



**CONSTRUCTION SPECIFICATION FOR
STEEL REINFORCEMENT FOR CONCRETE**

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905.01 SCOPE

This specification covers the requirements for the placement of all steel reinforcement and mechanical connections for concrete structures.

905.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

- OPSS 909 Prestressed Concrete - Precast Members
- OPSS 910 Stressing Systems for Post-Tensioning

Ontario Provincial Standard Specifications, Material

- OPSS 1440 Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications

Structural Manual

Laboratory Testing Manual:

LS-434 Method of Test for Mechanical Connectors Used to Splice Steel Reinforcement

LS-448 Method of Test for Determination of Tensile Properties of Welded Wire Reinforcement

CSA Standards

G30.18-09 (R2019) Carbon Steel Bars for Concrete Reinforcement

S6-19 Canadian Highway Bridge Design Code

W186-M1990 (R2012) Welding of Reinforcing Bars in Reinforced Concrete Construction

ASTM International

A276 / A276M - 17 Stainless Steel Bars and Shapes

A421 / A421M - 15 Stress - Relieved Steel Wire for Prestressed Concrete

A955 / A955M - 20 Deformed and Plain Stainless Steel Bars for Concrete Reinforcement

905.03 DEFINITIONS

For the purpose of this specification the following definitions apply:

Fabrication means the cutting, bending, storing, bundling, tagging and delivery of stainless and uncoated reinforcing steel bars.

Mechanical Connection means a joining of two reinforcing steel bars, stainless steel reinforcing bars, or post-tensioning tendons by means of a mechanical connector.

Post-Tensioning means a method of prestressing in which tendons are stressed after the concrete has reached a predetermined strength.

Prestressing Steel means steel strand or bar that exhibits the principal attributes of high tensile strength and ductility because of its composition and method of production.

Reinforcing Steel Bars means uncoated deformed steel bars made of carbon steel as defined in CSA G30.18, used for the reinforcement of concrete.

Slip means the axial displacement of the reinforcing bars measured relative to the mechanical connector. Displacement is measured at a rebar stress of 5% of specified yield after the mechanical connection has been loaded to a rebar stress of 50% of specified yield and then unloaded to a bar stress of 5% of specified yield.

Splice Bar means a reinforcing steel bar or stainless steel reinforcing bar that is further manufactured, other than by solely cutting threads, to be compatible with a specific mechanical connector.

Stainless Steel Reinforcing Bars means deformed stainless steel bars as defined in ASTM A955 used for the reinforcement of concrete.

Steel Reinforcement means all types of steel reinforcement for concrete including reinforcing steel bars, stainless steel reinforcing bars, splice bars, steel welded wire reinforcement, and prestressing strands and bars.

Steel Welded Wire Reinforcement means a wire mesh fabricated by means of resistance welding the crossing joints, available in rolls or flat sheets.

Strand means a group of wires laid helically over a central-core wire. A seven-wire strand would consist of six outer wires laid over a single wire core.

Structure means any bridge, culvert, tunnel, retaining wall, wharf, dock, or guideway, or any part thereof, or other reinforced concrete component designed to carry loads, including high mast pole footings and sign support footings.

Swaged means to apply circumferential pressure to a sleeve surrounding a bar to deform the sleeve sufficiently to achieve bearing between the deformed sleeve and the deformations on the bar.

Ultimate Tensile Strength means the breaking load of the material per unit area established by tensile testing.

Yield Strength means the stress at which the material exhibits a specified deviation of proportionality of stress and strain.

905.04 DESIGN AND SUBMISSION REQUIREMENTS

905.04.01 Submission Requirements

905.04.01.01 Working Drawings

905.04.01.01.01 Steel Reinforcement Working Drawings

Three sets of steel reinforcement Working Drawings shall be submitted to the Contract Administrator for information purposes only at least seven Days prior to the commencement of placing steel reinforcement. An Engineer's seal and signature shall be affixed on the Working Drawings verifying that they are consistent with the Contract Documents. The Working Drawings shall include at least the following: quantity, bar size, grade, mark number, location, and spacing for all steel reinforcement.

When a metric to imperial bar size substitution is made, the placing drawings shall include the quantity, bar size, grade, location, and spacing of both the metric and the substitute imperial bar.

When bar marks are indicated on the Contract Documents and reinforcing bar lists show the same bar marks, Working Drawings are not required.

The fabricator shall not commence fabrication until he has received one set of steel reinforcement Working Drawings sealed and signed by an Engineer. The fabricator shall have a copy of the Working Drawings at the manufacturing plant during fabrication.

A sealed and signed copy of these drawings shall be kept at the site before and during placing of steel reinforcement.

905.04.01.01.02 Steel Reinforcement Schedule

Three sets of steel reinforcement schedules shall be submitted to the Contract Administrator for information purposes only at least seven Days prior to the commencement of placing steel reinforcement. An Engineer's seal and signature shall be affixed on the steel reinforcement schedule verifying that they are consistent with the Contract Documents. The steel reinforcement schedules shall include at least: quantity, bar size, grade, reinforcing steel bars, stainless steel reinforcing bars, welded wire reinforcement, type if applicable, length, and bending dimensions.

When bar marks are shown on the Working Drawings, they shall be used in the schedule.

Steel reinforcement shall be detailed according to CSA-S6, and the Structural Manual.

The fabricator shall not commence fabrication until he has received one set of the steel reinforcement schedule sealed and signed by an Engineer. The fabricator shall have a copy of the steel reinforcement schedule at the manufacturing plant during fabrication.

A sealed and signed copy of the steel reinforcement schedule shall be kept at the site prior to and during placement of steel reinforcement.

905.04.01.02 Prestressed Concrete - Precast Members

Submission of proposals and shop drawings for prestressed concrete-precast members shall be according to OPSS 909.

905.04.01.03 Prestressed Concrete - Post-Tensioning

Submissions for post-tensioning shall be according to OPSS 910.

905.04.01.04 Welding Details

Three sets of welding details shall be submitted to the Contract Administrator for information purposes only at least seven Days prior to the commencement of steel reinforcement welding. An Engineer's seal and signature shall be affixed on the Working Drawings verifying that they are consistent with the Contract Documents. The welding details shall include materials, procedures, bars to be welded, location, and type of welds, as well as details of tack welds. Details shall be designed to prevent notching effects in the bars.

A sealed and signed copy of the welding details shall be kept at the site prior to and during welding of reinforcing.

905.04.01.05 Mechanical Connections Details

Three sets of mechanical connection details shall be submitted to the Contract Administrator for information purposes only at least seven Days prior to the commencement of installation of the connectors. Prior to making a submission, an Engineer's seal and signature shall be affixed on the Working Drawings verifying that they are consistent with the Contract Documents.

The connections details shall contain the following information:

- a) The type or series identification of the connector.
- b) The grade and size of the reinforcement to be joined by the connector.
- c) A copy of the manufacturer's catalogue giving complete data on the connector material and installation procedures.
- d) Location of splices, including type of splice.

905.05 MATERIALS

905.05.01 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

905.05.02 Post-Tensioning Materials

Post-tensioning materials shall be according to OPSS 910.

905.05.03 Mechanical Connections Details

905.05.03.01 Post-Tensioning Tendons

When tested in an unbonded condition, mechanical connections for post-tensioning tendons shall develop at least 100% of the ultimate tensile strength of the tendons, without exceeding the anticipated set.

The mechanical connection shall withstand without failure, two million cycles of stress through a range of 245 MPa for plain bars and 195 MPa for strands and ribbed bars. The upper limit of the range shall be 70% of the nominal tensile strength.

905.05.03.02 Reinforcing Steel Bars, Stainless Steel Reinforcing Bars

The mechanical connections shall be qualified by tests made on sample splices according to the Job Control Tests clause.

Mechanical connections for steel reinforcement shall develop, in tension, the greater of 120% of the specified yield strength of the bars or 110% of the mean yield strength of the actual bars used to test the mechanical connection.

The total slip of the reinforcing bars shall not exceed the following measured displacements between gauge points straddling the mechanical connector:

- | | |
|--|---------|
| a) For bar sizes up to and including No. 45M | 0.25 mm |
| b) For No. 55M bars | 0.75 mm |

Splice bars shall be supplied by the manufacturer of the associated mechanical connector.

Stainless steel splice bars shall be used with stainless steel reinforcing bars and shall be of a type according to OPSS 1440.

905.05.04 Mechanical Connectors

905.05.04.01 Post-Tensioning Tendons

Mechanical connectors shall be supplied by the manufacturer of the prestressing system.

905.05.04.02 Reinforcing Steel Bars, Stainless Steel Reinforcing Bars

Mechanical connectors shall be of an approved type and design and may be the form saver type, the filled sleeve type, the swaged sleeve coupler type, the threaded coupler type, the hot rolled thread bar coupler type, or the forged bar coupler type.

Stainless steel mechanical connectors shall be used with stainless steel reinforcing bars and shall be of a type according to OPSS 1440.

905.05.05 Associated Hardware

Only hardware, including spacers and support devices, approved by the Owner shall be used with steel reinforcement and the hardware shall meet the following requirements:

- a) All supports or support systems shall be capable of withstanding the loads to be placed on them.

- b) Except for tie wire, embedded hardware within 50 mm of exposed surfaces shall be stainless steel, galvanized steel, or of a non-metallic material verified not to react with concrete and approved by the ministry prior to use.
- c) Tie wire shall be 1.2 or 1.6 mm in diameter and shall be annealed ferrous wire except for the tie wire used to tie stainless steel reinforcing bars to stainless steel reinforcing bars, reinforcing steel bars, and shear studs, which shall be Type 316 LN or Type 316L, stainless steel wire.
- d) Bar chairs for supporting steel reinforcement shall be non-metallic.
- e) Concrete chairs shall not be used to support steel reinforcement except in footings and against granular surfaces.

905.07 CONSTRUCTION

905.07.01 General

All steel reinforcement and accessories shall be kept clean of all mud, oil, and other deleterious materials and stored clear of ground contact.

Steel reinforcement shall be placed according to the tolerances shown in Table 1. The tolerances listed include fabrication tolerances.

905.07.02 Reinforcing Steel Bars, Stainless Steel Reinforcing Bars, Splice Bars, Stainless Steel Splice Bars and Steel Welded Wire Reinforcing

905.07.02.01 Storage and Protection of Stainless Steel Reinforcing Bars

Stainless steel reinforcing bars shall be stored separately from reinforcing steel bars with the bar tags maintained and clearly visible until ready for placement.

905.07.02.02 Placing

Steel reinforcement shall be accurately placed in the positions as specified in the Contract Documents and held in the correct location during the operations of placing and consolidating concrete.

Bars shall be tied at least at every fourth intersection. The maximum untied length of any bar shall be 1 m.

For slab-on-girder type decks, the top layer of deck reinforcement shall be tied to the shear studs or shear stirrups on each girder at approximately 1.5 m centres.

Spacers for spirals shall be equally spaced around the spiral and shall be so that the specified pitch of the spiral is maintained.

905.07.02.03 Surface Condition

Steel reinforcement other than stainless steel reinforcing bars with rust, mill scale, or a combination of both shall be acceptable, provided the minimum physical properties including height of deformations and mass of a wire brushed test specimen are not less than the applicable specification requirements. Loose scale shall be removed.

Stainless steel reinforcing bars at the time the concrete is placed shall be free of deposits of iron and non-stainless steels.

905.07.02.04 Cutting

The cutting of stainless steel reinforcing bars, reinforcing steel bars, welded wire reinforcement, and splice bars by oxyacetylene torch may be carried out only when permitted in writing by the Contract Administrator.

905.07.02.05 Bending

Field bending of stainless steel reinforcing bars and reinforcing steel bars shall not be permitted, except when specified in the Contract Documents or authorized by the Contract Administrator.

905.07.02.06 Welding

Welding, including tack welding, shall not be permitted except as specified in the Contract Documents or as shown on the welding details submitted to the Contract Administrator.

The welding of stainless steel reinforcing bars and reinforcing steel bars shall be according to CSA W186 and shall be performed by companies certified by the Canadian Welding Bureau according to CSA W186.

Welding shall not be permitted within 3 m of any prestressing steel. Grounding welding equipment to prestressing steel or sheath shall not be permitted.

Except for splicing of stainless spirals, welding of stainless steel reinforcing bars shall not be permitted.

905.07.02.07 Splicing

Welded splices shall develop 100% of the tensile strength of the bar.

Splices for stainless steel reinforcing bars and reinforcing steel other than spirals shall be made as specified in the Working Drawings.

End anchorage of column spiral reinforcement shall be provided either by one and one half extra turns of spiral bar at each end of the spiral, one end embedded in the footing and the other end in the component supported above, or by a 90 degree bend around a longitudinal reinforcing bar plus an extension of at least 24 bar diameters into the core of the column.

Splicing of spiral reinforcing bars by means of a non-welded splice shall be made as specified in the Working Drawings. Non-welded splices shall be affected by mechanical connections or anchoring the ends of the spiral bars by means of a 90 degree bend around a longitudinal reinforcing bar with extensions of at least 24 bar diameters into the core of the column.

905.07.02.08 Mechanical Connections

905.07.02.08.01 General

Mechanical connections shall only be permitted as specified in the Contract Drawings. Locations of mechanical connections shall be as specified in the Working Drawings.

When a mechanical connector type is specified in the Contract Documents, only the specified mechanical connector type shall be used for that application.

The form saver type of mechanical connector shall only be used at construction joints.

The mechanical connections shall be qualified by tests made on sample splices according to the Job Control Tests clause.

All procedures and equipment for mechanical connections shall be according to the manufacturer's recommendations.

Ends of reinforcing bars to be joined shall be cut nominally square.

Connector sleeves shall have the clear cover as specified for the reinforcing steel in that location.

Stirrups, ties, and other reinforcement shall be adjusted or relocated, if necessary, to provide the required clear cover to the reinforcement.

Threads cut on the ends of the reinforcing steel bars shall match the internal threads in the connector.

905.07.02.08.02 Job Control Tests

When mechanical connectors are used, sample connections shall be assembled at the work site in the presence of the Contract Administrator. Frequency of sampling and method of sample assembly shall be according to the Quality Assurance section. Sample connections for testing shall be assembled on site in exactly the same manner as the connectors used in the Work. Sample connections fully assembled anywhere other than on site and in the presence of the Contract Administrator shall not be submitted for testing.

Samples for testing shall be submitted at least 10 Days prior to intended start of concrete placement.

905.07.03 Prestressing Steel for Prestressed Concrete

905.07.03.01 Surface Condition

All prestressing steel shall be clean and free of all rust, oil, dirt, scale, and pitting. Prestressing steel may have a light oxide coating.

905.07.03.02 Placing

Prestressing steel shall be accurately placed in the positions as specified in the Contract Documents and held in the correct location during the operations of placing and compacting concrete.

Prestressing steel shall be placed according to the tolerances shown in Table 1.

Mechanical connections in strand or high strength bars shall not be permitted in the Work, unless specified in the Contract Documents.

Mechanical connections shall be installed according to the recommendations of the manufacturer of the prestressing system used.

905.07.03.03 Welding

Welding of prestressing strand shall not be permitted.

905.07.04 Stressing Systems for Post-Tensioning

Construction requirements for stressing systems for post-tensioning shall be according to OPSS 910.

905.07.05 Inspection after Installation of Steel Reinforcement and Mechanical Connectors

A Request to Proceed shall be submitted to the Contract Administrator upon completion of the installation of the steel reinforcement and, if any, mechanical connectors.

The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

905.07.06 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

905.08 QUALITY ASSURANCE

905.08.01 Sampling

905.08.01.01 Prestressing Steel

The Contractor shall notify the Contract Administrator when prestressing steel is available for sampling.

Samples selected by the Contract Administrator shall be properly labeled by the Contractor for submission at least three weeks in advance of anticipated use to the Owner's laboratory or as directed by the Contract Administrator.

Samples of prestressing steel shall be provided as follows:

- a) For strand; one sample, 1.0 m long from each reel.
- b) For anchorages and connectors; samples shall be selected by the Contract Administrator on a random basis.

905.08.01.02 Reinforcing Steel Bars and Stainless Steel Reinforcing Bars

Reinforcing steel bars and stainless steel reinforcing bars shall be sampled for acceptance on a lot basis. A lot shall consist of reinforcing steel of the same grade, or stainless steel of the same Type and grade, of a single nominal size, and from the same mill and heat.

Three 1.5 m long samples shall be selected on a random basis at the site by the Contract Administrator and shall be accompanied by the mill certificate for that lot.

905.08.01.03 Mechanical Connectors - Sampling for Job Control Test

Mechanical connectors shall be sampled for acceptance on a lot basis. A lot shall consist of all connectors of one size and type from one supplier. If a lot contains more than 300 connectors, it shall be divided into sublots of a maximum of 300 connectors. Sublots shall be of approximately equal size.

The Contractor shall assemble six sample connections per subplot or six sample connections per lot if there are less than 300 connectors. The reinforcing bars from which the test samples are to be fabricated shall be selected on a random basis at the site by the Contract Administrator. The length of each bar to be joined shall be at least 500 mm. The same materials, position, location, equipment, and procedures as are being used to make connections in the reinforcing bars in the work shall be used when making the sample connections.

The Contractor shall complete Owner Standard Form, PH-CC-812, Field Sample Data Sheet-Mechanical Connectors, for each assembled sample. The Contractor shall submit the samples and the completed forms along with mill test certificates corresponding to the bars used, to the Contract Administrator for delivery to the laboratory designated by the ministry.

905.08.01.04 Steel Welded Wire Reinforcement- Sampling for Tensile Strength

Welded wire reinforcement shall be sampled for acceptance on a lot basis. A lot shall be 7000 m² of welded wire reinforcement or fraction thereof.

A minimum of five samples shall be taken per lot for testing and shall be extracted from the same sheet of mesh. Each specimen shall be a minimum length of 500 mm and shall contain at least one cross-wire in its middle section. The sampling time and location shall be determined by the Contract Administrator.

905.08.02 Testing

905.08.02.01 Prestressing Steel

The testing of prestressing steel shall be according to ASTM A421.

905.08.02.02 Reinforcing Steel Bar and Stainless Steel Reinforcing Bar

The testing of reinforcing steel bar shall be according to CSA G30.18 and the testing of stainless steel reinforcing bar shall be according to ASTM A276 and ASTM A955. Testing shall be carried out at the discretion of the ministry.

905.08.02.03 Mechanical Connections

905.08.02.03.01 Testing for Torque

When required by the manufacturers' installation procedure, torque shall be checked on 5% of the splices. Formwork that limits access to connectors for testing purposes shall not be placed until testing has been completed.

905.08.02.03.02 Job Control Test

Three of the six sample connections for each lot or subplot shall be tested for acceptance and the remaining three samples shall be retained by the testing laboratory for referee testing, if invoked.

The samples shall be tested for slip and tensile strength according to LS-434.

If one or more of the three test samples fails to meet the requirements of this specification for either the slip or tensile strength, the lot or subplot represented by the samples shall be rejected.

Individual test results shall be forwarded to the Contractor, as they become available.

905.08.02.03.03 Job Control Test - Referee Testing

Referee testing of mechanical connectors may be invoked by the Contractor within five Business Days of receiving the test result.

When referee testing is invoked, the three retained referee samples will be tested by the referee laboratory designated by the ministry. The samples shall be tested for slip and tensile strength according to LS-434.

Referee test results shall be forwarded to the Contractor, as they become available.

If one or more of the referee samples fails to meet the requirements of this specification for either the slip or tensile strength, the Acceptance Testing results are confirmed and shall be the basis of acceptance.

When all three referee samples meet the requirements of this specification for slip and tensile strength, the Acceptance Testing results are not confirmed and the referee test results shall replace the Acceptance Testing results as the basis of acceptance.

905.08.02.03.04 Referee Testing Cost

The cost of mechanical connector referee testing shall be as specified in the Contract Documents. When the referee results indicate that the acceptance test results for refereed lot or subplot are not confirmed, the Owner shall bear the cost. When the referee results indicate that the acceptance test results for refereed lot or subplot are confirmed, the Contractor shall be charged the cost of mechanical connector testing.

905.08.02.04 Steel Welded Wire Reinforcement for Tensile Strength

Testing of tensile strength of welded wire reinforcement shall be according to LS-448.

The lot of material shall be considered acceptable if the average of the valid test results meet or exceed 4% elongation, the specified yield strength and none of the individual valid test results have less than 3.2% elongation.

A minimum of three valid test results is required for acceptance. If less than three valid test results are obtained then the lot of material shall be resampled and tested until a total of five valid test results are obtained. No valid test results shall be discarded.

Unacceptable lots shall be rejected and replaced.

905.09 MEASUREMENT FOR PAYMENT

905.09.01 Actual Measurement

**905.09.01.01 Mechanical Connectors
Stainless Steel Mechanical Connectors**

For measurement purposes, a count shall be made of the number of connectors installed.

905.09.02 Plan Quantity

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

905.10 BASIS OF PAYMENT

**905.10.01 Reinforcing Steel Bar - Item
Stainless Steel Reinforcing Bar - Item**

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

**905.10.02 Mechanical Connectors – Item
Stainless Steel Mechanical Connectors – Item**

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

TABLE 1
Tolerances for Cover and Placing Accuracy

TYPE	TOLERANCE (mm)	
Steel Reinforcement	Cast-in-Place Concrete	Precast Concrete
	Cover to Surface of Concrete and Placing Accuracy (Notes 1 and 2)	
a) Principal Steel Reinforcement	± 20	± 10
b) Concrete Cast Against and Permanently Exposed to Earth	± 25	
c) Stirrups in Webs		+ 5, - 3
d) Stirrups, Ties, Spirals	± 20	± 10
e) Deck Slab i) Top ii) Bottom	± 20 ± 10	± 15 ± 10
f) Remainder	± 30	± 30
g) Lateral spacing in slabs and walls	± 30 (Note 3)	± 30 (Note 3)
h) Longitudinal location of bends and ends of bar in continuous member	± 50	± 50
i) Longitudinal location of bends and ends of bar at discontinuous end	± 20	± 20
Prestressing Steel	Placing Accuracy Horizontal and Vertical	
a) Prestressing strands or bars		± 5
<p>Notes:</p> <ol style="list-style-type: none"> The cover to the concrete surface shall not be reduced by more than one-third of the specified cover. The clear distance between bars shall not be less than one and one-half times the nominal diameter of the bar, one and one-half times the nominal size of the coarse aggregate, or 40 mm. In two or more layers, the rebar shall be directly above one another and the clear distance between layers shall not be less than 25 mm. The tolerances e) through f) do not apply to the lateral spacing of bars in slabs and walls. The number of bars specified per metre width shall be placed in the metre width. 		