Winnipeg PUBLIC WORKS DEPARTMENT • SERVICE DES TRAVAUX PUBLICS Engineering Division • Division de l'ingénierie	**Effective Date: February 12, 2025** **DIVISION 4**
CW 3310 – R19	**PORTLAND CEMENT CONCRETE PAVEMENT WORKS**

TABLE OF CONTENTS

1. DESCRIPTION

1.1 General

1.1.1 This specification covers the preparation of Portland Cement Concrete for, and all concreting operations relating to, the construction of Portland Cement Concrete pavements, curbs, gutters, private approaches, bull-noses, median slabs, medians, safety medians and boulevard splash strips, sidewalks and other related concrete works. This Specification is applicable to both reinforced and non-reinforced concrete construction, but not pre-stressed concrete.

1.1.2 All requirements and tests shall be in accordance with the latest edition of CSA A23.1-19/CSA A23.2-19, except as otherwise specified herein.

1.2 Definitions

1.2.1 Reinforced Concrete Pavement - A Portland Cement Concrete pavement with distributed steel reinforcement in the pavement slab and with deformed tie bars across longitudinal joints and smooth dowels across transverse contraction joints. Distributed steel reinforcement consists of smooth or deformed bars.

1.2.2 Plain-Dowelled Pavement - A Portland Cement Concrete pavement with no reinforcing steel in the pavement slab and with deformed tie bars across longitudinal joints and smooth dowels across transverse contraction joints.

1.2.3 Type 1 Concrete shall be used for expressways, major arterials, minor arterials, industrial/commercial collectors, residential major collectors, residential minor collectors, and industrial/commercial local pavements. Curbs and approaches shall match the concrete type based on the street classification.

1.2.4 Type 2 Concrete shall be used for residential streets and alleys, commercial approaches, residential approaches, miscellaneous concrete slab and splash strips. Type 1 Concrete can be used instead of Type 2 Concrete. Curbs and approaches shall match the concrete type based on the street classification.

1.2.5 Type 3 is early opening concrete and shall be used for 24 hours early opening after placement.

1.2.6 Type 4 is early opening concrete and shall be used for 72 hours early opening after placement.

1.2.7 Type 5 Concrete shall be used for Sidewalks. Type 1 or Type 2 Concrete can be used instead of Type 5 Concrete.

1.2.8 Type 6 is concrete for restoration of utility pavement cuts.

1.2.9 Type 7 is concrete for temporary restoration.

1.2.10 Cold Weather Concrete is concrete for Cold Weather and shall replace all other concrete types for all applications when Cold Weather exists, except Type 7.

1.2.11 Coarseness Factor (CF) - A measure of the coarseness of the combined aggregate materials being incorporated into the concrete mix.

$$\text{Coarseness Factor} = \frac{\sum \%\ \text{retained on 10 000 Sieve}}{\sum \%\ \text{retained on 2 500 Sieve}} \times 100$$

1.2.12 Period I will apply when the average daily temperature is 10˚C and rising for the next five (5) consecutive days of concrete placement as forecast by the nearest official meteorological office.

1.2.13 Period II will apply when the average daily temperature for more than five (5) consecutive days is expected to fall below 10˚C within fourteen (14) days of concrete placement as forecast by the nearest official meteorological office.

1.2.14 Hot Weather is defined as follows:

1.2.14.1 The ambient air temperature being at or above 27 °C; or,

1.2.14.2 When the nearest official meteorological office predicts the ambient air temperature to be at or above 27 °C during the concrete placing period; or,

1.2.14.3 When the evaporation rate may exceed 0.75 kg/m^2/h as estimated by Figure D1, Appendix D, Guidelines for Curing and Protection of CSA A23.1.

1.2.15 Cold Weather is defined as a period when the nearest official meteorological office predicts the ambient air temperature will be below 5 °C within 24 hours of placing concrete.

1.2.16 Protection Period is the time required to prevent concrete from being affected by exposure to Cold Weather and to develop a minimum compressive strength of 24 MPa. Concrete compressive strength shall be determined by maturity meters and field cured cylinders.

1.2.17 Curing Day is a day when the average ambient air temperature is above 5 °C according to the nearest official meteorological office.

1.2.18 Tie Bars are reinforcement bars installed to maintain alignment or prevent separation of adjacent slabs, curbs, or other concrete elements caused by movement.

1.2.19 Concrete Lot means a specific quantity of concrete represented by a specific testing set.

2. MATERIALS

2.1 Handling and Storage of Materials

2.1.1 All concrete constituent materials shall be stored in a manner that will prevent contamination or deterioration. Storage of materials shall be in accordance with the requirements of CSA-A23.1, Clause 5.1, Storage of Materials, except as otherwise specified herein. Access to the storage facilities shall be provided for inspection by the Contract Administrator.

2.1.2 All fabricated and incidental materials, such as reinforcing steel, curing compounds, bonding agent, cardboard forms, etc., shall be stored in accordance with the manufacturer's instructions.

2.2 Concrete Constituent Materials

2.2.1 Aggregate shall consist of crushed stone or gravel or a combination of these materials conforming to the requirements of this Specification.

2.2.1.1 Each of the fine- and coarse-fractions of the combined aggregate shall meet all the requirements of CSA A23.1, Table 10 (FA1) and Table 11, respectively and shall be handled and weighed separately to maintain uniformity. The supplier shall provide the City of Winnipeg, Research and Standards Engineer with test data in accordance with CSA A23.2-30A to demonstrate that the material will produce concrete of acceptable quality that meets all the relevant requirements of this Specification.

2.2.1.2 The combined aggregate gradation and allowable deviations shall comply with the requirements in Table CW 3310.1.

TABLE CW 3310.1 - Combined Aggregate Gradation Limits and Allowable Deviations

Sieve Size	Percent of Total Dry Weight Passing Each Sieve	Allowable Deviation from the Job Mix Formula, % By Mass Passing Sieve
28 000	100%	-
20 000	90% - 100%	± 2%
14 000	75% - 95%	± 2%
10 000	60% - 75%	± 3%
5 000	35% - 50%	± 3%
2 500	27% - 35%	± 2%
1 250	20% - 30%	± 2%
630	10% - 20%	± 2%
315	5% - 10%	± 2%
160	1% - 4%	± 1%
80	0% - 2%	± 1%

2.2.1.3 The fineness modulus of fine aggregate shall not be less than 2.3 or more than 3.1.

2.2.1.4 Aggregates shall conform to CSA-A23.1, Clauses 4.2.3.1 to 4.2.3.6. Each of the fine- and coarse-fractions shall comply with the physical requirements in Table CW 3310.2 and the test results shall be provided with the mix design submittal.

TABLE CW 3310.2 – Limits for Deleterious Substances and Physical Properties of Aggregates

Material	Parameter	Test Method	Limits		Frequency of Test
			Minimum	Maximum	
Coarse Aggregate	Clay lumps	CSA A23.2-3A	-	0.3%	2 years
	Low density granular material	CSA A23.2-4A	-	0.5%	2 years
	Material finer than 80 µm	CSA A23.2-5A	-	1.0%	1 year
	Bulk Relative density (Kg/m^3) and absorption	CSA A23.2-12A	2500	1.75	Bi-weekly
	Flat and elongated particles - Flat particles - Elongated particles	CSA A23.2-13B	-	25% 40%	1 year
	Petrographic examination – PN	CSA A23.2-15A	-	125	1 year
	Unconfined freeze-thaw	CSA A23.2 24A	-	6%	Twice per season
	Alkali-silica reactivity	CSA A23.2-25A	-	0.15%	2 years
	Micro-Deval	CSA A23.2-29A	-	17%	Twice per season
Fine Aggregate	Clay lumps	CSA A23.2-3A	-	1%	2 years
	Low density granular material	CSA A23.2-4A	-	0.5%	2 years
	Material finer than 80 µm	CSA A23.2-5A	-	3%	1 year
	Organic impurities	CSA A23.2-7A	-	free from injurious amounts	2 years
	Petrographic examination*	CSA A23.2-15A	-	Note**	1 year
	Micro-Deval	CSA A23.2-23A	-	20%	1 year
	Alkali-silica reactivity	CSA A23.2-25A	-	0.15%	2 years

- If the coarse aggregate is crushed, the maximum material finer than the 80 µm sieve shall be 2.0%. The material finer than the 80 µm sieve shall be free from clay or shale.
- Petrographic examinations shall be used to calculate the petrographic number (PN) to provide an appraisal of the physical-mechanical quality of coarse aggregate. Determination of PNs applies solely to coarse aggregates and should not be used for fine aggregates. The petrographic report for the fine aggregate shall include a comment on the material suitability for use in the production of concrete.
- The Coarseness Factor of the combined aggregate shall be between 45 and 65.
- Quarried limestone and dolomite shall not be acceptable as concrete aggregate materials.

2.3 Hydraulic Cement

2.3.1 Hydraulic Cement shall be either General Use (GU) or General Use Limestone (GUL) conforming to the requirements of the latest edition of CSA A3001. High-early-strength Portland cement (HE) may also be used for Cold Weather concreting only. Cement shall be kept in weathertight storage that will protect it from moisture and contamination.

2.3.2 Blended Portland cement will be permitted with approval of the City of Winnipeg, Research and Standards Engineer. No other blended cement will be permitted unless authorized in writing by the City of Winnipeg, Research and Standards Engineer.

2.4 Supplementary Cementitious Materials (SCMs)

2.4.1 Fly ash shall conform to the requirements of CSA A3001 Class F. Fly ash shall be added to concrete mixtures as a separate constituent material.

2.4.2 Ground Granulated Blast-Furnace Slag (GGBFS) shall conform to the requirements of CSA A3001 Grade 100 or higher. GGBFS shall be added to concrete mixtures as a separate constituent material.

2.4.3 The use of blended hydraulic cement is not permitted.

2.5 Water

2.5.1 Potable water, which is water suitable for human consumption, is permitted to be used as mixing water in concrete without testing.

2.5.2 Non-potable water and combined water shall conform to ASTM C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete. Testing to verify compliance with the requirements in Table 1 shall be conducted on the Period I, Type 1 hand placement paving mix. The testing frequency for mixing water shall be in accordance with Appendix X1 of ASTM C1602M. Information on the testing frequency of the concrete mixing water shall be included in the concrete supplier's quality control program.

2.6 Admixtures

2.6.1 Air-Entraining Admixture

2.6.1.1 The air-entraining admixture shall conform to the requirements of ASTM C260, Standard Specification for Air-Entraining Admixtures for Concrete.

2.6.2 Chemical Admixtures

2.6.2.1 Chemical admixtures shall conform to the requirements of ASTM C494, Standard Specification for Chemical Admixtures for Concrete. Chloride-based chemical admixtures shall not be permitted under any circumstances.

2.6.3 **Cold Weather Admixture Systems**

2.6.3.1 Cold weather admixture systems shall conform to the requirements of ASTM C1622, Standard Specification for Cold Weather Admixture Systems.

2.7 Incidental Materials

2.7.1 **Hot Poured Joint Sealer**

2.7.1.1 Hot poured joint sealer shall be low modulus Type IV Material Conforming to the requirements of ASTM Standard D 6690-21, Specification for Joint and Crack Sealants, Hot-poured, for Concrete and Asphalt Pavements.

2.7.1.2 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.2 **Expansion / Isolation Joint Filler**

2.7.2.1 Fibre joint filler shall be rot-proof and of the preformed, non-extruding, resilient type made with a bituminous fibre and shall conform to the requirements of ASTM Standard D1751, Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction.

2.7.3 **Reinforcing Steel**

2.7.3.1 Reinforcing steel shall be deemed to include all reinforcing bars, tie bars, dowel bars and bar mat reinforcement, including all bar accessories.

2.7.3.2 All reinforcing steel shall be supplied according to the type and dimensions shown on the Contract Drawings or the Standard Details.

2.7.3.3 All reinforcing steel shall conform to the requirements of CAN/CSA-G30.18-M21, Carbon steel bars for concrete reinforcement. If, in the opinion of the Contract Administrator, any reinforcing steel provided for the concrete works exhibits flaws in

manufacture or fabrication, such material shall be immediately removed from the site and replaced with acceptable reinforcing steel.

2.7.3.4 Bar Mat Reinforcement shall be Grade 300 bars with all bar intersections welded by an electric resistance spot welder. Welding shall be done in such a manner that the minimum requirements for tensile strength and yield point of the reinforcing steel shall be met when a specimen is tested across points of weld.

2.7.3.4.1 Longitudinal bars shall be plain bars. Transverse bars may be plain bars or deformed bars.

2.7.3.4.2 Bar mats with defective spot welds or with spot welds that have been broken while in transit, or during handling or placing operations, shall be replaced or repaired to the satisfaction of the Contract Administrator prior to installation.

2.7.3.5 Deformed Reinforcing Bars and Tie Bars shall be Grade 300 deformed bars.

2.7.3.6 Dowel bars shall be plain round bars of grade 300 or higher in accordance with CSA G40.21.

2.7.3.7 Bar Accessories shall be of a type approved by the Contract Administrator.

2.7.3.8 All reinforcing steel shall be straight and free from paint, oil, mill scale, dirt, grease, rusty and injurious defects.

2.7.4 **Epoxy-Coating**

2.7.4.1 For all new construction, or where specified, tie bars, dowels and stirrups (for separate curbs) shall be shop-coated with epoxy conforming to the requirements of ASTM Standard D3963M. All bar ends shall be free of burs and distortions. All visible defects in the epoxy coating shall be field-coated with epoxy.

2.7.4.2 Epoxy coating shall meet the requirements of ASTM Standard A775/A775M-19 Standard Specification for Epoxy-Coated Steel Reinforcing Bars.

2.7.5 **Curing Compound**

2.7.5.1 Curing compound shall be Type 2 Class B, white-pigmented, and water based liquid membrane-forming curing compound conforming to the requirements of ASTM Standard C309. Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.5.2 For colored concrete pavement only, clear or translucent curing compound with fugitive dye shall be Type 1D conforming to the requirements of ASTM Standard C309. Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.6 **Polyethylene Film**

2.7.6.1 Polyethylene film shall be clear or white opaque and conform to the requirements of ASTM Standard C171, Standard Specification for Sheet Materials for Curing Concrete.

2.7.7 **Dowel Adhesive**

2.7.7.1 Epoxy resin shall meet the requirements of ASTM Standard C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete. Type 1, Grade 3 epoxy shall be used for bonding tie bars and dowels into hardened concrete.

2.7.7.2 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.8 **Form Coating**

2.7.8.1 Form coating shall be of a type approved by the Contract Administrator.

2.7.9 **Evaporation Retardant**

2.7.9.1 Evaporation retardant shall be water based, monomolecular and shall be applied in accordance with the manufacturer's recommendations.

2.7.9.2 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.10 **Backer Rod**

2.7.10.1 Backer rod shall be Type 1, heat-resistant, round foam rod sized to approximately 25% larger than joint width so as to employ wall tension to allow backer rod installation at required depth in accordance with ASTM D5249.

2.7.10.2 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

2.7.11 **Bonding Agent**

2.7.11.1 Bonding agent shall be Acryl-stix. Polyvinyl acetate-based latexes will not be permitted.

2.7.11.2 The bonding grout shall be well mixed and shall be applied in accordance with the manufacturer's recommendations.

2.7.11.3 The consistency of the bonding grout shall be such that it can be applied in a thin, even coating on the slab so that it will not run or puddle in low spots.

2.7.11.4 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at: https://www.winnipeg.ca/matmgt/spec/default.stm

3. DESIGN REQUIREMENTS

3.1 Testing Laboratories

3.1.1 The City of Winnipeg, Research and Standards Engineer will maintain a list of approved Testing Laboratories. To obtain approval, Testing Laboratories must submit the following information to the Research and Standards Engineer annually prior to April 1st:

3.1.1.1 Valid basic concrete and concrete aggregate certification meeting the requirements of CSA A283;

3.1.1.2 Valid Category "Q" concrete laboratory certification or higher by Canadian Council of Independent Laboratories (CCIL) or another association approved by the City of Winnipeg, Research and Standards Engineer; and,

3.1.1.3 A complete list of testing lab and field personnel and their qualifications.

3.2 Concrete Suppliers

3.2.1 The City of Winnipeg, Research and Standards Engineer will maintain a list of approved concrete suppliers. To obtain approval, concrete suppliers must annually submit the following information to the Research and Standards Engineer prior to April 1st:

3.2.1.1 Concrete suppliers Approval Guidelines and Application is available at the City of Winnipeg, Corporate Finance, Material Management Division website at; https://www.winnipeg.ca/matmgt/Spec/Default.stm

3.2.1.2 Names of suppliers and sources for all materials and admixtures;

3.2.1.3 Concrete mix designs with unique mix design codes signed and dated by person selecting the mix proportions;

3.2.1.4 Copy of valid Concrete Manitoba certificate for concrete batch plant;

3.2.1.5 Copies of valid scale calibration reports for the concrete batch plant;

3.2.1.6 Test data for aggregates (in accordance with Clause 2.2);

3.2.1.7 The source(s) of concrete mixing water and test data indicating compliance with ASTM C1602M;

3.2.1.8 The mill certificate for the cement and SCMs, including chemical and physical composition and analysis, SCMs source and name of supplier;

3.2.1.9 Sieve analysis test reports for the individual aggregates and the combined aggregate gradations to be used in the concrete. The sieve analysis test reports shall be representative of the material to be used during concrete production;

3.2.1.10 Performance data from trial batches prior to construction to demonstrate the concrete mix will achieve the performance criteria in Table CW 3310.3 and Table CW 3310.4;

3.2.1.11 Maturity relationships for Cold Weather Concrete (Hand placement and slip form); and,

3.2.1.12 Quality control program for all materials, including a proposed sampling and testing plan with minimum sampling and testing frequencies;

3.2.1.13 The suppliers or their representative laboratory(s) to be used and its credentials;

3.2.1.14 The quality control personnel and their qualifications; and,

3.2.1.15 Frequency of production equipment inspection, verification of calibration, and certification of the production facility.

3.2.2 The City of Winnipeg, Research and Standards Engineer will conduct inspections at least once a year during production. Samples of materials may be taken and tested.

3.2.3 Testing for qualification or acceptance purposes shall be done in accordance with this Specification and the applicable test procedures and standard practices of CSA A23.2. There shall be no charge for any materials taken for testing purposes.

3.2.4 Changes in the source of any concrete constituent materials will not be permitted without approval of the City of Winnipeg, Research and Standards Engineer. For new sources, all materials shall be tested.

3.2.5 Once approved, all concrete shall be supplied in accordance with the approved Mix Design Statement. No changes in the concrete mix designs will be permitted without written permission from the City of Winnipeg, Research and Standards Engineer.

3.2.6 Any change in the constituent materials of the concrete shall require a new concrete mix design. If, during the progress of the work, the mix design is found to be unsatisfactory for any reason, the concrete supplier shall revise the mix design(s) and re-submit the proposed changes to the City of Winnipeg, Research and Standards Engineer for approval.

Table CW 3310.3: Performance Criteria and Testing Based on Compressive Strength

	Time (day)	Type 1	Type 2	Type 3, and Cold Weather Concrete	Type 4	Type 5	Type 6**	Type 7
A minimum of one (1) set* of concrete compressive strength tests for the slipform paving mix with and without SCMs according to CSA A23.2-9C	@ 1	--	--	20 MPa	--	--	--	--
	@ 3	15 MPa	15 MPa	--	20 MPa	--	--	--
	@ 7	--	--	--	--	--	--	--
	@ 28	35 MPa	32 MPa	35 MPa	35 MPa	--	--	--
A minimum of one (1) set* of concrete compressive strength tests for the hand placement paving mix with and without SCMs according to CSA A23.2-9C	@ 1	--	--	20 MPa	--	--	--	--
	@ 3	15 MPa	15 MPa	--	20 MPa	12 MPa	20 MPa	12 MPa
	@ 7	--	--	--	--	--	--	--
	@ 28	35 MPa	32 MPa	35 MPa	35 MPa	30 MPa	35 MPa	30 MPa
Air-void test according to ASTM C457	@ 28	See Note***						
Rapid chloride penetrability test (RCPT) according to CSA A23.2-23C	@ 91	See Note ****						

*Each set contains at least three (3) specimens at each specified date. The average of each set shall be equal to or greater than the specified strength, with no single result less than 85% of the specified strength.

** Type 6 is concrete for restoration of utility pavement cuts and shall be adjusted to meet the specified strength for other types based on the application and shall include set retarders or hydration stabilizers to extend the discharge time to 150 minutes.

***A minimum of one sample for air-void test at 28 days shall be performed for each cement for Type 1, Type 2, and Type 3 slipform with SCMs, and Cold Weather Concrete (Hand placement and slip form). The air-void test shall meet the following requirements:

- Spacing factor shall not exceed 230 µm, with no single value greater than 260 µm; and,
- Air content shall be greater than or equal to 5.0% and less than 8.0%.

****A minimum of two samples for rapid chloride penetrability test shall be performed for Type 1, Type 2, Type 4 and Cold Weather Concrete slipform for mixes with and without SCMs. For Type 1, Type 4 and Cold Weather Concrete, the average penetrability shall be equal to or less than 1250 coulombs at 91 days based on the charge passed, with no single result greater than 1500 coulombs for mixes with and without SCMs. For Type 2, the average of chloride ion penetrability shall be equal to or less than 1500 coulombs at 91 days based on the charge passed, with no single result greater than 1750 coulombs.

Table CW 3310.4: Performance Criteria and Testing Based on Flexural Strength

	Time (day)	Type 1	Type 2	Type 3, and Cold Weather Concrete	Type 4	Type 5	Type 6**	Type 7
A minimum of one (1) set* of concrete flexural strength tests for the hand paving mix with and without SCMs according to CSA A23.2-8C	@ 1	--	--	2.4 MPa	--	--	--	--
	@ 3	--	--	--	2.4 MPa	--	--	--
	@ 28	5 MPa	4.5 MPa	5 MPa	5 MPa	4.5 MPa	5 MPa	--
Air-void test according to ASTM C457	@ 28	See Note***						
Rapid chloride penetrability test (RCPT) according to CSA A23.2-23C	@ 91	See Note ****						

*Each set contains at least three (3) specimens at each specified date. The average of each set shall be equal to or greater than the specified strength, with no single result less than 85% of the specified strength.

** Type 6 is concrete for restoration of utility pavement cuts and shall be adjusted to meet the specified strength for other types based on the application and shall include set retarders or hydration stabilizers to extend the discharge time to 150 minutes.

***A minimum of one sample for air-void test at 28 days shall be performed for each cement for Type 1, Type 2, and Type 3 slipform with SCMs, and Cold Weather Concrete (Hand placement and slip form). The air-void test shall meet the following requirements:

- Spacing factor shall not exceed 230 µm, with no single value greater than 260 µm; and,
- Air content shall be greater than or equal to 5.0% and less than 8.0%.

****A minimum of two samples for rapid chloride penetrability test shall be performed for Type 1, Type 2, Type 4 and Cold Weather Concrete slipform for mixes with and without SCMs. For Type 1, Type 4 and Cold Weather Concrete, the average penetrability shall be equal to or less than 1250 coulombs at 91 days based on the charge passed, with no single result greater than 1500 coulombs for mixes with and without SCMs. For Type 2, the average of chloride ion penetrability shall be equal to or less than 1500 coulombs at 91 days based on the charge passed, with no single result greater than 1750 coulombs.

3.3 Concrete Properties

3.3.1 The Mix Design Statements for all concrete types shall be submitted to the City of Winnipeg, Research and Standards Engineer for approval. The concrete mix shall be proportioned such as to yield concrete having the required workability, strength and durability in Table CW 3310.5.

Table CW 3310.5: Concrete Properties

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Cold Weather Concrete
Minimum Cementitious Content (kg/m^3)	360	340	360	360	320	340	300	400
Maximum Supplementary Cementing Materials – SCMs** (%)	20%	20%	20%	20%	20%	20%	20%	10%
Maximum Water/Cementitious Ratio								
- Slip form paving	0.4	0.4	0.4	0.4	-	-	-	0.35
- Hand placement	0.42	0.42	0.42	0.42	0.42	0.42	0.45	0.36
Slump (mm)								
- Slip form paving	50 ± 20	50 ± 20	50 ± 20	50 ± 20	-	-	-	50 ± 20
- Hand placement	70 ± 20	70 ± 20	70 ± 20	70 ± 20	80 ± 20	100 ± 20	100 ± 20	70 ± 20
Nominal Maximum Aggregate Size (mm)	20	20	20	20	20	20	20	20
Air Content (%)	5-8	5-8	5-8	5-8	5-8	5-8	5-8	5-8
Minimum Compressive Strength (MPa)								
- @ 1 days	-	-	20	-	-		-	20
- @ 3 days	15	15	-	20	-	Note *	-	24
- @ 28 days	35	32	Note *	Note *	30		30	35
Maximum Rapid Chloride Penetrability Test*** (coulombs) @ 91 days.	1500	1750	Note *	Note *	-	-	-	1500

*The concrete shall meet Type 1 or Type 2 based on the application.

**The use of SCMs in concrete mix will be permitted as a partial replacement of cement for Period I and will be permitted as additional to the cement for Period II unless authorized in writing by the City of Winnipeg, Research and Standards Engineer. For Cold Weather Concrete, the use of SCMs will be permitted as additional to the cement unless authorized in writing by the City of Winnipeg, Research and Standards Engineer. The Contractor will have the option to replace cement up to but not exceeding the above limits, by weight of total cementitious materials, depending on the concrete type.

***Rapid chloride penetrability test will be required where there is evidence of concrete damage as a result of inadequate curing and adverse weather conditions, including hot weather, wind, rain, sleet, snow and cold weather. The Contract Administrator shall be allowed access to all sampling locations and reserves the right to take samples for testing at any time.

3.4 Plant Quality Control

3.4.1 The concrete supplier shall be responsible for quality control of the plant to ensure all materials meet the approved mix designs. This information shall be submitted bi-weekly and will be monitored by the City of Winnipeg, Research and Standards Engineer. Failure to submit the quality control results shall be cause for immediate suspension of the concrete supplier.

3.4.2 Tests used for purposes of assessing compliance with this specification or for acceptance of any products shall be conducted by a laboratory certified in accordance with the requirements of Clause 4.4.1.6 of CSA A23.1 and approved by the City of Winnipeg, Research and Standards Engineer. Laboratory and field personnel shall meet the requirements of Clauses 4.4.1.6 and 4.4.1.7 of CSA A23.1, respectively.

3.4.3 A new mill certificate for cement and SCMs shall be provided monthly during production.

3.4.4 Testing of any concrete constituent materials may be undertaken by a Testing Laboratory designated by the City of Winnipeg, Research and Standards Engineer. The concrete supplier shall be equipped with suitable means or a device for obtaining a representative sample of the cement and SCMs. The device shall enable the sample to be readily taken in proximity to the cement or SCMs weigh hopper and from a container or conveyor holding only cement or SCMs to prevent contamination. Any material which fails to comply with the requirements of CSA A3001 will be rejected. Material that has been rejected must be removed immediately by the concrete supplier.

4. SUPPLY OF MATERIALS

4.1 General

4.1.1 All concrete for Portland Cement Concrete pavement works shall be supplied by a concrete supplier that has been approved by the City of Winnipeg, Research and Standards Engineer. A list of approved concrete suppliers is available at the City of Winnipeg, Corporate Finance, Material Management Division website at:
https://www.winnipeg.ca/matmgt/Spec/Default.stm

4.1.2 Unless otherwise specified, only use of ready-mix concrete will be permitted. Concrete shall be proportioned, mixed and delivered in accordance with the requirements of CSA A23.1, Clause 5.2, Production of Concrete, except that the transporting of ready-mix concrete in non-agitating equipment is not permitted without the written permission of the Contract Administrator.

4.1.3 The discharge of ready-mix concrete from the transit mixer shall be completed within the specified times identified in Table CW 3310.6 following the introduction of the mixing water to the cement and aggregates.

TABLE CW 3310.6 – Allowable Time for Delivery

Concrete Type	Maximum time limit (minutes)
Type 1, Type 2, Type 5, Type 7	120
Type 3 and Type 4	90
Type 6	150
Cold Weather Concrete	90

Note: With approval of the City of Winnipeg, Research and Standards Engineer, the maximum time limit may be adjusted, if required, by using set retarders or hydration stabilizers.

4.1.4 Transit mixers supplying concrete under this specification shall have a Manitoba Ready Mix Concrete Association (MRMCA) certification sticker affixed to the rear window of the driver's cab. All delivery tickets shall indicate the time of batching.

5. EQUIPMENT

5.1 Ready Mixed Concrete Production Facilities

5.1.1 Commercial ready-mix concrete plants and batch plants supplying Portland Cement Concrete under this Specification shall be certified in accordance with the MRMCA's Certification of Ready Mixed Concrete Production Facilities. Proof of certification shall be submitted with the Mix Design Statement.

5.1.2 Batch plants must be equipped with batch weight recorders and the results made available to the City of Winnipeg, Research and Standards Engineer upon request.

5.2 Paving Equipment

5.2.1 If a slip form paving machine is used for concrete placement, it shall be of a size and type adequate to handle the width and thickness of the concrete pavement to be constructed. The slip form paver shall distribute the fresh concrete evenly to the required grade without segregation and without disturbing the reinforcing steel. The concrete shall be thoroughly consolidated by means of vibrators, struck off to exact grade, and given a float finish, all automatically and continuously by the machine and with a minimum of hand finishing. The machine shall be equipped with automatic controls capable of controlling both the elevation and direction of the machine within a tolerance of 5 mm from the specified grade and alignment. Slip forms shall extend the full depth of the pavement and shall be of sufficient length that the concrete will not deform at the edges by the time the forms have passed. If a slip form paver is not being used, the paving equipment used for placing concrete shall have a demonstrated ability to meet the specified tolerances for

concrete pavement. The Contract Administrator shall reject any paving equipment should the paving equipment not field perform within the specified tolerances.

5.3 Paving Equipment Vibratory Devices

5.3.1 The paving equipment vibratory devices shall be checked by use of a vibrating reed tachometer prior to commencement and during the paving operations.

5.3.2 Performance and checking of the vibrators shall conform to the paving equipment manufacturer's specifications.

5.4 Moveable Work Bridges

5.4.1 Where more than one lane is being paved at a time, two moveable work bridges independent of the paving machine shall be required, one for finishing and one for curing operations.

6. CONSTRUCTION METHODS

6.1 General

6.1.1 All construction methods shall conform to CSA-A23.1, except as otherwise specified herein.

6.2 Forms

6.2.1 Forms for concrete shall be constructed of steel or wood and shall be sufficiently rigid to prevent lateral or vertical distortion from the loading environment to which the forms will be subjected. All forms shall be set to the design grades, lines and radii as shown on the Drawings. Forms shall be adequately anchored and firmly set over bearing areas to prevent displacement during concrete placement. All formwork in place shall be subject to inspection and correction of grade and alignment prior to, and at any time during concrete placement.

6.2.2 The surfaces of all formwork to come in contact with the concrete shall be thoroughly cleaned and treated with form coating before concrete placement. The form coating shall be applied by brush or spray so as to give the forms an even coating without excess or drip, and shall not be allowed to get on any reinforcing steel. The form coating shall not cause a softening or permanent staining of the concrete surface and, further, it shall not impede the proper functioning of the curing compound.

6.2.3 Forms shall not be removed for a period of at least twenty-four (24) hours after the concrete placement has been completed. Removal of forms shall be done in a manner that avoids damage to, or spalling of, the concrete. Concrete damaged as a result of early removal of formwork shall be removed and replaced at the Contractor's expense.

6.3 Placing Reinforcing Steel

6.3.1 Bar Mat Reinforcement

6.3.1.1 All reinforcing steel shall be positioned as shown on the Drawings and shall be held in place by positive and satisfactory means so that the correct position of the reinforcing steel will be maintained after the concrete has been placed, vibrated and finished. If reinforcing steel is displaced during concrete placing operations, concrete placement shall cease and shall not resume until the displaced reinforcing steel has been reset to its true design position.

6.3.1.2 Field lap joints shall be securely wired or clipped. Splices, other than those shown on the Drawings or approved by the Contract Administrator, will not be permitted. Splices shall have a length sufficient to develop the full strength in bond of the bar and shall be well distributed and only located in areas of low tensile stress. Reinforcing steel shall be securely fastened at all laps, intersections and splices.

6.3.1.3 Longitudinal steel bars which cross transverse joints shall be aligned parallel to the centreline and surface of the slab with a maximum allowable tolerance of ± 6 mm from the transverse joint to the end of the bar.

6.3.1.4 Once all reinforcing steel is in position, it shall be inspected and approved by the Contract Administrator before any concrete is placed. Otherwise the concrete will be rejected by the Contract Administrator and shall be removed by the Contractor at his own expense.

6.3.2 Tie bars

6.3.2.1 Tie bars shall be positioned as shown on the Drawings. They shall be placed at mid-depth of the pavement and parallel to the pavement surface and the transverse joints. Hand placement of tie bars into the plastic concrete shall not be permitted. Where required, tie bars shall be drilled after the concrete has hardened and developed a minimum of 20 MPa compressive strength.

6.3.2.2 Tie bars shall be placed according to the following minimum requirements:

6.3.2.2.1 Holes with a diameter between 4 to 6 mm greater than the bar diameter shall be drilled laterally into the hardened concrete slabs at one half the slab depth. Holes shall be cleaned out with compressed air using a wand

attachment that fits into the hole and is long enough to reach to the back of the holes. Holes shall be brushed out with a stiff bristled cylindrical brush that is at least 5 mm larger than the diameter of the holes. Holes shall be blown out with compressed air after brushing until there is no longer any evidence of dust, debris or loose material in the holes.

6.3.2.2.2 An approved dowel adhesive shall be used and installed according to the manufacturer's instructions. Dowel adhesive shall be placed in the back of each hole with an applicator that will reach the end of the drilled hole. A sufficient amount of dowel adhesive shall be placed in each hole to ensure that the bar will be completely covered. Dowel adhesive shall be placed on the bar before inserting the bar into the hole. The bar shall be inserted into the hole using a twisting motion to facilitate covering the bar and the inside surface of the hole with dowel adhesive minimizing voids or air pockets.

6.3.2.2.3 The final position of each tie bar shall be within the following tolerances:

6.3.2.2.3.1 Vertical Placement: ±T/8 for any part of the tie bar (T = slab thickness)

6.3.2.2.3.2 Transverse Placement (side shift): ± 50 mm when measured perpendicular to the longitudinal joint line

6.3.2.3 Once tie bars are in position, they shall be inspected and approved by the Contract Administrator before any concrete is placed. Otherwise the concrete shall be rejected by the Contract Administrator and shall be removed by the Contractor at his own expense.

6.3.2.4 If tie bars are displaced during concrete placing operations, concrete placement shall cease and shall not resume until the displaced tie bars have been reset to the true design position.

6.3.2.5 Where directed by the Contract Administrator, the tie bars shall be checked for pullout resistance in accordance with ASTM E488, Standard Test Methods for Strength of Anchors in Concrete Elements. The Contract Administrator shall be responsible for performing the testing. A minimum of 6 tie bars shall be tested. The tie bar pullout resistance shall be at least 50 kN with slippage of 1.5 mm or less after 48 hours. If two or more tie bars do not meet the required pullout resistance, then another 10 tie bars shall be tested. If any of the second 10 tie bars do not meet the required pullout resistance, then all remaining tie bars shall be tested. All steps taken to test bars, and to correct, repair or replace failed tie bars and the surrounding failed area shall be at the Contractor's expense.

6.3.2.6 Supply and Installation of tie bars shall be incidental to the construction of Portland cement concrete pavements.

6.3.3 **Dowels**

6.3.3.1 Dowel bars shall be plain round bars of grade 300 or better in accordance with CSA G40.21. Epoxy coating shall meet the requirements of ASTM Standard A934/A934M, Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.

6.3.3.2 Dowels shall be located at all transverse joints by means of an approved dowel assembly positioned as shown on the drawings. The methods for fastening the dowel assembly to the base shall be subject to the approval of the Contract Administrator. The dowels shall be aligned parallel to the centreline and surface of the slab with a maximum allowable tolerance of ± 5 mm. The dowel assemblies shall be fabricated sufficiently rigid so the dowels are held in alignment within the specified tolerance, both horizontally and vertically, until the concrete placing and setting cycle is complete.

6.3.3.3 For dowel assemblies with side members and ties, the dowels shall be securely fastened at alternate ends to the side members to prevent any movement of the dowels.

6.3.3.4 All areas of the dowel bar with damaged epoxy coating shall be cleaned and painted to the satisfaction of the Contract Administrator.

6.3.3.5 All dowels shall be thoroughly coated with a thin uniform coating of bond breaker or lubricant such as oil, grease, or synthetic materials to prevent bonding with the concrete for the length of the dowel. The bond breaker coating shall be smooth and free of voids.

6.3.3.6 Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at:
https://www.winnipeg.ca/matmgt/Spec/Default.stm

6.3.3.7 The position of the dowel assembly shall be clearly marked by the Contractor on the forms or by stakes so that the location of the transverse joint can be accurately located for joint construction.

6.3.3.8 If dowels are displaced during concrete placing operations, concrete placement shall cease and shall not resume until the displaced dowels have been reset to the true design position.

6.3.3.9 Once dowels are in position, they shall be inspected and approved by the Contract Administrator before any concrete is placed. Otherwise the concrete will be rejected by the Contract Administrator and shall be removed by the Contractor at his own expense.

6.3.4 **Tying into Existing Pavement**

6.3.4.1 Where the Drawings call for a new slab to be tied into an existing slab along a longitudinal joint, the Contractor shall install tie bars into the existing slab. Tie bars shall be installed in accordance with Clause 6.3.2. Tie bars drilled into existing pavement shall be paid for in accordance with Specification CW 3230.

6.3.4.2 Where the Drawings call for a new slab to be tied into an existing slab along a transverse joint, the Contractor shall install dowels into the existing slab. Dowels shall be installed in accordance with Clause 6.3.2. Following installation of dowels, the ends of the dowels that extend into the new area shall be completely coated with a thin uniform coating of approved bond breaker or lubricant. Dowels drilled into existing pavement shall be paid for in accordance with Specification CW 3230.

6.4 Concrete Placement

6.4.1 No concrete shall be placed until the Contract Administrator has examined and approved the layout of the forms, reinforcing steel, dowels, tie bars and joints and the condition and grade of the compacted base course.

6.4.2 The placing of concrete on a base course which is too wet or too dry, or which is frozen, will not be permitted. The prepared grade shall be sufficiently moist to prevent absorption of water from the freshly placed concrete, but must be free from mire or water pondage.

6.4.3 Concrete shall be uniformly deposited as nearly as practicable to its final position in a rapid and continuous operation in such a manner as to require as little re-handling as possible and to avoid segregation and separation of the materials.

6.4.4 Concrete shall not be dumped directly from the hauling vehicles onto dowel assemblies. Necessary hand spreading shall be done with shovels, not rakes. Workers shall not walk in freshly mixed concrete with footwear coated with earth or foreign substances.

6.4.5 The sequence of concrete placement shall be arranged so that no concrete, which has partially hardened, will be subjected to injurious vibration or shock.

6.4.6 Concrete shall be placed while fresh and before it has taken its initial set. Retempering of partially hardened concrete with additional water will not be permitted.

6.4.7 The deposited concrete shall be spread by means of a mechanical spreader or by an approved hand method. The Contract Documents shall identify where double lane-at-a-time paving is required. Hand placement shall be minimized wherever possible. The surface of the concrete shall then be screeded by mechanical means in a manner such

that when the concrete is vibrated and screeded the finished concrete will conform to the cross-section and elevation shown on the Drawings.

6.4.8 In areas inaccessible to mechanical equipment, after the concrete has been vibrated, the surface of the concrete shall be struck-off manually with appropriate tools and in an approved manner so that the concrete will conform to the cross-section and elevation shown on the Drawings. Neat cement or mortar shall not be used to facilitate the finishing surfaces.

6.4.9 Mechanical vibrators only shall be used to consolidate the concrete. Spading, hand tamping, using puddling rods, or using other similar methods will not be permitted in place of vibration.

6.4.10 Vibration shall be applied at the point of deposit and in areas of freshly deposited concrete. Vibrators shall be inserted vertically into and withdrawn vertically out of the concrete slowly. Vibrations shall be of sufficient duration and intensity to thoroughly consolidate the concrete, but shall not be continued so as to cause segregation. Vibrators shall not be used for flowing the concrete or spreading it into place.

6.4.11 Concrete shall be worked thoroughly around any reinforcement, dowels, tie bars and around embedded fixtures and into the angles and corners of the forms. During placement, concrete shall be sufficiently vibrated with suitable equipment to ensure a secure bond with the reinforcement, dowels and tie bars, to eliminate entrapped air voids, and to ensure a homogeneous structure and adequate consolidation. Particular care shall be given to placing and vibrating the concrete along the faces of the forms to ensure a dense, smooth surface devoid of imperfections.

6.4.12 No persons shall be permitted to walk in the screeded concrete. Any remedial work shall be done from the sides of the concrete pour or from work bridges.

6.4.13 Once the placing and vibrating of the concrete has been completed, the forms shall not be jarred, and any projecting reinforcing steel shall not be disturbed, for a period of at least twenty-four (24) hours. At the end of a slip form paving pour, concrete shall be sawcut full-depth and removed. There shall be no measurement or pavement for the saw cutting, removal or concrete lost.

6.4.14 Where concrete is placed adjacent to a recently constructed lane of pavement with the paving equipment operating on the recently constructed lane, the recently constructed concrete shall have attained a minimum compressive strength of 20 MPa prior to commencing paving. Determination that the concrete has reached 20 MPa shall not relieve the Contractor of his responsibility to protect the pavement.

6.4.15 Bonding agent shall be applied to the surface of the slab immediately prior to placement of plastic concrete for separate curb. Use compressed air that has an oil free air jet having

sufficient volume and pressure to remove dust and loose particles immediately prior to applying bonding grout. Apply in a thin, even coating so that the bonding grout does not run or puddle. Bonding agent shall be applied where the concrete pavement will not be overlayed with asphalt.

6.4.16 Concrete shall not be placed if rain is sufficient to separate cement (paste) from the surface of the concrete mix or to hinder finishing operations. The surface of the concrete shall not be finished when water is present on the surface. Concrete already placed shall be protected against the effects of rain until the concrete has sufficiently hardened to resist damage.

6.4.17 Concrete damaged as a result of inadequate protection against weather conditions shall be tested using rapid chloride penetrability in accordance with CSA A23.2-23C at 91 Curing Days. A minimum of three (3) cores shall be collected and tested for every 30 cubic meters of inadequately protected concrete placed. The Contract Administrator shall apply a payment adjustment in accordance with Clause 7.3. against the entire quantity represented by the failed test(s). All costs associated with coring, transmittal of cores, filling of cores and testing shall be borne by the Contractor regardless of the outcome of the test.

6.5 Concrete Finishing

6.5.1 Finishing shall be regulated in order that quality of the surface is not impaired by overworking or by bringing excessive fines and water to the surface. The use of steel trowels is not permitted.

6.5.2 Water shall not be added to the surface of the concrete to assist in finishing operations. Concrete damaged as a result of adding water shall be tested using rapid chloride penetrability in accordance with CSA A23.2-23C at 91 Curing Days. Acceptance of the concrete shall be based on the test results defined in Clause 7.3 All costs associated with coring, transmittal of cores, filling of cores, and testing shall be borne by the Contractor regardless of the outcome of the test.

6.5.3 The surface shall be finished to a uniform texture, true to grade and cross section, and free from porous areas. When the finishing machine, either form, slip form, or hand finishing method, leaves a surface that is not acceptable, the operation shall stop and corrective action shall be taken. Inability of the finishing machine to provide an acceptable surface finish, after corrective action, will be cause for replacement of the finishing machine.

6.5.4 Prior to final finishing, the surface grade of concrete slabs shall be checked, with a 3.0-meter-long metal straight edge, to meet concrete pavement roughness unless otherwise specified. The straight edge shall be drawn across the pavement in a scraping motion to

identify deviations for immediate correction. The straight edge shall be advanced one-half of its length for successive checks.

6.5.5 Where placement of the concrete pavement is facilitated by use of a slip form paving machine, additional floating of the surface by hand methods shall only be done if required to correct surface imperfections identified by checking with the 3.0-meter-long metal straight edge, or as directed by the Contract Administrator.

6.5.6 Following completion of floating operations, but prior to initial set of the concrete, the edges of all formed concrete slabs shall be carefully finished with an appropriate edging tool.

6.5.7 Upon completion of finishing operations, and when excessive moisture has evaporated, the plastic surface of the entire pavement shall be given a textured finish by means of broom finishing with a steel or fibre broom of a type approved by the Contract Administrator at right angles to the direction of traffic. Surface depressions introduced by the broom strands in the brooming operations shall not be more than 3 mm deep. Broom finishing will similarly be required for surfaces of private approaches, gutters, bull-nose slabs, boulevard and median slabs, and other related slabs. Broom finishing will not be required when the concrete will not be the finished surface.

6.6 Concrete Curing

6.6.1 Immediately after the finishing operations have been completed the entire surface and exposed sides of the placed concrete shall be sprayed uniformly with a curing compound meeting the requirements of Clause 2.7.5.

6.6.2 An initial application of curing compound shall be applied under pressure by mechanical means at the rate of at least 0.15 liters per square meter of pavement surface immediately after surface moisture has disappeared, but no later than 10 minutes after finishing. A second application of curing compound shall be applied within 15 minutes after the initial application at right angles to the first application. The second application rate shall be at least 0.1 liters per square meter of pavement surface. Additional curing compound shall be applied as needed to ensure that 100 percent of the pavement is covered. With approval of the Contract Administrator, the timing of cure application may be adjusted due to varying weather conditions to ensure acceptable texture is achieved and bleed has evaporated.

6.6.3 During application, the curing compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the sprayer. Hand spraying is not permitted except for irregular widths or shapes and small areas unless approved by the Contract Administrator. The sides of pavement slabs shall be immediately sprayed with curing compound when the forms are removed.

6.6.4 Failure to cover the surface of the concrete with curing compound within the specified time or the sides after removing the forms directly shall be cause for immediate suspension of the paving operations. Concrete damaged as a result of inadequate curing shall be tested using rapid chloride penetrability in accordance with CSA A23.2-23C at 91 Curing Days. A minimum of two cores shall be collected and tested from the affected area. The Contract Administrator shall apply a pay adjustment in accordance with Clause 7.3 against the entire quantity represented by the failed test(s). All costs associated with coring, transmittal of cores, filling of cores, and testing shall be borne by the Contractor regardless of the outcome of the test.

6.6.5 If the contractor fails to cover the concrete surface with curing compound within one hour from finishing for all concrete types and within 30 minutes from finishing for early-age strength (Type 3 and Type 4) concrete, the concrete shall be removed and replaced at the Contractor's expense without testing.

6.6.6 Should the curing film become damaged, within 72 hours after concrete placement, the damaged portions shall be repaired immediately with additional curing compound at the Contractor's expense.

6.6.7 Curing compound shall not be used when the pavement is otherwise protected from Cold Weather for a period of not less than seven days. If the protection is removed before seven days, curing compound shall be directly applied after removing the protection.

6.7 Joints

6.7.1 Contraction, longitudinal and construction joints shall be constructed, where required, in accordance with the details shown on the Drawings or as directed by the Contract Administrator. The joints shall be vertical and shall not deviate more than 15 mm from the horizontal alignment shown on the Drawings. All joints in pavement slabs shall be continuous through the curbs, median slabs, bull-noses, safety medians and boulevard or median splash strips.

6.7.2 Expansion joints shall be constructed where new concrete is being placed up against existing non-pavement structures, where directed by the Contract Administrator. A 15 mm thick fibre joint filler shall be installed in expansion joints. The fibre joint filler shall extend from the base of the concrete slab up to the concrete surface, but no higher.

6.7.3 Transverse construction joints shall be constructed when the concrete placement is interrupted for more than 30 minutes or initial set is imminent. The concrete shall be removed to the preceding transverse joint and the bulkhead placed in accordance with the requirements for a standard transverse contraction joint.

6.7.4 Where concrete is to be placed against an existing pavement structure, the joint shall be constructed as shown on the Drawings, or as directed by the Contract Administrator.

6.7.5 The Contractor shall obtain the Contract Administrator's approval on all placement of reinforcing steel in odd shaped installations to ensure proper alignment with saw-cut joints.

6.7.6 Contraction joints shall be saw-cut in succession by a single cut, 3 mm wide to the depths and alignments as shown on the Drawings, as soon as the concrete is sufficiently hard so that it will not be ravelled or damaged by the blade. The time at which all such saw-cutting is to be undertaken shall be determined by the Contractor to prevent random cracking, and raveling from the sawing.

6.7.7 All saw-cut operations shall be dust free to the satisfaction of the Contract Administrator. When sawing longitudinal joints, the Contractor shall ensure that any residue cleaned from the longitudinal joint does not go into the previously cleaned contraction joints.

6.7.8 When a transverse joint is saw cut more than 75 mm from the designated location, the pavement shall be removed and replaced to the nearest sawn joints.

6.7.9 When a longitudinal joint is saw cut more than 25 mm from the designated location, the pavement shall be removed and replaced.

6.7.10 When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slabs. This corrective action shall be at the Contractor's expense.

6.7.11 For late season construction, second cut shall not be completed if ambient temperature is below 4°C. The second cut shall be completed the next season when temperature requirements can be met.

6.8 Joint Sealing

6.8.1 When joints are to be sealed, the joint must be second cut to a width and depth as shown in the drawings.

6.8.2 Joints and the pavement surface shall be cleaned of all residue left by the sawing operation. Joints shall be allowed sufficient time to thoroughly dry before the application of the joint sealer.

6.8.3 Install backer rods immediately after cleaning and before sealant installation. Backer rods shall be inserted uniformly to the required depth to achieve the required shape factor.

Backer rods shall be inserted using a double wheel steel roller and shall not be punctured or stretched during the installation process.

6.8.4 The joint shall then be filled with hot poured joint sealer meeting the requirements of Clause 2.7.1 to the depth shown on the Drawings using an approved mechanical pressure joint filling system. Overfilling of joints shall not be permitted. Overfilled joints shall have excess material removed to the satisfaction of the Contract Administrator. The joint must be surface dry at the time of filling, and the ambient temperature must be at least 4 ˚C and rising. The seals are to be installed in accordance with the manufacturer's specifications.

6.9 Filling of Core Holes

6.9.1 Where cores are required, the Contractor shall fill each core hole immediately after coring with an approved non-shrink product. Use only those materials listed as Approved Products for Surface Works. The Approved Products are available in Adobe Acrobat (.pdf) format at the City of Winnipeg, Corporate Finance, Material Management Internet site at:

https://www.winnipeg.ca/matmgt/spec/default.stm

6.9.2 The patch shall be finished flush with the surface of the concrete slab. Immediately before filling, the surface of each hole shall be thoroughly cleaned of the paste to ensure a proper bond between the existing concrete and the grout. After filling each hole, all excess material shall be removed from the surface of the concrete slab.

6.10 Surface Tolerance

6.10.1 The surface of the concrete pavement shall be checked with a 3-metre-long metal straight edge and be within ± 5 mm. Areas of pavement that do not meet these tolerances shall be corrected to the satisfaction of the Contract Administrator.

6.10.2 Where the posted speed limit is 60 km/hr or greater, the Contract Documents shall identify smoothness requirements for longitudinal profile of the pavement surface. The smoothness requirements shall be approved by the City of Winnipeg, Research and Standards Engineer.

6.11 Diamond Grinding

6.11.1 Where a diamond grinder is used, it shall be power-driven, self-propelled equipment specifically designed to grind and texture concrete pavement and concrete base. It shall be equipped with a grinding head with at least 50 diamond blades per 300mm of shaft. The grinding head shall be at least 0.90 m wide. The grinder shall be capable of adjusting

the depth, slope and crossfall to ensure that concrete is removed to the desired dimensions and uniformly feathered and textured across the width and length of the required area. The equipment shall also include a slurry pick-up system.

6.12 Hot and Cold Weather Concreting

6.12.1 The Contractor shall be responsible for taking all necessary measures to protect freshly laid concrete from adverse weather conditions, including hot weather, wind, rain, sleet, snow and cold weather, except as otherwise specified herein.

6.12.2 Hot Weather concreting

6.12.2.1 When Hot Weather applies, the plastic concrete surface shall be protected from drying by application of an evaporation retardant unless otherwise specified by the Contract Administrator. The evaporation retardant shall be applied according to the manufacturer's recommendations. If the evaporation retardant application film is broken during finishing operations, the application film shall be reapplied.

6.12.2.2 The drying conditions shall be estimated using Figure D1, Appendix D, Guidelines for Curing and Protection of CSA A23.1.

6.12.2.3 Evaporation Retarder is not required where there is less than 10 minutes of delay between finishing operations (screeding, floating, brooming, and placement of curing compound) unless otherwise specified by the Contract Administrator.

6.12.3 Cold Weather concreting

6.12.3.1 When there is a probability of the air temperature falling below 5 °C within 24 hours of placing concrete as forecast by the nearest official meteorological office, Cold Weather concreting requirements shall apply unless otherwise specified by the City of Winnipeg, Research and Standards Engineer. In no case shall placing concrete be allowed if the minimum air temperature is below – 8 °C within 24 hours of placing concrete or the average daily temperature for three consecutive days is expected to fall below – 10 °C as forecast by the nearest official meteorological office.

6.12.3.2 Concrete shall be placed on unfrozen base material, free of water, snow, and ice. Frozen base material will be identified by measuring the surface temperature using infrared thermometers or similar devices. If the surface temperature is less than or equal to 0°C, the base will be considered frozen. The Contractor shall use suitable heating methods to maintain the base temperature above 0°C. Salt shall not be used to thaw ice, snow, or frost.

6.12.3.3 Cold Weather Concrete shall be used for Cold Weather concreting.

6.12.3.4 The Contractor shall maintain the internal concrete temperature above 10 °C for a minimum of five (5) days after completion of placing operations, and until the concrete has developed a minimum compressive strength of 24 MPa. The protection method(s) may be removed after three (3) days where the concrete has achieved its design strength (35 MPa). Temperature and concrete compressive strength shall be determined by maturity meters and field cured cylinders.

6.12.3.5 The Contractor shall be responsible for the methods of protecting the concrete from Cold Weather such as insulation (blankets and boards), heating systems such as electric blankets and hydronic heating systems, unheated or heated enclosures, or a combination of the methods to maintain the internal concrete temperature above 10 °C. In no case shall the protection method be less than a combination of one layer of polyethylene film and one layer of insulated tarp with R-value of 0.5.

6.12.3.6 The recommended protection method using an insulated tarp(s) is shown in Table CW 3310.7.

Table CW 3310.7: Minimum Thermal Resistance Values for Insulated Tarp

Slab thickness (mm)	The Low Temperature within 24 hours of Placing or Average Low Ambient Air Temperature within three (3) days of Placing			
	R=1	R=2	R=3	R=4
<150 mm	-	-	5 > T ≥ 0	0 > T ≥ -5
150mm - 200 mm	-	5 > T ≥ 3	3 > T ≥ 0	0 > T ≥ -8
> 200 mm	5 > T ≥ 3	3 > T ≥ 0	0 > T ≥ -3	-3 > T ≥ -8

6.12.3.7 A minimum of one location shall be monitored by maturity meters. Where 30 cubic meters of concrete or more will be placed, the first maturity meter shall be placed in the first 4 m of paving, and the second maturity meter shall be placed in the final 4 m of paving. Each maturity meter shall be capable of recording the time and temperature at two depths; 12 mm below the surface and 12 mm above the bottom of the pavement. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the concrete.

6.12.3.8 The Contract Administrator shall provide all necessary wires and connectors and will be responsible for the placement of maturity meters. The Contractor shall be responsible for the protection and maintenance of all wires and connectors. The Contract Administrator shall allow the Contractors to access the maturity meters. No additional measurement or payment will be made for the placement, protection, and maintenance of all wires and connectors.

6.12.3.9 If the internal concrete temperature at any location in the concrete falls below 10 °C but not less than 5°C during the Protection Period, alternative methods such as additional insulation (blankets and boards) or heating systems for protecting the concrete shall be applied immediately.

6.12.3.10 If the internal concrete temperature at any location in the concrete falls below 5 °C during the Protection Period, cores shall be collected and tested.

6.12.3.10.1 A minimum of six (6) cores shall be tested at 91 Curing Days in accordance with CSA A23.2-23C, Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. Where the average of chloride ion penetrability is greater than the specified penetrability by a maximum of 500 coulombs, with no individual core more than 500 coulombs above the specified penetrability, the concrete will be monitored for damage over a 5-year period and the Contractor shall provide a 5-year warranty for the entire area represented by the failed test(s). Where the average of chloride ion penetrability or any individual core exceeds the specified penetrability by more than 500 coulombs, the entire area represented by the failed test(s) shall be removed and replaced by the Contractor at his expense;

6.12.3.10.2 A minimum of three (3) cores shall be tested at 28 Curing Days in accordance with CSA A23.2-14C, Obtaining And Testing Drilled Cores For Compressive Strength Testing. The Contract Administrator shall apply a payment adjustment in accordance with Clause 7.3. against the entire quantity represented by the failed test(s).

6.12.3.11 If the internal concrete temperature at any location in the concrete falls below 0 °C during the Protection Period, the concrete shall be removed and replaced by the Contractor at his own expense.

6.12.3.12 The protection method shall not be completely removed until the concrete has cooled to the temperature differential given in CSA A23.2, Table 20. The Contractor shall be responsible for the methodology to gradually cool the concrete such as loosening the forms while maintaining cover with plastic sheeting or insulation, gradual decrease in heating inside an enclosure, or turning off the heat and allowing the enclosure to slowly equilibrate to ambient

temperature. If the concrete cracks due to a sudden temperature change, concrete shall be removed and replaced by the Contractor at his own expense.

6.12.3.13 The Contractor shall be responsible for minimizing heat loss during saw cutting and shall receive approval of the Contract Administrator prior to proceeding. If the concrete cracks due to sudden temperature change, concrete shall be removed and replaced by the Contractor at his own expense.

6.12.3.14 No additional measurement or payment will be made for Cold Weather concreting.

6.13 Opening to Traffic

6.13.1 In no case shall traffic or construction equipment be allowed on the pavement until the concrete has reached a minimum compressive strength of 20 MPa, as determined by maturity meters or field cured cylinders.

6.13.2 The Contract Administrator's decision as to when the pavement will be opened to traffic shall be final. Prior to opening to traffic, the pavement shall be swept clean.

6.14 Temporary Restoration of Utility Pavement Cuts

6.14.1 Prior to the placement of concrete for temporary restoration of utility pavement cuts, stabilized fill material shall be placed to within 150 mm (minimum) to 250 mm (maximum) of the top of the existing pavement surface in accordance with CW2160. Upon acceptance of the placed stabilized fill by the Contract Administrator, the contractor shall place concrete supplied in accordance with the requirements of Clause 3.3 of this specification.

6.14.2 All snow, ice and loose concrete or asphalt along the edges shall be removed before placement of concrete.

6.14.3 The concrete shall be placed by hand methods and finished to match the existing pavement surface.

6.14.4 When air temperatures at time of concrete placement are less than 5°C, the concrete shall be covered with insulated tarps for a minimum of three (3) days prior to opening to traffic.

7. QUALITY ASSURANCE

7.1 General

7.1.1 Tests used for purposes of assessing compliance with this specification or for acceptance of any products shall be conducted by a laboratory certified in accordance with the requirements of Clause 4.4.1.6 of CSA A23.1 and approved by the City of Winnipeg, Research and Standards Engineer. Laboratory and field personnel shall meet the requirements of Clauses 4.4.1.6 and 4.4.1.7 of CSA A23.1, respectively.

7.1.2 Field sampling and testing of concrete shall be performed by a person holding either of the following certifications:

7.1.2.1 CSA Certified Concrete Testing Technician, Concrete Testing and Sampling Certificate; or,

7.1.2.2 ACI Concrete Field Testing Technician - Grade 1.

7.1.3 The field personnel shall have a valid original card issued by the certifying agency in their possession at all times.

7.1.4 The Contract Administrator shall be allowed access to all sampling locations and reserves the right to request quality assurance sample(s) at any time.

7.1.5 Samples of concrete for all tests shall be taken in accordance with CSA A23.2-1C, Sampling Plastic Concrete.

7.1.6 The Contractor shall provide and maintain, for the sole use of the testing agency, adequate facilities for safe storage and proper curing of concrete test specimens on the project site for the initial curing period (a minimum of 24 hours). Adequate facilities shall include a protected and temperature-controlled designated area to comply with CSA A23.2-3C. The moulds shall be placed on a rigid horizontal surface free from vibration and other disturbances. During initial curing, the test specimens shall be stored in a controlled environment that maintains the temperature between 15 and 25 °C.

7.1.7 The test specimens shall be transported from the field to the laboratory only after curing for a minimum of 24 hours. After removing the specimens from their moulds in accordance with CSA A23.2, Clause 9.3.1, the specimens shall be stored in a moist condition in the lab with free water maintained on all surfaces of the specimens at all times at 23 ± 2 °C until the time of the test.

7.1.8 The test specimens shall be protected during transportation from any shocks or exposure to adverse conditions. The curing conditions and the date received shall be stated in the test report.

7.1.9 If any test specimen shows distinct evidence of improper sampling, moulding, handling, curing, or testing, the test specimen shall be disregarded. The average of the remaining sample(s) shall be considered the test result.

7.1.10 The Contract Administrator shall ensure the delivery ticket for each load complies with CSA A23.2, Clause 5.2.5.5.

7.2 Testing Frequency

7.2.1 The concrete shall be sampled for acceptance in accordance with Table CW 3310.8.

Table CW 3310.8: Frequency of Sampling and Testing of Concrete

Concrete Type	Quantity (m^3)	Laboratory testing*
Type 1, Type 2	< 30 30 - 100 100 – 400 > 400	1 set/day 3 sets/day 2 sets/100 m^3 1 set/100 m^3
Type 3, Type 4, Type 5, Type 7, Type 8	< 50 50 – 300 > 300	1 set/day 2 sets/100 m^3 1 set/100 m^3
Cold Weather Concrete	< 50 50 – 300 > 300	2 sets/day 3 sets/100 m^3 2 set/100 m^3

*Air, slump and temperature tests shall be carried out when cylinders are cast. For cold and Hot Weather concreting, the temperature of the fresh concrete shall be measured for each load.

7.2.2 Each set represents a Concrete Lot and shall consist of:

7.2.2.1 Concrete temperature: Temperature shall be conducted in accordance with CSA A23.2-17C, Temperature of Freshly Mixed Hydraulic Cement Concrete.

7.2.2.2 Slump: Slump test shall be conducted in accordance with CSA A23.2-5C, Slump of Concrete.

7.2.2.3 Air content: Air content test shall be in accordance with CSA A23.2-4C, Air Content of Plastic Concrete by the Pressure Method.

7.2.2.4 Strength: Compressive strength of concrete cylinders shall be conducted in accordance with CSA A23.2-9C Compressive Strength of Cylindrical Concrete Specimens. A minimum of one cylinder at each specified date and two cylinders at 28

days shall be tested in accordance with Clause 3.3. For Type 3 and 4, additional field cured cylinder(s) shall be cast with a break time to match the specified date of the concrete mix.

7.2.2.5 Penetrability: If required, rapid chloride penetrability test shall be conducted in accordance with CSA A23.2-23C, Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. A minimum of three cores shall be tested.

7.2.3 The Contract Administrator shall determine the thickness of freshly finished concrete pavement at a minimum frequency of one measurement per 50 m per lane with a minimum of three measurements in each pour. Pavement thickness may be determined during paving using a pin or by coring pavement sections representing each lot. If there is a discrepancy between the thickness of freshly finished concrete pavement and the cores, the cores shall be used to determine the final thickness.

7.2.4 Additional testing shall be as directed by the Contract Administrator.

7.2.5 Copies of all test results shall be sent to the Research and Standards Engineer for the Public Works Department and to the Contract Administrator.

7.2.6 Copies of Plant Batch tickets shall be sent to the Research and Standards Engineer for the Public Works Department upon request by the Research and Standards Engineer.

7.3 Acceptance Criteria

7.3.1 The Contractor shall reimburse the City for any costs the City incurs as a result of failed tests.

7.3.2 Where the work is not funded or administered by the City of Winnipeg or their representative, the party approved by the City of Winnipeg to execute the work will be responsible for making pay adjustments to the City of Winnipeg.

7.3.3 Acceptance of concrete shall be based on the following:

7.3.3.1 Concrete Temperature:

7.3.3.1.1 The temperature of the fresh concrete shall not be less than 10.0°C nor greater than 30.0°C. If the temperature falls outside the limits specified, the concrete shall be rejected.

7.3.3.2 Slump:

7.3.3.2.1 If the measured slump falls outside the limits specified in Clause 3.3 of this Specification, a second test shall be conducted. If the second test fails but is

less than the specified slump, plasticizer or superplasticizer admixture may be added. Water may be added on the following basis only:

7.3.3.2.1.1 The specified water-to-cementitious materials ratio shall not be exceeded;

7.3.3.2.1.2 No more than the lesser of 12 L/m^3 or 10% of the mixing water shall be added; and,

7.3.3.2.1.3 No more than 60 minutes shall have elapsed from the time of batching.

7.3.3.2.2 If water is added, the mixer drum shall be turned at mixing speed for at least 30 revolutions (or equivalent time limit) after the addition of water. The amount of water or admixture added shall be recorded in the test report.

7.3.3.2.3 If any of the above conditions are not met (e.g., water-to-cementitious materials ratio exceed the specified limits or more than 60 minutes has elapsed from the time of batching), the concrete shall be rejected.

7.3.3.2.4 If the slump test (second slump) fails by more than the specified slump, the concrete shall be rejected.

7.3.3.3 Air Content:

7.3.3.3.1 If the measured air content falls outside the limits specified in Clause 3.3 of this Specification, a second test shall be made. If the second test fails, the air content of the concrete shall be adjusted to within the specified range by the Contractor by adding an air-entraining admixture in the field if no more than 60 minutes have elapsed from the time of batching. Mixing shall follow to ensure proper dispersion. The air content shall be retested.

7.3.3.3.2 If the new test falls outside the limits or more than 60 minutes have elapsed from the time of batching, the concrete shall be rejected.

7.3.3.3.3 The amount of air-entraining admixture added, time for testing, and air content results shall be recorded in the test report.

7.3.3.4 Concrete Strength:

7.3.3.4.1 A concrete lot is deemed unacceptable if the concrete compressive strength at 28 days does not meet all of the following:

7.3.3.4.1.1 The average compressive strength for two consecutive compressive strength tests shall be equal to or greater than the specified strength;

and,

7.3.3.4.1.2 No individual strength test shall be more than 3.5 MPa below the specified strength.

7.3.3.4.2 If the concrete compressive strength falls outside the limits specified in Clause 7.3.3.4.1 of this Specification, a minimum of three cores shall be collected and tested from the affected concrete lot at 35 Curing Days in accordance with CSA A23.2-14C. The concrete represented by the core tests shall be considered adequate if:

7.3.3.4.2.1 The average of the cores is equal to at least 90% of the specified strength; and

7.3.3.4.2.2 No single core is less than 85% of the specified strength.

7.3.3.4.3 If the concrete compressive strength falls outside the limits specified in Clause 7.3.3.4.2 of this Specification, the Contract Administrator shall apply a payment adjustment in accordance with Table CW 3310.9 against the entire lot represented by the failed test(s). All costs associated with coring, transmittal of cores, filling of cores, and testing shall be borne by the Contractor regardless of the outcome of the test.

TABLE CW 3310.9 – Payment Adjustment for Concrete Strength

Average of the failed test	Percent of Price Reduction %
≤ 3.5 MPa below specified compressive strength	[1- ((Actual compressive strength)^3 / (Specified compressive strength)^3)] * 100
> 3.5 MPa below specified compressive strength	Remove and replace at Contractor's expense

Note: The actual compressive strength refers to the cylinder compressive strength at 28 days. Compressive strength shall be in MPa.

7.3.3.5 Penetrability:

7.3.3.5.1 A concrete lot is deemed unacceptable if the concrete penetrability at 91 Curing Days does not meet all of the following:

7.3.3.5.1.1 The average of chloride ion penetrability shall be equal to or greater than the specified penetrability; and,

7.3.3.5.1.2 No individual core shall be more than 250 coulombs above the specified penetrability.

7.3.3.5.2 The Contract Administrator shall apply a payment adjustment in accordance with Table CW 3310.10 against the entire lot represented by the failed test(s).

TABLE CW 3310.10 – Payment Adjustment for Chloride Ion Penetrability

Average of the failed test	Percent of Price Reduction %
≤ 250 coulombs above specified penetrability	$[1 – ((\text{Specified penetrability})^2 / (\text{Actual penetrability})^2)]* 100$
> 250 coulombs above specified penetrability	Remove and replace at Contractor's expense

Note: Penetrability shall be in coulombs.

7.3.3.6 Concrete Thickness:

7.3.3.6.1 A concrete lot is deemed unacceptable if the concrete thickness does not meet all of the following:

7.3.3.6.1.1 The average thickness shall be equal to or greater than the required thickness; and,

7.3.3.6.1.2 No individual thickness shall be less than 90% of the required thickness.

7.3.3.6.2 The Contract Administrator shall apply a payment adjustment in accordance with Table CW 3310.11 against the entire lot represented by the failed test(s).

TABLE CW 3310.11 – Payment Adjustment for Pavement Thickness

Average of the failed test	Percent of Price Reduction %
Less than specified thickness but more than 90% of specified thickness	$[1- ((\text{Actual thickness}^*)^3 / (\text{Specified thickness}^*)^3)] * 100$
Less than 90% of specified thickness	Remove and replace at Contractor's expense

Note: Thickness shall be in millimetres.

7.3.3.7 Concrete Scaling:

7.3.3.7.1 Where scaling of the concrete surface occurs during the Warranty Period, a minimum of two cores for each lot shall be collected and tested for thickness and penetrability. If the concrete thickness loss is more than 5 mm or the penetrability does not meet the requirements of Clause 7.3.3.5, the concrete shall be removed and replaced at the Contractor's expense.

7.3.3.7.2 If the concrete thickness loss is less than 5 mm and the penetrability meets the requirement of Clause 7.3.3.5, the Contractor shall solely, at his expense, diamond grind the scaled areas by mechanical means acceptable to the Contract Administrator or replace the full thickness of pavement for those areas. The pavement surface after diamond grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 3 mm when measured with a 3.0-meter-long metal straight edge placed parallel to the centreline. All areas of deviation shall be reground at no additional cost. The unit price shall be reduced for deficiencies in pavement thickness and penetrability as per Clause 7.3.3.5 and Clause 7.3.3.6 of this Specification. The pay adjustment will be the highest price reduction identified in accordance with Tables CW3310.7 and CW3310.8.

8. MEASUREMENT AND PAYMENT

8.1 Concrete Pavements, Median Slabs, Bull-noses and Safety Medians

8.1.1 Construction of concrete pavements, median slabs, bull-noses and safety median will be measured and paid for at the Contract Unit Price per square meter for the "Items of Work" listed here below, measured as specified herein, which price shall be payment in full for supplying all materials and performing all operations herein described and all other items incidental to the work included in this Specification. The unit price shall be reduced for deficiencies in pavement thickness as per Clause 7.3 of this Specification.

Items of Work:

i. "Construction of 250 mm Type (*) Concrete Pavement (**)(***)"
ii. "Construction of 230 mm Type (*) Concrete Pavement (**)(***)"
iii. "Construction of 200 mm Type (*) Concrete Pavement (**)(***)"
iv. "Construction of 150 mm Type (*) Concrete Pavement (**)(***)"
v. "Construction of Type (*) Concrete Median Slabs (****)"
vi. "Construction of Monolithic Type (*) Concrete Median Slabs (****)"
vii. "Construction of Type (*) Concrete Safety Medians (****)"
viii. "Construction of Monolithic Type (*) Concrete Curb and Sidewalk (****)"

ix. "Construction of Monolithic Type (*) Concrete Bull-noses"

* Specify the Concrete Type
** Specify either Reinforced or Plain-Dowelled
*** Specify Slip Form Paving if required
**** Specify referenced Standard Detail

8.2 Concrete Pavements for Early Opening

8.2.1 Construction of concrete pavements for early opening will be measured and paid for at the Contract Unit Price per square meter for the "Items of Work" listed here below, measured as specified herein, which price shall be payment in full for supplying all materials and performing all operations herein described and all other items incidental to the work included in this Specification. The unit price shall be reduced for deficiencies in pavement thickness as per Clause 7.3 of this Specification.

Items of Work:

i. "Construction of 250 mm Type (*) Concrete Pavement for Early Opening (**)(***)"
ii. "Construction of 230 mm Type (*) Concrete Pavement for Early Opening (**)(***)"
iii. "Construction of 200 mm Type (*) Concrete Pavement for Early Opening (**)(***)"
iv. "Construction of 150 mm Type (*) Concrete Pavement for Early Opening (**)(***)"

* Specify either Type 3 or Type 4
** Specify either Reinforced or Plain-Dowelled
*** Specify Slip Form Paving if required

8.3 Concrete Curbs, Curb and Gutter, and Splash Strips

8.3.1 Construction of concrete curbs, curb and gutter, and splash strips will be measured and paid for at the Contract Unit Price per meter for the "Items of Work" listed here below, measured as specified herein, which price shall be payment in full for supplying all materials and performing all operations herein described and all other items incidental to the work included in this Specification.

Items of Work:

i. "Construction of Type (*) Concrete Barrier Curb (**)"
ii. "Construction of Type (*) Concrete Modified Barrier Curb (**)"
iii. "Construction of Type (*) Concrete Curb and Gutter (**)"
iv. "Construction of Type (*) Concrete Mountable Curb (**)"
v. "Construction of Type (*) Concrete Lip Curb (**)"
vi. "Construction of Type (*) Concrete Curb Ramp (**)"
vii. "Construction of Type (*) Concrete Safety Curb (**)"

viii. "Construction of Type (*) Concrete Splash Strips (***)"

* Specify the Concrete Type
** Specify height, type and Referenced Standard Detail
***Specify height, monolithic or separate, type, width, and referenced Standard Detail

8.3.2 No measurement or payment shall be made for supply or placement of bonding grout for concrete curbs.

8.3.3 Drilled curb ramp tie bars are to be paid in accordance with CW 3230.

8.4 Dowel Assemblies

8.4.1 Supply and installation of dowel assemblies will be measured and paid for at the Contract unit Price per meter for "Supply and Installation of Dowel Assemblies", measured as specified herein, which price shall be payment in full for supplying all materials and performing all operations herein described and all other items incidental to the work included in this Specification.

*Specify diameter(s) of dowels.