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AUSTROADS TECHNICAL SPECIFICATION ATS 5321
Maturity Method

Contents

1. Scope

1.1 Austroads Technical Specification ATS 5321 sets out the requirements for the application of maturity principles to determine the Strength - Maturity Relationship of a concrete mix (the "Maturity Method") and apply it to production concrete. It may apply to either cast-in-place concrete or precast concrete.

1.2 The Contractor may use the Maturity Method for the purpose of facilitating early formwork removal, lifting of precast members or the early application of loading, subject to the Principal's approval of the Quality Plan in accordance with Clause 4.1.

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 2:	Preparing concrete mixes in the laboratory
Method 8.1:	Method for making and curing concrete—Compression and indirect tensile test specimens
Method 9:	Compressive strength tests – Concrete, mortar and grout specimens

Austroads

ATS 5315	Supply of Special Class Concrete
ATS 5320	Placement of Concrete
ATS 5325	Precast Concrete Members

ASTM International

C1074	Standard Practice for Estimating Concrete Strength by the Maturity Method

3. Definitions

3.1 The following definitions apply to this Specification:

Maturity:	The extent of the development of compressive strength of concrete.
Maturity Index:	An indicator of Maturity that is calculated from the temperature history of the concrete during the curing period The maturity index is expressed in terms of a temperature-time factor calculated in accordance with Clause 6.4.
Strength - Maturity Relationship:	The correlation between concrete compressive strength and Maturity.

4. Quality System Requirements

4.1 Unless the Contractor's facilities and processes have been assessed and approved under a Principal's Registration Scheme, the Contractor must prepare and implement a Quality Plan which includes the documentation in Table 4.1.

Table 4.1: Quality Plan

Clause	Description of document
5.1	Details of the facilities, equipment and the curing system
6.1	Procedure for the Maturity Method

HOLD POINT 1.	
Process Held	Application of the Maturity Method to curing of concrete.
Submission Details	The Quality Plan must be submitted to the Principal at least 10 working days prior to the commencement of concrete production to which this Specification applies.

5. Equipment

5.1 Unless the Contractor's facilities and equipment have been previously assessed and approved by the Principal, the Quality Plan must include:

a) details of the TMC bath and other equipment;

b) the proposed number, type and location of temperature sensors; and

c) details of the data loggers (including the rate of data collection) and any other instrumentation.

5.2 The heat control system must be able to maintain the enclosure temperature or the hot water temperature (as applicable) at ± 5°C of the target temperature at all times.

5.3 The Contractor must ensure that sufficient instrumentation is in place to control and digitally record the relevant temperatures in accordance with this Specification throughout the entire heat accelerated curing process. Data must be collected at a rate not less than one reading per 5 minutes.

6. Maturity Method

General

6.1 The Quality Plan must include:

a) an outline of the purpose of the Maturity Method (e.g., determine the time for stripping, early lifting of precast members or the early application of loading to concrete members);

b) methodology/procedures for undertaking maturity testing and developing the Strength - Maturity Relationship, including the period of testing;

c) if not previously submitted to the Principal, details and location of the sensors and temperature recording device to be used to monitor the concrete temperature (refer Clause 8);

d) the methodology for validation testing;

e) the factor of safety to be applied to the Strength - Maturity Relationship when used in production; and

f) any documented evidence of previous performance of tested samples, including accuracy and deviations.

6.2 The constituent materials used in the production of the concrete must not vary from the mix design used for Maturity Testing by more than the tolerances specified in ATS 5315. The Contractor must ensure that the accuracy of the Strength-Maturity Curve is not reduced by the deviations between the concrete used in testing and the production concrete.

6.3 A Strength-Maturity Relationship must be determined for each mix design.

Maturity Index

6.4 The Maturity Index is determined by the temperature - time factor, which is calculated in accordance with the following equation:

$$M_t = \sum (T_{ave} - T_0) \times \Delta t$$

Where:

M_t = temperature-time factor at age (°C.hours);

T_{ave} = average temperature during the corresponding time interval (°C);

T_0 = datum temperature (°C);

Δt = time interval (in hours).

6.5 When calculating the Maturity Index, Δt must not exceed 5 minutes.

Developing the Strength - Maturity Relationship

6.6 The Strength - Maturity Relationship must be determined in accordance with ASTM C1074 with the following modifications:

a) Specimens are taken in accordance with AS 1012.1 from a mix prepared in accordance with AS 1012.2 or from the production mix.

b) Test cylinders are prepared in accordance with AS 1012.8.1.

c) The specimens are cured in accordance with this Specification and compressive strength testing in accordance with AS 1012.9, is undertaken at ages of 6, 12 and 24 hours and 3, 7 and 28 days. At least 3 specimens must be cast for each age assessed. If appropriate, alternative time intervals may be specified in the approved Quality Plan; for example, to match the proposed formwork stripping times or if high early strength concrete is used.

6.7 The Strength - Maturity Relationship must be calculated using the procedure in the approved Quality Plan.

6.8 Unless otherwise determined from laboratory testing in accordance with C1074, the datum temperature for the Strength - Maturity Relationship (T_o) may be taken as 0°C.

6.9 If the difference in test results between one specimen and two others is 10% or greater, the specimen must be discarded and the average of the two other specimens must be used. However, a new Strength-Maturity Relationship must be determined if the difference of two or more specimens varies by more than ±10% of the average strength of the two conforming test specimens.

6.10 A report must be submitted to the Principal which includes the concrete test results in accordance with AS 1012.9 and details of the calculation of the Strength - Maturity Relationship.

HOLD POINT 1.	
Process Held	Application of the Maturity Method.
Submission Details	The report on the Strength - Maturity Relationship must be submitted to the Principal at least 5 working days prior to the commencement of concrete curing.

Estimating the In-Place Strength of Concrete Members

6.11 For the purpose of estimating the in-place strength of production concrete, the temperature must be recorded using a minimum of two temperature sensors per concrete member. Unless approved otherwise, one temperature sensor must be positioned to record the core temperature in accordance with Clause 8.4 and the other positioned to record the surface temperature in accordance with Clause 8.5. Installation of additional sensors at other locations may be required to increase the accuracy of strength estimation.

6.12 The concrete temperature must be monitored in accordance with Clause 8.1.

6.13 The concrete is deemed to have reached its required design strength once results indicate the strength is equal to or greater than the estimated strength from the Strength-Maturity Relationship at the same Maturity, subject to the application of any safety factor specified by the designer of the concrete member or specified in the contract documents.

7. Verification of the Strength - Maturity Relationship

7.1 To verify the Strength - Maturity Relationship, the actual compressive strength of the production concrete must be sampled and determined using AS 1012.9 and compared to that predicted from the Strength - Maturity Relationship. For each Lot, the verification testing must be undertaken at the commencement of production and subsequently on a monthly basis (unless the Principal has approved a reduced rate of testing).

7.2 For the purpose of this Clause 7 only, a Lot is concrete which is produced to one mix design under uniform conditions, using the same constituent materials, and placed in the same type of concrete member. A minimum of three specimens must be cast for this purpose and the specimens must be cured in accordance with this Specification.

7.3 The deviation between the measured average concrete strength (from 3 test specimens) and the strength estimated from the Strength-Maturity Relationship must be assessed in accordance with Table 7.3.

Table 7.3: Validity of Strength-Maturity Relationship

Deviation between the measured concrete strength and the strength estimated from the strength-maturity relationship	Outcome
≤ 12% of the measured concrete strength	The relationship is deemed to be valid and may be used for production.
> 12% of the measured concrete strength	The relationship is deemed to be invalid and a new Strength-Maturity Relationship must be determined.

7.4 If the Strength-Maturity Relationship is deemed to be invalid, standard compressive strength testing for determining early age concrete strength must be used until a new valid Strength-Maturity Relationship has been determined in accordance with Clause 6.6.

7.5 If the volume of concrete exceeds 500 m^3 for the specified application, additional concrete specimens must be taken and the Strength-Maturity Relationship recalculated in accordance with Clause 6.6 for comparison with the original Strength-Maturity Relationship. The process must be repeated for every 500 m^3 of concrete.

8. Temperature Monitoring

General

8.1 Where temperature monitoring is required by this Specification, the temperature must be recorded continuously or at intervals not exceeding 5 minutes. Unless specified otherwise, the monitoring must commence at the completion of the concrete pour and continue for a period of 48 hours or until temperatures have dropped to 10°C below the peak temperature, whichever occurs first. The temperature records must be submitted to the Principal in accordance with Clause 9.

8.2 Thermometers and recording devices must maintained in good condition and calibrated in accordance with the manufacturer's instructions.

8.3 Thermometers and recording devices must not be disturbed or moved in any way until after the completion of curing.

Temperature Monitoring Locations

8.4 Where the core temperature of a concrete member is measured, the temperature sensor must be positioned at:

a) the geometric centre of the member's largest concrete cross-section; or

b) the centre of mass of the largest concrete volume.

8.5 Where the surface temperature of a concrete member is measured, the temperature sensor must be placed in the concrete at a position which is between 30 mm and 50 mm inside the external concrete surface. It must not be deeper than the concrete cover to reinforcement.

8.6 Temperature sensors must not be in direct contact with any steel that may affect the temperature recorded by the sensor.

9. Records

9.1 In addition to the records that the Contractor must prepare under ATS 5315, ATS 5320 and / or ATS 5325, the following records must be submitted to the Principal:

a) verification of the Strength - Maturity Relationship in accordance with Clause 7.1; and

b) all temperature records in accordance with Clause 6.11.

9.2 All temperatures must also be displayed in a graphical time verses temperature format.

9.3 Records must be submitted in an electronic format which is acceptable to the Principal.

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 curing of concrete		Quality Plan
6.10	2. Application of the Maturity Method.		Report on the Strength - Maturity Relationship
9.1			Maturity Method records

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