

**Construction Specification for
Streetcar Track Pavement and Foundation Slab**

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TS 3.75.01 SCOPE

This specification covers the requirements for the construction of the streetcar track pavement and the foundation slab.

TS 3.75.02 REFERENCES

This specification refers to the following standards, specifications or publications:

City of Toronto Standard Specifications

TS 2.10	Construction Specification for General Excavation
TS 2.20	Construction Specification for Excavation for Track Allowance
TS 4.50	Construction Specification for Utility Adjustments
TS 405	Amendment to OPSS 405 – Construction Specification for Pipe Subdrain
TS 501	Amendment to OPSS.MUNI 501 – Construction Specification for Compacting
TS 1010	Amendment to OPSS.MUNI 1010 – Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
TS 1350	Amendment to OPSS.MUNI 1350 – Material Specification for Concrete – Material and Production

City of Toronto Standard Drawings

T-216.02-10	Streetcar Track Allowance Cross-Section
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Ontario Provincial Standard Specifications

OPSS 180	General Specification for the Management of Excess Materials
OPSS 919	Construction Specification for Formwork and Falsework

Canadian Standards Association

A 23.1	Concrete Materials and Methods of Concrete Construction
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American Society of Testing and Materials

C 174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
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Toronto Transit Commission

W8T-859	Standard Expansion Joint Locations for Tangent Track Installation
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TS 3.75.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

GU/GUL means general use or general use limestone hydraulic cement.

HE means high early strength hydraulic cement.

Track Allowance means the area bounded by the outermost rails, plus the outer margins (560 ± mm) as shown in T-216.02-10.

Foundation means the concrete slab (typically 280 mm thick) that supports the track pavement and associated rail system.

TTC means the Toronto Transit Commission.

TS 3.75.04 DESIGN AND SUBMISSION REQUIREMENTS

Any required submissions shall be in writing. All submissions shall be submitted to the City at least three weeks prior to the beginning of the work.

The requirements for submissions and design requirements are given in TS 1350. Documentation from the concrete supplier, that concrete will be supplied at any time, day or night, as required provided 24 hours notice is provided for any concrete order or within one and one-half hours of batching.

TS 3.75.05 MATERIALS

TS 3.75.05.01 Concrete

The materials for and the production of regular concrete streetcar allowance shall meet the requirements of TS 1350 and the following:

1) Cement type	Normal Portland GU Portland limestone GUL
2) Minimum 7 day compressive strength	32 MPa
3) Class of exposure	C-2
4) Maximum nominal size of coarse aggregate	19 mm
5) Slump at plant	max. 50 mm
6) Slump at point of discharge without plasticizer	max. 20 mm
7) Slump at point of discharge with plasticizer	150 ± 30 mm
8) Air content	6.5 ± 1.5%
9) Maximum water/cementing materials ratio	0.45

The materials for and the production of special mix concrete streetcar allowance shall be according to TS 1350.

The materials for and the production of concrete to be used in streetcar track allowance during weekend pours shall be according to TS 1350 and the following:

For 24-hour concrete:

- 1) The concrete shall reach initial set with 4 to 6 hours.
- 2) Minimum 24-hour compressive strength: 32 MPa.
- 3) 24-hour concrete can only be manufactured using high early strength hydraulic cement (HE).

TS 3.75.05.02 Admixtures and Additives

The materials for and the production of all surface concrete shall be according to TS 1350 and polypropylene fibres additive such as Grace Fibres or Fibremesh or approved equivalent applied at a rate of one kilogram per cubic metre.

The water-reducing agent, non-chloride accelerator and super-plasticizer shall be preapproved by the Ontario Ministry of Transportation (MTO) and be listed on the latest version of their Designated Sources List. They shall be applied at a rate to maximize strength gain and to meet the specified requirements without any adverse affect to long term properties of the concrete.

All additives and admixtures shall be applied in strict accordance with the manufacturer's instructions. In addition, the Contractor may use an approved super-plasticizer to improve flow and handling during placement.

No extra payment will be made for any admixture or additive.

TS 3.75.05.03 Curing of Concrete Samples

The Contractor shall supply and maintain a lockable temperature controlled curing box that will maintain the curing samples according to the CSA A23.2-09, Clause 8.3. The box shall be positioned, at a location, close to each concrete pour and securely fastened to a street furniture element that will deter theft and vandalism. The Contractor should note that the box may need to be relocated several times during the course of the construction. No additional payment will be made to relocated the curing box.

TS 3.75.05.04 Expansion Joint Material

Expansion joint material shall be bituminous fibre board that is 12 mm thick and 50 mm wide.

TS 3.75.05.05 Bond Breaker

The Contractor shall use a bond breaker between the surface concrete and the previous lift of concrete and only in those sections between the outer rails of the TTC track allowance. Bond breaker shall not be used in the outer margins. The recommended bond breaker for such application is 810-07 by Henry Company (Bakor Inc). Physical properties and product application can be obtained from a product data sheets available from the aforementioned company. However, any alternative product that proves to be equivalent will be acceptable subject to the approval by the Contract Administrator.

TS 3.75.05.06 Bonding Agent

The Contractor shall use a bonding agent between lifts in the margin when only the first 175 mm thick lift is removed. The bonding agent to be used shall be SikaTop Armatec 110 EpoCem.

TS 3.75.06 EQUIPMENT

TS 3.75.06.01 Forms

Forms shall be steel, wood or metal plate forms and shall be according to OPSS 919.

They shall be of sufficient cross section and strength, and so secured as to resist the pressure of the concrete when placed, and the impact and vibration of any construction equipment they support without springing or settlement.

Forms shall be pinned or staked in place with not less than 3 pins for each 3 m length, and with a pin at each side of each form butt joint. The top surface of the formwork shall comply with the specified tolerances. The inside face of the form shall be vertical. The form shall not deviate from grade by more than 3 mm in 3 m, and shall not deviate in alignment by more than 6 mm in 3 m.

Forms shall be cleaned and coated with form oil, prior to each use.

TS 3.75.06.02 Finishing Tools

Finishing tools shall be according to CSA A23.1 and TS 1350.

TS 3.75.06.03 Testing Equipment

The Contractor shall supply an air meter, slump cone and all their associated equipment to the City, at all times, when concrete is being placed. The air meter is to have been calibrated, just prior to construction, by a technician with CSA certification.

TS 3.75.07 CONSTRUCTION

Prior to starting the work, the Contractor shall submit the verification that either the foreman/lead hand or the supervisor of the placing crew has ACI Flatwork Certification.

TS 3.75.07.01 Excavation

Where an existing track exists, the excavation shall be according to TS 2.20. Otherwise, the excavation shall be according to TS 2.10.

Excavation shall be to the lines and grades as shown on the Contract Drawings.

TS 3.75.07.02 Subgrade Preparation

The subgrade shall be compacted according to TS 501, except that the compaction shall be to a minimum of 100% of the maximum dry density.

The subgrade shall be proof rolled, and any soft or yielding areas shall be sub excavated and replaced with material that is similar to the surrounding subgrade.

TS 3.75.07.03 Subdrain

The subdrain shall be supplied and installed according to TS 405.

TS 3.75.07.04 Granular Base Placement

The granular base shall be placed to the required thickness and compaction, and shall be according to TS 1010 for Granular A. The moisture content and compaction of the granular base shall be uniform and shall be according to TS 501.

The granular base shall be moistened prior to the placement of concrete, but without any standing water. At the time of placing concrete, the base shall not be wet, soft or frozen.

TS 3.75.07.05 Utility Adjustment

Utility adjustments shall be according to TS 4.50, except that box-outs shall not be required. Expansion joints shall be constructed adjacent to all utility frames and covers according to TTC drawing W8T-859.

TS 3.75.07.06 Placing Concrete

Concrete used for TTC track work shall meet the 7 day compressive strength requirement for base, infill and surface course. The use of 24-hour compressive strength concrete shall only be at the direction of the Contract Administrator. Typical uses may include accelerate completion of weekend closures and accelerate completion at contract limits to allow for the next lift.

TS 3.75.07.06.01 *General*

Concrete shall be placed and consolidated according to TS 1350.

The Contractor shall ensure the presence of sufficient workers to place, vibrate, finish and cover the concrete in good time, as the accelerator in the mix will speed the initial set.

The Contractor shall ensure that the supplies of concrete will arrive at the site, at the proper time, in order to achieve the earliest possible set and the maximum possible strength gain, prior to the resumption of the streetcar service. Also, the concrete supplier must be on constant standby over weekend periods, so that the concrete can be supplied at any time of the day or night.

Concrete trucks shall not wash out their chutes onto any part of the work area. The Contractor shall provide other means for chute washing.

TS 3.75.07.06.02 *Foundation Slab*

The foundation slab shall be placed in one pour of 280 mm thick lift as shown on the Contract Drawings.

Extreme care must be taken to place this slab at the correct grade to prevent the compromising of the track elevations. Also the progress of the TTC track crews will be greatly affected by the speed with which the Contractor places the foundation slab and the speed at which the foundation concrete reaches sufficient strength to support a worker.

The outer edges of the foundation slab shall always be side formed for their full depth.

TS 3.75.07.06.03 *Track Pavement*

Concrete shall be placed in two lifts in addition to the Foundation Slab, infill and surface, with a minimum of three hours elapsing between the completion of the infill lift and the start of the surface lift.

The surface lift, first lift, shall extend from the infill lift to the finished road surface, to a thickness of 175 mm. The second lift, infill, shall extend from the foundation slab to the tops of the ties, to a thickness of 225 mm thick.

Concrete shall be puddled under each tie and rail, from one side only, until it emerges from the other side, along the entire length. Concrete shall not be deposited on both sides of a tie or rail at the same time. This is to ensure that no voids are created under the track members.

Outer margins shall in all cases be side-formed for their full depth of new concrete, 400 mm thick.

Concrete in tracks through intersections shall not be formed with the normal crown, but shall be screeded flat between the rails. On approaches to intersections, the normal crown, as shown on the Contract Drawings, shall be formed.

TS 3.75.07.06.04 *Load Transfer Bars*

The Contractor shall supply and install load transfer bars at locations where the new concrete base meets the existing concrete base using 20M@300 O.C. Epoxy coated bars complete with Hilti HIT-HY 200 adhesive minimum 800 embedment.

All costs associated with this work shall be considered incidental to all related items of Work.

No separate payment shall be made.

TS 3.75.07.07 *Finishing Concrete*

The concrete surface shall be finished while it is still sufficiently plastic to achieve the desired grades, elevation and texture. The surface of the concrete shall not be finished when standing water is present on the surface. The surface shall be uniform, dense, and free from undulations and projections.

The top surface shall be screeded to true grade and cross section and finished with a magnesium or aluminum float. The finishing shall be performed in a manner that does not draw water to the surface. The surface of the road base shall have no irregularities exceeding 6 mm when tested with a 3 m straightedge in any direction.

TS 3.75.07.08 *Joints*

Transverse expansion joints shall be constructed 12 mm wide and 50 mm deep. They shall be placed across the track allowance over every tie-rod, at every joint between adjacent lengths of rail and at other locations, in areas of special track work.

The expansion joint material shall not be placed until the concrete surface has been shaped, screeded and trowelled. The joint shall be flush with the concrete surface and at no point covered by concrete.

Expansion joint material shall extend in one unbroken piece across the concrete surface with no shortening near the rails.

At the end of each day's work, or in the event of an unavoidable stoppage of concrete placement extending more than 30 minutes, a 50 mm keyed construction joint shall be placed. Where possible, the construction joint shall coincide with the planned location of a contraction joint.

TS 3.75.07.09 Concrete Curing

Due to the strict requirements of the curing temperature, the Contractor may be required to use extra material, such as thermal blankets, to maintain the concrete within the required temperature range. Concrete curing shall be according to TS 1350.

Immediately after each lift of concrete is placed and floated, an evaporation retardant shall be applied in accordance with the manufacturer's recommendations.

As soon as the concrete in the second lift has set, it shall be covered by two layers of water-soaked burlap and a layer of polyethylene sheet. No part of the concrete shall be left uncovered.

Joints in the burlap and polyethylene sheet, shall be overlapped a minimum of 200 mm and they shall extend a minimum of 300 mm beyond the limits of the concrete, in all directions. The covers shall be suitably weighted to prevent flapping and displacement.

The covers shall remain in place for 7 Days or until within 30 minutes of the resumption of streetcar service. The Contractor shall ensure that all covers are removed, prior to the resumption of streetcar service.

TS 3.75.07.10 Concrete Protection

Concrete protection shall be according to TS 1350.

TS 3.75.08 QUALITY ASSURANCE

Quality assurance shall be according to TS 1350.

TS 3.75.08.01 Visibly Defective or Damaged

Concrete that is visibly defective or damaged is not acceptable and shall be removed and replaced at no extra cost to the City.

Concrete is visibly defective or damaged when:

- The concrete is honeycombed.
- The concrete contains embedded debris.
- The concrete has been damaged by freezing.
- The concrete temperature at the time of placement exceeded the requirements of this specification.
- The concrete surface has been damaged by rain.
- The concrete contains footprints or other undesirable impressions.
- The concrete has been subjected to traffic before the concrete attained 20 MPa.
- The concrete has cracked or separated.
- The concrete surface has spalled as defined in the *General Conditions of Contract* that the Contract Administrator will be the sole judge to the determination.
- Expansion and isolation joints are not vertical.
- The concrete sections have heaved or sunk, from their original position.

TS 3.75.08.02 Frequency of Field Testing and Sampling

The concrete supplied shall be sampled for acceptance tests according to Table 1. Field testing on air, sump and temperature shall also be done whenever compressive cylinders are cast. The concrete within the track allowance shall be divided into lots up to 100 linear metres or daily production, whichever is less.

Table 1: Field testing

Concrete placed	Quantity (linear metre)	Cylinders required	Field testing
foundation slab, infill and surface concrete within the track allowance	< 35 m	1 set/day (lot)	one test for each load of concrete until satisfactory control is establish; then one test for each five loads of concrete
	between 35 m and 65 m	2 sets/day (lot)	
	between 65 m and 100 m	3 sets/day (lot)	

TS 3.75.08.03 Concrete Thickness

The thickness of the concrete structure shall be determined by field measurement or according to the thickness measurement method as specified in the Contract Documents.

The Contract Administrator reserves the right to verify the thickness of the concrete structure for structural integrity check and payment purposed using a non-destructive testing method of by coring.

When a measurement of concrete thickness is carried out by coring, the measurement shall be based on either a 100 or 150 mm diameter core. The diameter of the core shall be at least three times the size of the maximum coarse aggregate according to CSA A23.1.

No core shall be taken within 250 mm from the joint or edges. The length of each core shall be determined according to ASTM C174. Core samples that are broken or obviously damaged shall not be used for concrete determination. The damaged cores shall be replaced by acceptable cores taken from the same subplot(s). Core samples taken for concrete thickness determination shall not be used for compressive strength test.

Regardless of the method used, concrete thickness shall be determined on a lot basis. Each lot shall have four sublots or equal size, where each subplot is represented by a thickness measurement. The Contract Administrator will determine the size of the lot(s) and sublots for the purpose of concrete thickness acceptance and payment.

The concrete thickness for track allowance in a lot shall be average concrete thickness of the lot (Tx). The average concrete thickness for a lot shall be calculated from the following formula:

$$T_x = \frac{T1 + T2 + T3 + T4}{4}$$

Where: Tx is the average concrete thickness for a lot, rounded off to the nearest mm.
T1, T2, T3 and T4 are the concrete thickness for sublots 1, 2, 3 and 4.

For the purposes of the calculation, any individual subplot measurement that is more the 5 per cent above the specified thickness shall be assumed to be equal to the specified thickness plus 5 per cent.

A lot will be accepted, on a thickness basis, if the average concrete thickness of the lot equals or exceeds 100 per cent of the specified thickness. Payment for the lot shall be determined according to subsection TS 3.75.10.01, herein.

At the sole discretion of the Contract Administrator, a lot may be accepted and allowed to remain in place, if the average concrete thickness of the lot is between 95 and 100 per cent of the specified thickness. The lot accepted based on the above conditions will not be eligible for full payment. Payment for the lot will be determined according to Table 2.

Table 2: Payment adjustment for thickness

Thickness Tx	Per cent payment
100 per cent of specified thickness or above	100
100 per cent of specified thickness to 95 per cent of specified thickness	$\frac{(Actual\ Thickness)^2}{(Specified\ Thickness)^2} \times 100$
less than 95 per cent of specified thickness	see note 1

Note 1: If the concrete thickness of an individual subplot is less than 95 per cent of the specified thickness, the subplot shall be determined unacceptable. The City has the option to conditionally accept the failed subplot or have the Contractor remove and replace the subplot at no extra cost to the City even if the average concrete thickness of a lot is more than 95 per cent of the specified thickness. If the City decides to conditionally accept the subplot, payment will be made at 40 per cent of the Contract Price or based on the thickness formula, whichever is less.

All replacement lots shall be accepted on the same basis as the original lot.

TS 3.75.08.04 Compressive Strength

The compressive strength requirements for 7 day and 24 hour concrete shall be according to TS 1350, except that "28 day" shall be replaced with "7 day" or "24 hour" as required. Acceptance of the compressive strength shall be according to subsection TS 1350.10.02, except that the City has the option to conditionally accept the failed lot or have the Contractor remove and replace the lot at no extra cost the City. If the Contract Administrator decides to conditionally accept the lot, payment shall be made at 40 per cent of the Contract Price.

Price adjustments for concrete will be non-payment for any and all premium costs or based on Table 3, whichever is greater:

Table 3: Price adjustment for compressive strength

Average tested high early compressive strength	Per cent payment of concrete
up to 3.5 MPa below specified high early strength	$\frac{(Actual\ Strength)^{2.5}}{(Specified\ Strength)^{2.5}} \times 100$
between 3.5 MPa and 7.0 MPa below specified high early strength	$\frac{(Actual\ Strength)^3}{(Specified\ Strength)^3} \times 100$
greater than 7.0 MPa below specified high early strength	remove and replace at no extra cost to the City

Concrete that is to be removed and replaced at no extra cost to the City, may be deemed usable if all the following conditions are met:

- high early strength concretes meet the specified compressive strength within the next time constraint, for example 24 hour within 7 days and 7 day with 28 days;
- the contract schedule did not incur any delays;
- the major interim schedules did not incur any delays, that is delays in opening the intersection to full operation;
- the public did not incur any delays, that is delayed access to private property; and
- the concrete passes all other requirements.

In lieu of removing and replacing concrete that does not meet the compressive strength requirements, the City has the option to allow usable concrete to be left in place. However, payment for appropriate item of extra work related to the usable concrete shall be 40 per cent of the Contract Price for the entire contract item or no payment shall be made for the concrete portion of the extra work performed, including any labour and Equipment that was used to supply and/or placement of the concrete.

All replacement lots shall be accepted on the same basis as the original lot.

TS 3.75.09 MEASUREMENT FOR PAYMENT

TS 3.75.09.01 Concrete in Foundation Slab and Streetcar Pavement

Measurement for the above tender item shall be in square metres (m²) regardless of depth. Measurement shall be based on the surface area of the placed concrete, with no additional measurement for the strip of pavement removed to provide space for the forms or the surface area of the existing track allowance.

TS 3.75.09.02 Concrete in Track Margin

Measurement for the above tender item shall be in linear metres (m) regardless of depth.

TS 3.75.09.03 Supplemental Cost for 24-hour Concrete

Measurement of 24-hour concrete shall be by surface area placed in square metres (m²). Concrete delivery tickets shall not be used for measurement purposes.

TS 3.75.10 BASIS OF PAYMENT

**TS 3.75.10.01 Concrete in Foundation Slab and Streetcar Pavement – Item
Concrete in Track Margin – Item**

Payment at the Contract Price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work.

At the discretion of the Contract Administrator, payment for the item may be adjusted according to section TS 3.75.08, herein.

The cost of thickness testing shall be borne by the City unless the results indicate a thickness deficiency of 5 per cent or more, in which case the Contractor shall bear all further costs of thickness testing.

TS 3.75.10.02 Supplemental Cost for 24-hour Concrete – Item

The supplemental cost for 24-hour concrete shall be the premium cost in addition to the cost for 7 day concrete.