Clause 14.3	As per Clause 14.3
14.3	Void content of cores	TfNSW T378	As per Clause 14.3
15.1	Thickness	As per Clause 15.1	As per Clause 15.1
Placed asphalt interlayer			
13.4	Surface levels	As per Clause 13.4	As per Clause 13.4
15.1	Thickness	As per Clause 15.1	As per Clause 7.2

Note:

1. *Provided that all of the 6 previous tests have met specified requirements for both wet strength and wet/dry strength variation, the following reduced frequency applies:*

   where all wet/dry variation results are < 25%: 1 per 10,000 t

   where all wet/dry variation results are < 30%: 1 per 4000 t

Amendment Record

Amendment no.	Clauses amended	Action	Date
-	New specification	New	February 2025

Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed