DIAMOND
PRECAST CONCRETE &
MUNICIPAL CASTINGS

Compliance Documentation

MMCD Platinum *[2009 Edition]*

Section 33 44 01 - Manholes and Catchbasins

A23.4-09 - D1
ASTM C478M

PLATINUM
2009 EDITION

diamondprecast.com/mmcd

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MUNICIPAL CASTINGS

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SUPPORTING MEMBER
MMCD
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Contents

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March 3, 2016

Diamond Precast Concrete Ltd.
7520 Conrad Street
Burnaby, BC V5A 2H7

Re: *Compliance with MMCD Platinum Section 33 44 01 - Manholes and Catchbasins*

To comprehensively assess all MMCD Platinum 33 44 01 requirements, the following documents were reviewed:

1. MMCD Platinum Edition - Section 33 44 01 Manholes and Catchbasins (with accompanying Standard Detail Drawings S1 thru S15)
2. ASTM C478M – Standard Specification for Circular Precast Reinforced Manhole Sections
3. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures (Includes Oil-Water Separators)
4. CSA 23.4-09 – Precast Concrete Materials and Construction
5. Diamond Precast Concrete - Certificate of Compliance to CSA 23.4-09
6. Diamond Precast Concrete - Certificate of Compliance to CSA Standard for Reinforced Circular Manhole Sections and Catch Basins - Certified to ASTM Standards for Canada (ASTM C478M)
7. Diamond Precast Concrete - Quality Control Manual
8. Diamond Precast Concrete - Structural Drawings
9. Standards Council of Canada - Accredited Third Party Certification Bodies (includes CSA)
10. Standards Council of Canada - Scope of Accreditation for CSA Group (includes ICS No. 91.100.30)

MMCD Platinum Edition Section 33 44 01 Manholes and Catchbasins make the following relevant references:

> *1.0 GENERAL .1 This section must be referenced to and interpreted simultaneously with all other sections pertinent to the works described herein.*
>
> *1.4 Material Certification .1 Products having CSA certification to be used where readily available. Product to be certified to CSA standard(s) by an approved independent third party certification body accredited by the Standards Council of Canada.*
>
> *2.1 Materials*
>
> *.4 Precast manhole sections: to be precast reinforced concrete to ASTM C478M complete with ladder rungs.*
> *.6 Manhole lids manufactured from precast reinforced concrete. shall be designed to withstand H20 loading.*
> *.8 Ladder rungs to be:*
> *.2 To conform to .. ASTM C478M load test.*
> *.10 Precast catchbasin sections:*
> *.2 To be precast reinforced concrete to ASTM C478M.*

.12 Catchbasin lids: to be designed to withstand H20 loading.
.16 Adjusting rings manufactured to:
.1 Concrete to ASTM C478M
.22 Prebenched manhole bases:
.1 Where precast manhole sections are incorporated into precast base by bonding to concrete benching, use precast reinforced concrete manhole sections to ASTM C478M complete with ladder rungs above benching.
.2 Where base benching is cast monolithically with manhole walls, reinforce wall and joint sections as specified in ASTM C478M

MMCD Platinum Section 33 44 01 1.0.1 states requirement to *"…reference …and interpret …simultaneously with all other sections pertinent to the works described herein."* This requires simultaneous reference and interpretation of design standard ASTM C478M (plus ASTM C913), quality standard CSA 23.4-09, SCC 3rd party verification, and Diamond Precast Concrete's internal design and quality documentation.

Diamond Precast Concrete's Manhole and Catchbasin products are designed in accordance with ASTM C478M as required by MMCD Platinum 33 44 01. (ASTM C913 was followed for Oil-Water Separators)

MMCD Platinum Section 33 44 01 1.4.1 requires: "*Product to be certified to CSA standard(s) by an approved independent third party certification body accredited by the Standards Council of Canada.*" Diamond Precast Concrete is certified to CSA Standard 23.4-09. CSA provides third party certification to Diamond Precast Concrete. CSA's scope of Standards Council of Canada accreditation includes the Structural Safety and Performance of Concrete and Concrete Products (ICS No. 91.100.30).

In some applications concrete structures are at risk of corrosion, scouring, infiltration or exfiltration. In such applications Diamond Precast Concrete integrates Concrete Protective Liners into its concrete products as protection to the at risk concrete. Concrete Protective Liners are non-structural elements. They do not add or take away from the structural integrity of the underlying precast concrete product. Diamond Precast Concrete products with Concrete Protective Liners comply with MMCD Platinum 33 44 01 so long as they conform to all 33 44 01's requirements.

Upon comprehensive review, Diamond Precast Concrete Manholes and Catchbasins meet all requirements of MMCD Platinum Section 33 44 01.

Sincerely,

Vincent Wang, P.Eng.(Structural)
APOC Engineering Ltd.

Certificate of Compliance

Certificate: 70055917 **Master Contract:** 260881

Project: 70055917 **Date Issued:** March 2, 2016

Issued to: **Diamond Precast Concrete Ltd.**
7520 Conrad Street,
Burnaby, BC, V5A 2H7
Canada
Attention: Mr. Jed Friesen, President

The products listed below are eligible to bear the CSA Mark shown

Issued by: *Justin Billey*
Justin Billey Justin Billey

PRODUCTS

CLASS - C808306 - PRECAST CONCRETE – Reinforced Circular Manhole Sections and Catch Basins-Certified to ASTM Standards for Canada

For details related to rating, size, configuration, etc. reference should be made to the CSA Certification Record or the descriptive report.

Certification of prefabricated circular reinforced concrete manhole sections and catch basins including the followings:

1) **Grade rings** used for final adjustment of manholes to grade;
2) **Flat slab tops** used in the construction of manholes for use in sewer, drainage, and water works;
3) **Risers and Conical Tops** used in construction of manholes for use in sewer, drainage, and water works;
4) **Base Sections** used in the construction of manholes used in sewer, drainage, and water works; and
5) **Steps and Ladders** used for providing access through manholes for use in sewer and water works.

CSA certification covers the manufacturing and performance requirements of products used for the assembly and construction of circular vertical precast reinforced concrete manholes and structures used in sewer, drainage, and water works under the following conditions:

a) This certification program covers the manufacturing requirements in the factory and does not include requirements for site backfill, or the relationship between field load conditions and the strength requirements of the manhole & catch basin products and appurtenances.
b) This certification program does not include certification to CSA A257 Standard.

c) This certification program does not include concrete pipes.

d) Some provinces in Canada reference ASTM standards as the compliance standards for these products, this report covers certification in Canada for the ASTM standards referenced below.

APPLICABLE REQUIREMENTS

ASTM Standard C478M – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM Standard C139 – Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes

MARKINGS

The manufacturer is required to apply the following markings:

- Products shall be marked with the markings specified by the particular product standard.
- Products certified for Canada shall have all Caution and Warning markings in both English and French.

Additional bilingual markings not covered by the product standard(s) may be required by the Authorities Having Jurisdiction. It is the responsibility of the manufacturer to provide and apply these additional markings, where applicable, in accordance with the requirements of those authorities.

Individual circular reinforced concrete manhole sections and catch basins shall be legibly marked with the following information, in a permanent manner, either on the product or on a tag attached to the product, or on the documentation accompanying the product (provided the latter is cross-referenced with the documentation), or by any other means acceptable to CSA Group:

1) Manufacturer's name, trade name, trademark, or CSA file number;
2) Specification and product designation: MH for manhole base, riser, conical tops, and grade rings;
3) Date of manufacturing; and
4) CSA Mark.

Marking shall be indented into the concrete at the time of manufacturing or shall be painted thereon with waterproof paint or ink. Certain jurisdictions in Canada require the use of French language in markings. It is the responsibility of the manufacturer to determine where this is required

Supplement to Certificate of Compliance

Certificate: 70055917 **Master Contract:** 260881

The products listed, including the latest revision described below, are eligible to be marked in accordance with the referenced Certificate.

Product Certification History

Project	Date	Description
70055917	March 2, 2016	Certification of Reinforced Circular Manhole Sections and Catch Basins, Certified to ASTM Standards for Canada

CSA Group

Certificate of Qualification
Pre-cast Concrete Products
Certification Program

This is to certify that

Diamond Precast Concrete Ltd.
at
7520 Conrad Street, Burnaby, BC, V5A 2H7

has been qualified by CSA Group, Certification and Testing, as a manufacturing facility of pre-cast concrete products under the CSA Pre-cast Concrete Products Certification Program in accordance with CSA Standard A23.4-09 – Precast Concrete, Materials and Construction; in the following categories:

Group D – Standard Drainage Products: D1
Group S – Standard Products without Architectural Finish

Issued by: Richard A. Frederick

Authorized by: Neil Forsyth

Date Issued: March 24, 2015
Date Expires: March 24, 2017

Master Municipal Construction
Documents Association

The Documents of Choice

www.mmcd.net

Platinum Edition

Published by:
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Printed 2009

1.0 GENERAL

.1 Section 33 44 01 refers to those portions of the work that are unique to the supply and installation of manholes, cleanouts, catchbasins, storm sewer endwalls, lawn drains and related appurtenances. This section must be referenced to and interpreted simultaneously with all other sections pertinent to the works described herein.

1.1 Related Work

.1	Excavating, Trenching and Backfilling	Section 31 23 01
.2	Storm Sewers	Section 33 40 01
.3	Sanitary Sewers	Section 33 30 01
.4	Concrete Reinforcement	Section 03 20 01
.5	Cast-in-Place Concrete	Section 03 30 53

1.2 References

.1 The abbreviated standard specifications for testing, materials, fabrication and supply, referred to herein, are fully described in Section 01 42 00 – Reference Specifications – Site and Infrastructure.

1.3 Samples

.1 Samples may be required.

1.4 Material Certification

.1 Products having CSA certification to be used where readily available. Product to be certified to CSA standard(s) by an approved independent third party certification body accredited by the Standards Council of Canada and that is acceptable to the Contract Administrator. Products to be marked with certification body logo and CSA standard markings.

.2 At least 14 days prior to commencing work, submit to the Contract Administrator the manufacturer's recent test data and certification that materials to be incorporated into works are representative and meet requirements of this section. Include manufacturer's drawings where pertinent.

1.5 Measurement and Payment

.1 Payment for manholes will be made by items or components installed for each type and size as shown on Contract Drawings and specified in Schedule of Quantities and Prices. No payment will be made for excavation and all other associated work required to accommodate manhole in the new sewer system constructed under this Contract for which manhole forms a part.

.1 Payment for manhole base, lid, slab, frame and cover includes all components shown on Standard Detail Drawings for manholes except riser. Payment includes dewatering, base preparation, all in-situ concrete work.

.2 Payment for manhole riser sections will be for risers of standard or non-standard heights required to complete manhole from specified invert to finishing level. Payment includes all risers and necessary work for installing risers as shown on e Standard Detail Drawings. Measurement will be made vertically for the length of risers required from the top of the manhole base or tee section to reach the underside of concrete lid or slab.

.3 Payment for precast manhole tee for "Tee" manhole on large sewers will be for additional cost of providing a special mainline pipe section with a tee opening ready to receive the first standard manhole riser including rungs within tee as shown on Standard Detail Drawing S5. Payment for installation of precast tee section will be deemed as sewer installation with no other additional payment.

Payments for lid, slab, frame and cover and riser sections to complete "Tee" manhole will be made under 1.5.1.1 & 2 of this Section.

Measurement will be for each unit of precast tee of specified tee and pipe diameters required and installed.

.4 Payment for re-benching existing manholes includes all the materials and work including dewatering and temporary water diversion to enable re-benching the existing manholes to change the direction or pattern of flows.

.5 Additional payment for drop or ramp type manhole connections as shown on Standard Detail Drawings S3 and S4 including re-benching will be made for each drop or ramp type manhole connection as shown on the Contract Drawing.

.6 Payment for constructing additional manholes onto existing sewer system will be made under appropriate items in this Section including all excavation, dewatering, breaking into existing system, disposal of surplus excavated material, supply of all components, cast-in-place concrete, pipe, fittings and related materials, bedding, imported or native backfill as shown on Contract Drawings, cleaning, testing where applicable, surface restoration and all other work and materials necessary to complete the installation.

.2 Payment for catchbasins, lawn drains, cleanouts, and inspection chambers will be for each type, size and depth range constructed to details shown on Standard Detail Drawings as applicable under respective payment items. Payment includes excavation, disposal of surplus excavated material, supply of all units, cast-in-place concrete, pipes, fittings and related materials, bedding, imported or native backfill as shown on Contract Drawings, cleaning, testing where applicable, surface restoration and all other work and materials necessary to complete the installation as shown on Contract Drawings and specified herein.

.3 Payment for adjustment of tops of existing catchbasins, lawn drains, cleanouts, and inspection chambers will only be made for adjustments not related to paving work under Section 32 12 16 - Hot-Mix Asphalt Concrete Pavement and 32 13 13 - Portland Cement Concrete Pavement.

.4 Payment for removal of existing catchbasins, lawn drains, cleanouts, and inspection chambers includes excavation, backfilling and, where applicable, temporary and permanent paving surface restoration.

.5 Payment for concrete bedding, encasement, backfill, or controlled density fill, where shown on Contract Drawings or directed by Contract Administrator, will be additional to items described above. No payment will be made for concrete bedding, encasement, backfill, or controlled density fill required as a result of unauthorized excavation beyond neat lines or limits of excavation shown on Contract Drawings or Standard Detail Drawing G4.
Payment will be based on volume calculated from actual measurement of dimensions of components constructed as detailed in Contract Drawing.

.6 Payment for asphalt apron around catchbasin includes the preparation of base, supplying, hand forming and compacting asphalt around the catchbasin to channel the surrounding flow into the catchbasin, all to details as shown on Contract Drawings.

1.6 Inspection and Testing

.1 Refer to General Conditions, Clause 4.12, Inspections.

2.0 PRODUCTS

2.1 Materials

.1 Concrete: To Section 03 30 53 - Cast-in-Place Concrete.

.2 Concrete to be minimum 20 MPa or as specified otherwise on Contract Drawings.

.3 Concrete reinforcement: to Section 03 20 01 - Concrete Reinforcement.

.4 Precast manhole sections: to be precast reinforced concrete to ASTM C478M complete with ladder rungs.

.5 Precast "Tee" Sections: precast "Tee" sections constructed as an integral component of mainline pipe will be acceptable where shown on Contract Drawings as an approved alternative.

.6 Manhole lids manufactured from precast reinforced concrete or PVC shall be designed to withstand H20 loading.

.7 Cast iron frame and cover: as shown on Standard Detail Drawing S1 and as specified in Municipal Supplementary Specifications.

.1 Frame and cover must conform to ASTM A48 and be designed to withstand H20 loading.

.2 Frame and cover must bear manufacturer identification on castings

.8 Ladder rungs to be:

.1 As shown on Standard Detail Drawing S1.

.2 To conform to ASTM C497, ASTM C478M load test.

.3 20 mm cold rolled steel, hot dipped after bending to CSA G164, welded to reinforcing bars and cast with manhole sections or epoxy grouted into manhole walls.

.4 20 mm aluminum alloy #6351-T6 (CSA S157 and NBC 1977), complete with polyethylene anchor insulating sleeves and installed in 25 mm or 26 mm precast or drilled holes in manhole sections.

.5 Polypropylene encased steel ladder rungs: polypropylene ASTM D4101 steel core to be ½ inch dia grade 60 as per ASTM A615M.

.6 Distance from top of manhole cover to top rung to be maximum 500 mm where no handhold provided. Maximum distance may be extended to 660 mm where handhold provided.

.7 In compliance with all requirements of Worksafe BC.

.9 Safety platform: to be installed as shown on Contract Drawings in all manholes in excess of 6 m deep.

.10 Precast catchbasin sections:

.1 As shown on Standard Detail Drawing S11.

.2 To be precast reinforced concrete to ASTM C478M.

.11 Catchbasin leads to be minimum 150 mm diameter and of PVC DR35.

.12 Catchbasin lids: to be designed to withstand H20 loading.

.13 Cast iron catchbasin frame and grate: as shown on Standard Detail Drawing S11 or as specified otherwise in Supplementary Specifications.

.1 Frame and grate must conform to ASTM A48 and be designed to withstand H20 loading.

.2 Frame and grate must bear manufacturers identification on casting.

.14 Joints: make watertight using cement mortar or rubber gaskets to ASTM C443M.

.15 Mortar:

.1 Aggregate: to CSA A82.56.

.2 Cement: to CAN/CSA-A8.

.16 Adjusting rings manufactured to:

.1 Concrete to ASTM C478M

.2 HDPE to ASTM D1248

.17 Concrete Brick: to CAN3-A165 Series.

.18 Drop manhole pipe: to be as shown on Contract Drawings.

.19 Lawn drains to be: As shown on Standard Detail Drawing S12.

.20 Concrete bags to be: Jute, burlap or synthetic bag of suitable size and texture filled to 2/3 capacity with mixture of 1 part Portland cement to 2 parts sand, thoroughly mixed, and weighing approximately 27 kg.

.21 Concrete blocks: to be H type concrete construction blocks conforming to latest ASTM specifications.

.22 Prebenched manhole bases:

.1 Where precast manhole sections are incorporated into precast base by bonding to concrete benching, use precast reinforced concrete manhole sections to ASTM C478M complete with ladder rungs above benching.

.2 Where base benching is cast monolithically with manhole walls, reinforce wall and joint sections as specified in ASTM C478M.

.3 Precast concrete base section minimum thickness to be 120 mm, measured from underside of base to lowest point in concrete channelling.

.23 Pre-fabricated Corrugated Steel Pipe Manholes may be used with installation of Corrugated Steel Storm Sewers. Pre-fabricated Corrugated Steel Pipe Manholes to be as shown on the Contract Drawings and in accordance with the manufacturers specifications.

3.0 EXECUTION

3.1 Excavation and Backfill

.1 Excavate and backfill in accordance with Section 31 23 01 - Excavating, Trenching and Backfilling.

3.2 Concrete Work

.1 Place concrete reinforcement in accordance with Section 03 20 01 - Concrete Reinforcement.

.2 Do concrete work in accordance with Section 03 30 53 - Cast-in-Place Concrete.

3.3 Manhole Installation

.1 Install manholes as shown on Standard Detail Drawings, concurrently with pipe laying.

.2 Ensure excavation free of water prior to placing concrete.

.3 Place minimum 100 mm of 25 mm bedding gravel compacted to minimum 95% Modified Proctor density in compliance with ASTM D1557.

.4 Construct base to ensure first precast riser section is set plumb.

.5 Set all inlet and outlet pipes to specified alignments and elevations.

.6 Connect concrete pipe into manhole using spigot or bell precast into manhole wall or, alternatively, grout pipe into pre-formed rough core in manhole wall using fast-setting grout.

.7 Connect PVC pipe into manhole using "manhole adapter ring" or approved equal.

.8 Ensure placement of concrete does not disturb connecting pipes.

.9 Set remaining precast riser sections plumb with joints consisting of cement mortar or gaskets to ASTM C443M.

.10 Where possible, form channelling using half-sections of pipe or suitable fittings. Bench to direct flow parallel to main flow of sewer. Form top of benching as high as crown of sewer pipe. Finish concrete to smooth surface using steel trowel.

.11 Brace capped inlets or stubs to withstand testing head.

.12 Installation of Masonry & Cementitious Riser Rings:

.1 Allowable number of courses is three and minimum is one.

.2 Allowable products is; bricks, precast concrete risers, and cast-in-place form system

.3 Due regard must be observed to the maximum distance to the first step.

.4 Pre-wet all joints before placing Mortar.

.5 Butter inside and outside paces of brick with mortar to ensure neat even grout.

.6 Grout inside, outside and between courses or grade rings with mortar to ensure neat even finish.

.13 Installation of interlocking High Density Polyethylene Manhole Adjustment Riser Rings.

.1 Insure base has a flat seating area, remove all protrusions.

.2 Dry stack (without sealant) necessary flat and bevelled rings to provide necessary grade and cross fall with casting.

.3 Apply a vertical strip of paint to allow identical reassembly, after disassembling casting and rings.

.4 Apply a 12mm bead of approved sealant to the underside circumference of the ring against the male lip. A second bead is required for the base ring and may be applied directly to the concrete base.

.5 Continue with step 4 until all adjustment rings are sealed together.

.6 Also place sealant on the top of the last ring prior to installing the casting

.7 Provide a dry mix around the stack, protecting the rings from contact with hot asphalt.

.8 Approved sealants as per the manufacturer, conforming to ASTM D1850.

.14 Plug lifting holes in pipe.

.15 Install drop structures where required to Standard Detail Drawings S3 and S4.

.16 Paint manhole covers if specified in Supplementary Specifications.

.17 Ensure frames conform to design contour of pavement or existing surface.

.18 Pre-fabricated Corrugated Steel Pipe Manholes to be installed as shown on the Contract Drawings and to manufacturers specifications.

3.4 Cleanout Installaton

.1 Install cleanouts as shown on Standard Detail Drawing S6 to standards and installation procedures described in 3.3 of this Section

3.5 Catchbasin Installation

.1 Install catchbasins as shown on Standard Detail Drawing S11, to general standards and installation procedures described in 3.3 of this Section.

.2 Place minimum of 100 mm bedding gravel under base, compact to 95% Modified Proctor density.

.3 Install catchbasin leads in accordance with Section 33 40 01 – Storm Sewers.

3.6 Lawn Drain Installation

.1 Install lawn drains as shown on Standard Detail Drawing S12.

3.7 Endwall Installation

.1 Install concrete block endwalls as shown on Standard Detail Drawing S14 using H type concrete construction blocks.

.2 Install reinforced concrete endwalls as shown on Standard Detail Drawing S13 or as shown otherwise on Contract Drawings and in accordance with Section 03 20 01 - Concrete Reinforcement and Section 03 30 53 - Cast-in-Place Concrete.

.3 Precast concrete endwalls may be installed where shown on Contract Drawings as an approved alternative.

3.8 Grillage Trash Screens

.1 Where specified, install grillage trash screens as shown on Standard Detail Drawing S13.

3.9 Adjusting Tops of Existing Units

.1 Remove existing gratings, frames and store for re-use at locations specified in Supplementary Specifications.

.2 Precast units:

.1 Raise or lower precast units by adding or removing precast sections as required.

.2 When amount of raise is less than 300 mm use standard manhole bricks, precast riser rings or cast-in-place form system.

.3 Cast-in-Place units:

.1 Raise cast-in-place units by roughening existing top to ensure proper bond and extend to required elevation with cast- in-place concrete.

.2 Lower cast-in-place units with straight wall by removing concrete to elevation indicated for rebuilding.

.3 Install additional manhole ladder rungs in adjusted portion of units as required.

.4 Re-use existing gratings, frames.

.4 Re-set gratings and frames to required elevation on not more than 3 courses of brick. Make brick joints and join brick to frame with cement mortar, parge and trowel smooth.

.5 Ensure adjustments conform to requirements regarding distance to first step.

3.10 Remove Existing Units

.1 Remove existing structures where shown on Contract Drawings. Backfill in accordance with Section 31 23 01 - Excavating, Trenching and Backfilling.

3.11 Leakage Test

.1 Perform leakage testing of sanitary manholes in accordance with Section 33 30 01 - Sanitary Sewers.

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END OF SECTION 33 44 01

STORM AND SANITARY SEWERS

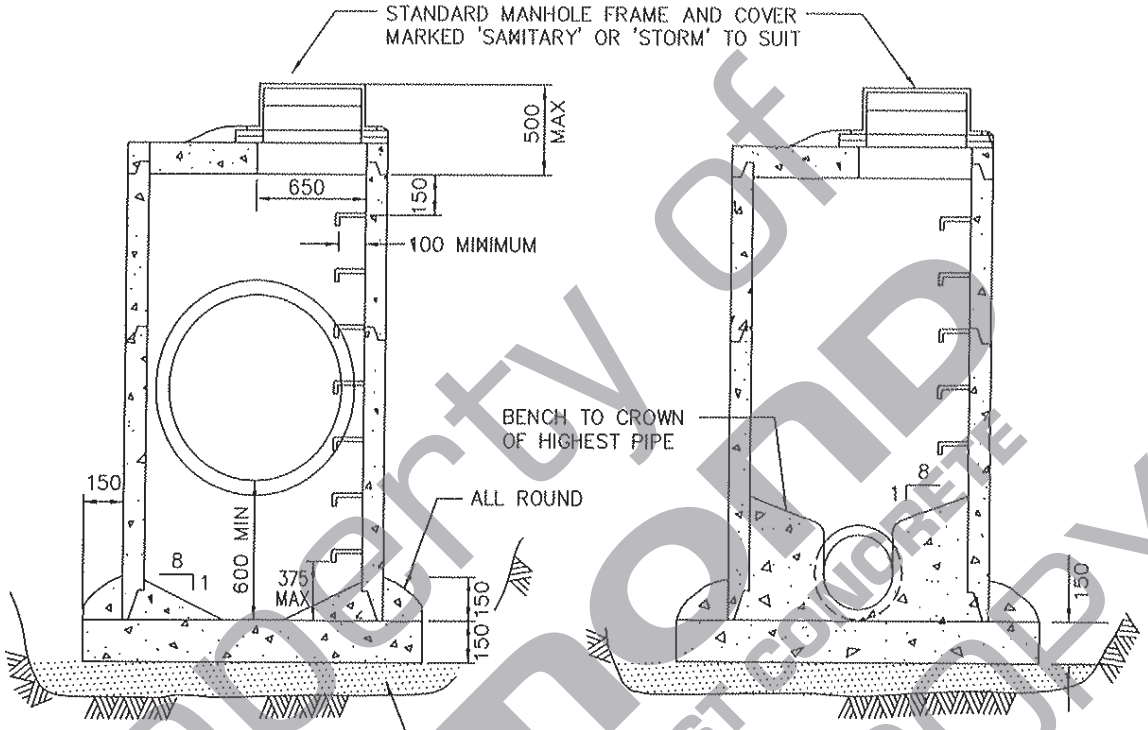
S1	STANDARD AND SUMP MANHOLES
S2	STANDARD MANHOLE CONNECTION DETAILS
S3	MANHOLE CONNECTION DETAILS – DROP AND RAMP TYPE
S4	INSIDE DROP MANHOLE
S5	PRECAST RISER MANHOLE
S6	SEWER CLEANOUT
S7	SANITARY SEWER SERVICE CONNECTION
S8	STORM SEWER SERVICE CONNECTION
S9	INSPECTION CHAMBER FOR 100 TO 200 SANITARY SEWER CONNECTION
S10	INSPECTION CHAMBER FOR 250 TO 375 STORM SEWER CONNECTION
S11	TOP INLET CATCHBASIN
S12	LAWN DRAINS
S13	STORM SEWER INLET WITH SAFETY GRILLAGE
S14	CONCRETE BLOCK ENDWALL
S15	DRIVEWAY CULVERT WITH CONCRETE BLOCK ENDWALLS

NOTE: 1. ALL DIMENSIONS ON STANDARD DETAIL DRAWINGS SHOWN IN MILLIMETRES UNLESS STATED OTHERWISE.

2008

DRAWING INDEX – STORM AND SANITARY SEWERS

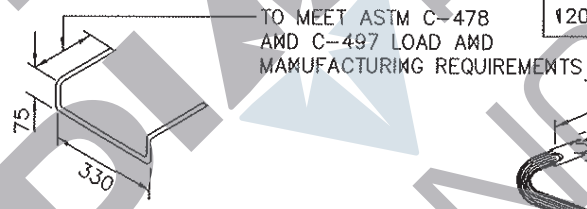
DRAWING NUMBER: **S0**



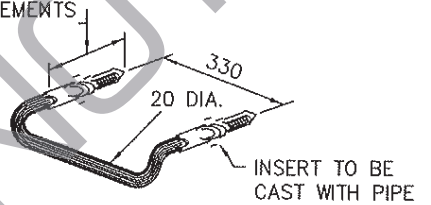
MANHOLE WITH SUMP

STANDARD 1050mm MANHOLE

INSIDE PIPE DIA.	INSIDE MANHOLE DIA.
450mm AND LESS	1050
525 AND 600	1200
675 AND 750	1350
900 AND 1050	1500
1200 AND OVER	RISER MANHOLE



GALVANIZED LADDER RUNG
TO BE CAST WITH PIPE



GALVANIZED, ALUMINUM OR POLY-
ENCASED LADDER RUNG

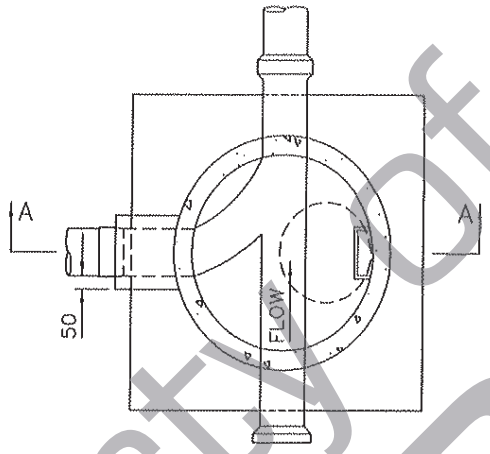
NOTE:
1. DETAILS ARE DRAWN FOR PRECAST RISERS ON CAST-IN-PLACE BASE. PRECAST BASES APPROVED BY CONTRACT ADMINISTRATOR ARE ACCEPTABLE.
2. MAXIMUM DEPTH TO FIRST RUNG IS 500mm. WHEN HANDHOLD IS INSTALLED BETWEEN TOP AND FIRST RUNG, MAXIMUM DEPTH MAY BE INCREASED TO 660mm
3. FOR MANHOLES OVER 1200mm DIA. BASE THICKNESS TO BE 200mm.
4. REFER TO DRAWING S2 FOR CONNECTION DETAILS.
5. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

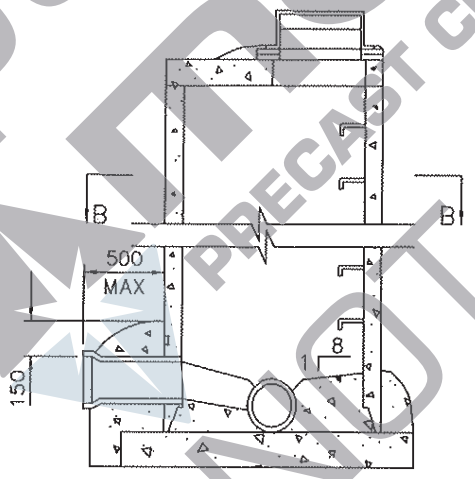
2008

STANDARD AND SUMP MANHOLES

DRAWING NUMBER:
S1



SECTION B–B



SECTION A–A

NOTE: 1. THIS DRAWING SHOWS CONNECTION DETAILS ONLY, REFER TO DRAWING S1 FOR ALL OTHER DETAILS PERTAINING TO MANHOLE REQUIREMENTS AND INSTALLATION

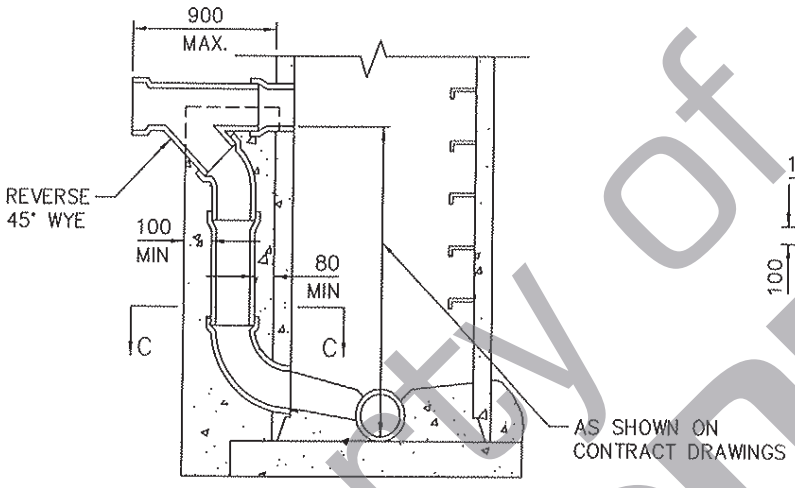
2. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

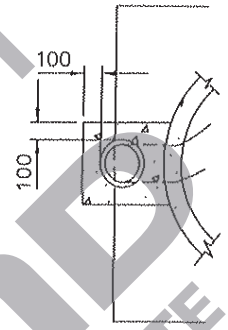
2008

STANDARD MANHOLE CONNECTION DETAILS

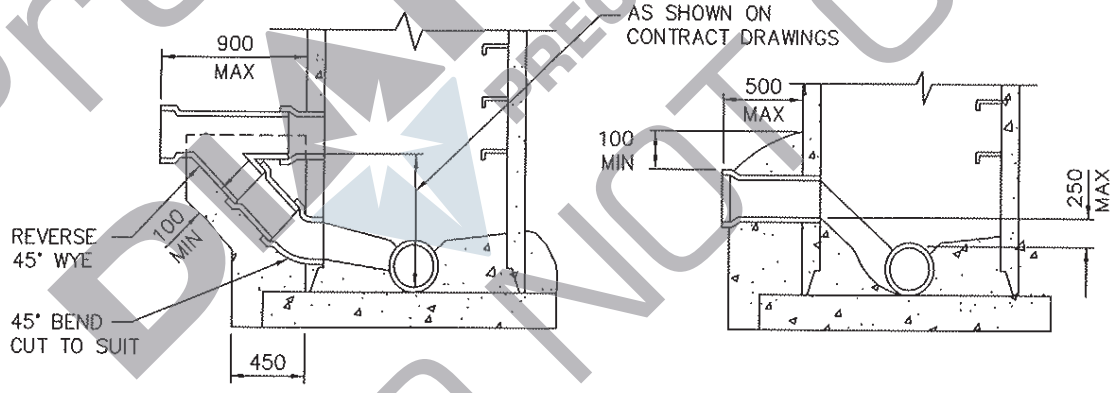
DRAWING NUMBER: **S2**



OUTSIDE DROP TYPE



SECTION C--C



OUTSIDE RAMP TYPE

INSIDE RAMP TYPE

NOTE: 1. THIS DRAWING SHOWS CONNECTION DETAILS ONLY, REFER TO DRAWING S1 FOR ALL OTHER DETAILS PERTAINING TO MANHOLE REQUIREMENTS AND INSTALLATION.

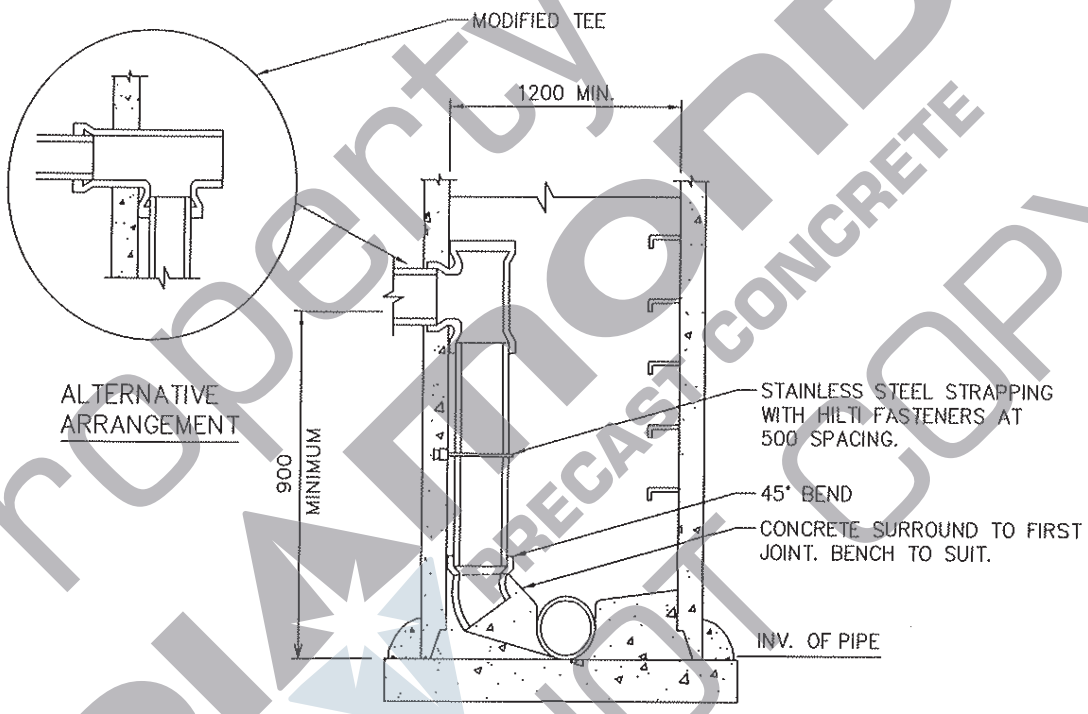
2. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

2008

MANHOLE CONNECTION DETAILS – DROP AND RAMP TYPE

DRAWING NUMBER: **S3**



INSIDE DROP TYPE

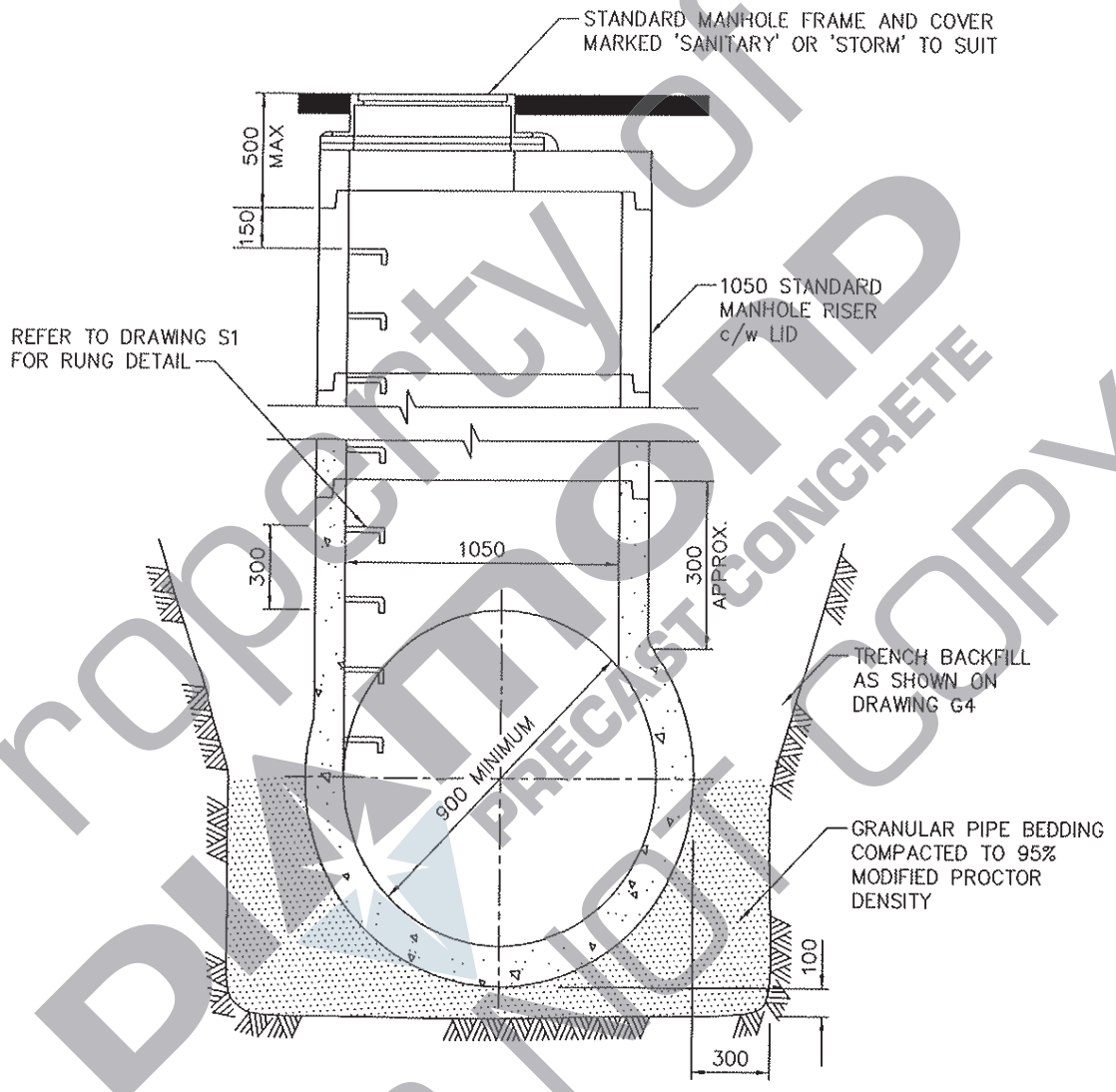
NOTE:
1. INSIDE DROP TO BE USED ONLY WHERE SPECIFIED BY CONTRACT ADMINISTRATOR.
2. ALL INSIDE PIPE AND FITTINGS PVC DR 28/35
3. THIS DRAWING SHOWS INSIDE DROP ONLY. SEE DRAWING S1 FOR ALL OTHER DETAILS PERTAINING TO MANHOLE REQUIREMENTS.
4. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS

NOT TO SCALE

2008

INSIDE DROP MANHOLE

DRAWING NUMBER: **S4**



ELEVATION

NOTE: 1. PRECAST RISER MANHOLES SUBJECT TO CONTRACT ADMINISTRATOR'S APPROVAL.

2. MAXIMUM DEPTH TO FIRST RUNG IS 500mm. WHEN HANDHOLD IS INSTALLED BETWEEN TOP AND FIRST RUNG, MAXIMUM DEPTH MAY BE INCREASED TO 660mm.

3. REFER TO CONTRACT DRAWINGS, SECTIONS 33 40 01 OR 33 30 01 AS APPLICABLE AND SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

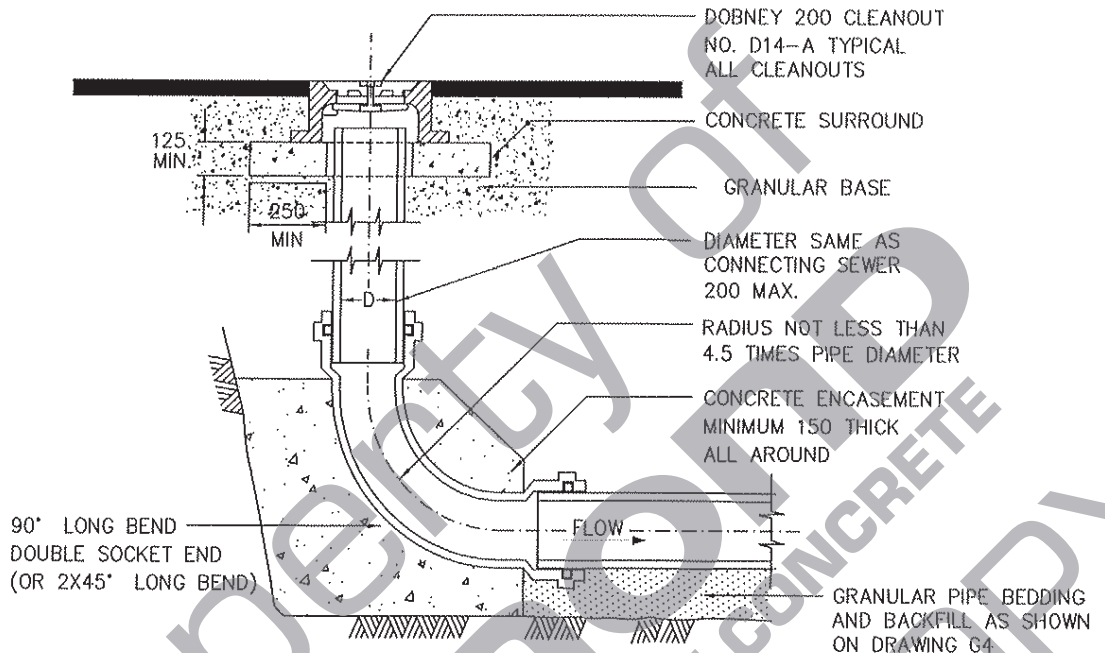
NOT TO SCALE

2008

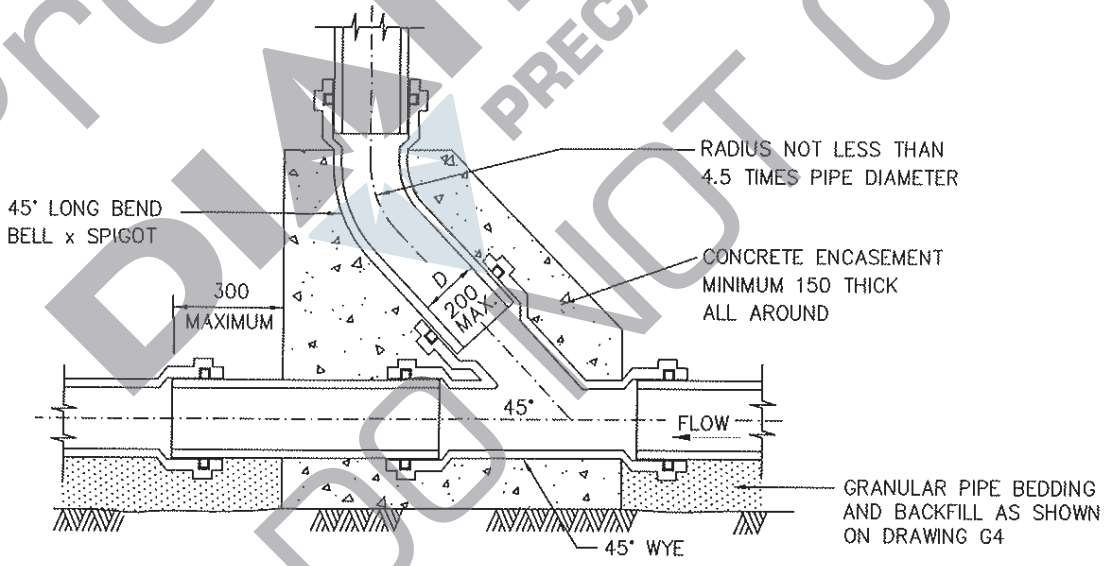
PRECAST RISER MANHOLE

DRAWING NUMBER:

S5



TERMINAL CLEANOUT



MIDBLOCK CLEANOUT

NOTE: 1. ALL PIPE FITTINGS PVC DR28 c/w GASKETS

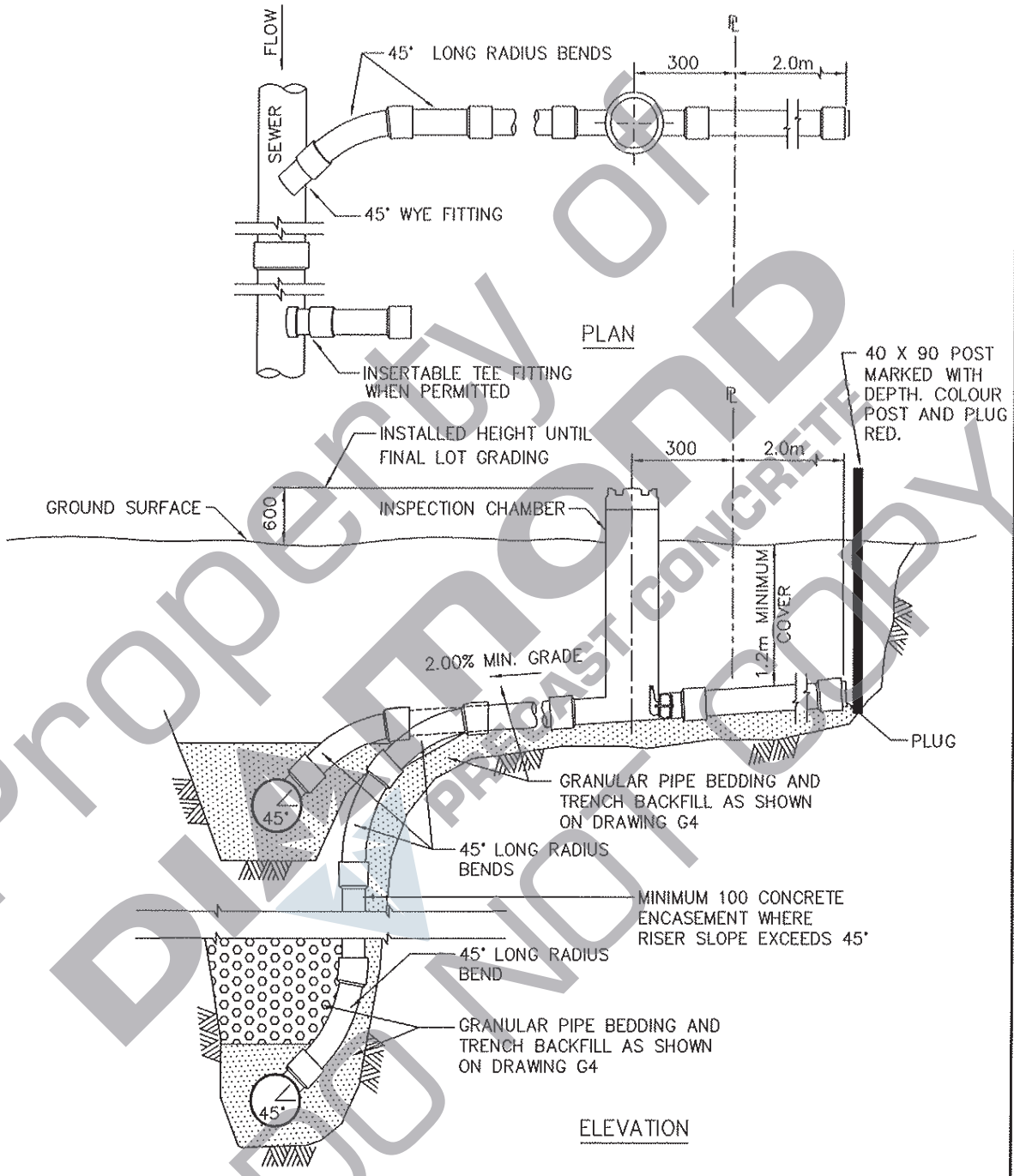
NOT TO SCALE

2008

SEWER CLEANOUT

DRAWING NUMBER:

S6



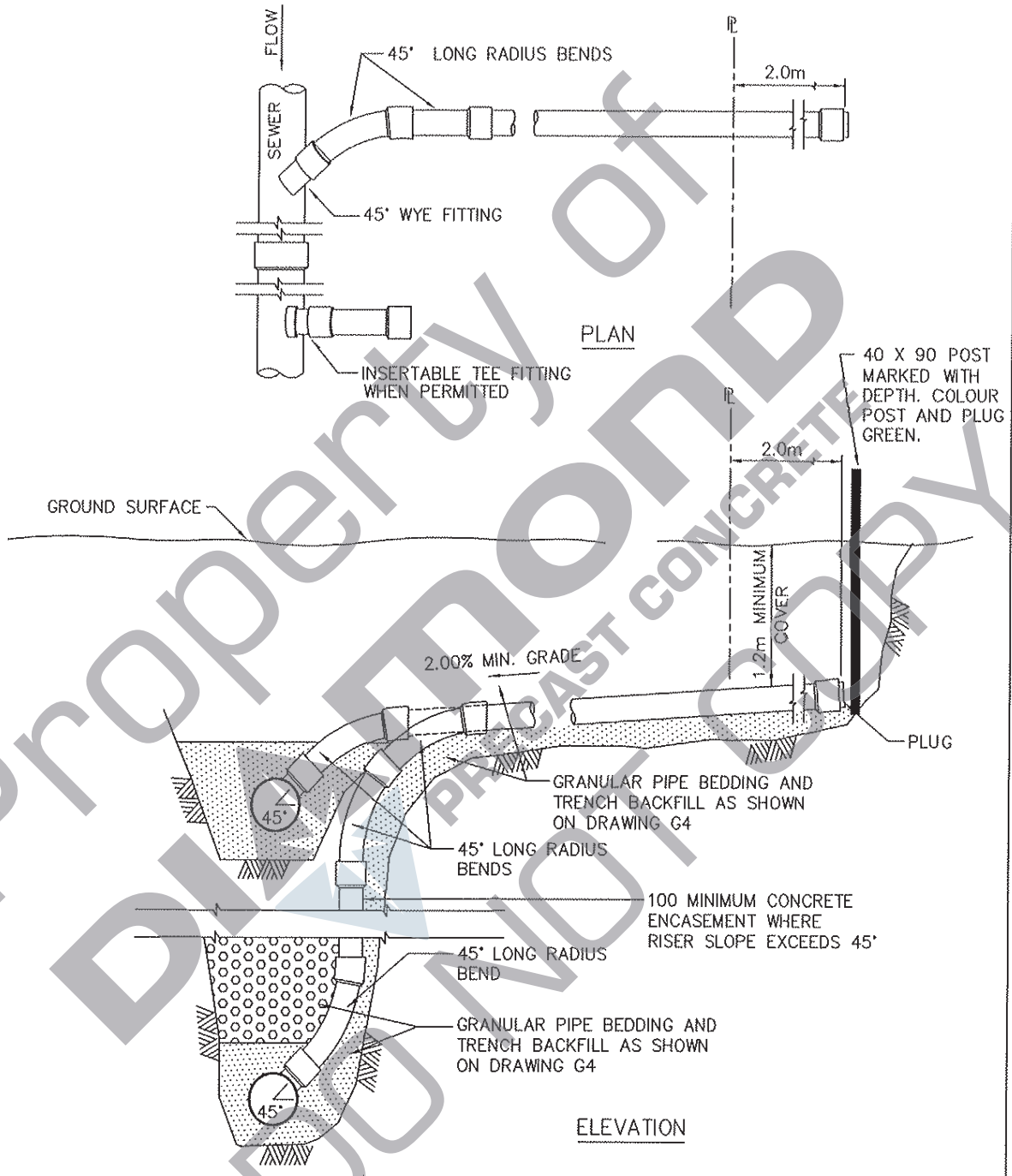
NOTE:
1. CONNECTIONS TO BE 100 OR AS SPECIFIED ON CONTRACT DRAWINGS.
2. RISER TYPE SERVICE TO BE USED ONLY WHEN SERVICE IS MORE THAN 2.4m ABOVE WYE INVERT OR AS DIRECTED BY CONTRACT ADMINISTRATOR.
3. LOCATION OF SERVICE AND MARKER AS SHOWN ON CONTRACT DRAWINGS.
4. SEE DRAWING S9 FOR DETAILS OF INSPECTION CHAMBER AND INSTALLATION REQUIREMENTS.

NOT TO SCALE

2008

SANITARY SEWER SERVICE CONNECTION

DRAWING NUMBER: **S7**



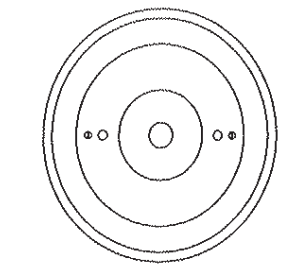
NOTE:
1. CONCRETE STORM SEWER PIPES TO BE PROVIDED WITH SUPPLIER INSTALLED PVC STUB.
2. CONNECTIONS TO BE 100 MINIMUM OR LARGER AS SPECIFIED ON CONTRACT DRAWINGS.
3. RISER TYPE SERVICE TO BE USED ONLY WHEN SERVICE IS MORE THAT 2.4m ABOVE WYE INVERT OR AS DIRECTED BY CONTRACT ADMINISTRATOR.
4. LOCATION OF SERVICE AND MARKER AS SHOWN ON CONTRACT DRAWINGS.

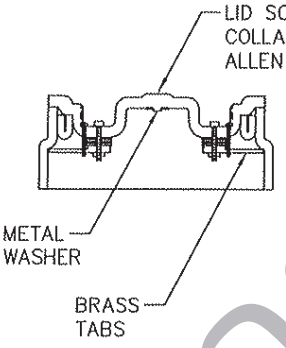
NOT TO SCALE

2008

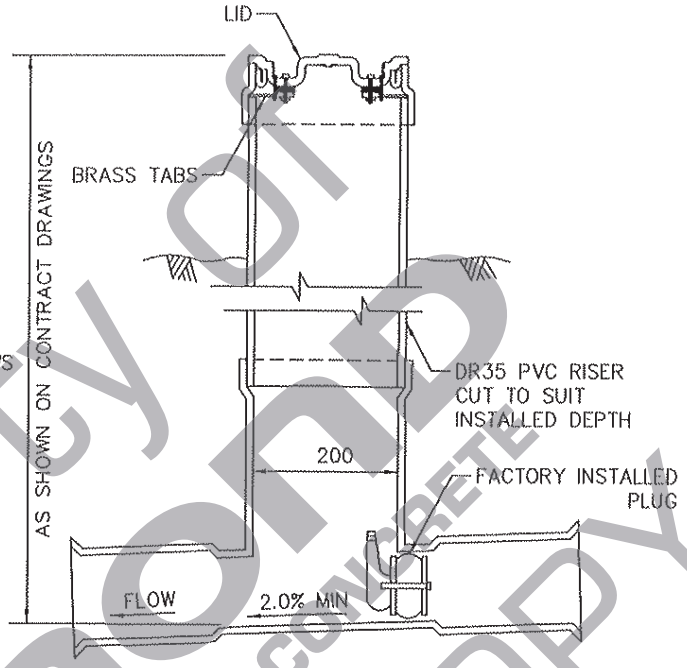
STORM SEWER SERVICE CONNECTION

DRAWING NUMBER: **S8**

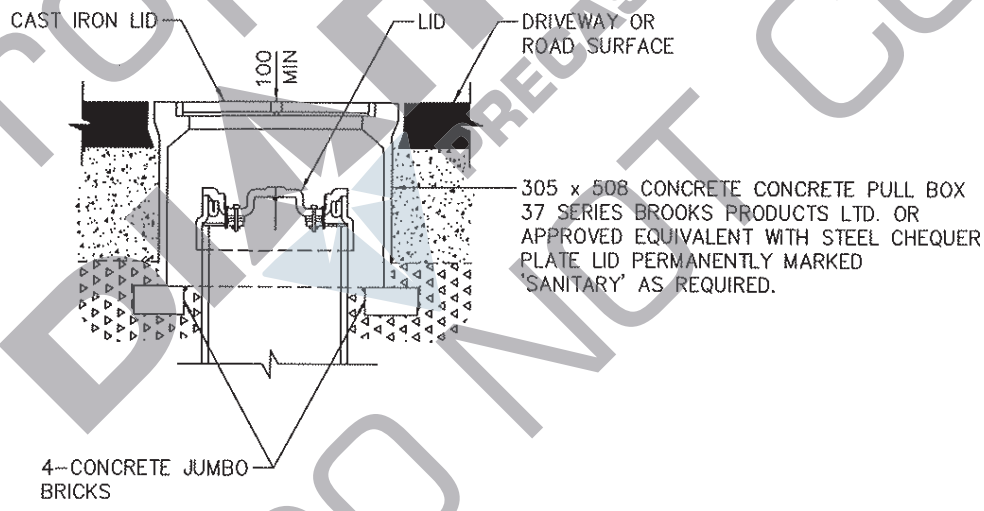




LID DETAIL



INSTALLATION IN BOULEVARD



INSTALLATION IN DRIVEWAY AND ROAD

NOTE: 1. REFER TO DRAWING S7 FOR INSTALLATION REQUIREMENTS.

2. INSPECTION CHAMBER TO BE APPROVED MANUFACTURED FITTING.

3. REFER TO CONTRACT DRAWINGS FOR SITE SPECIFIC DIMENSIONS. REFER TO SECTION 33 30 01 FOR DETAILED SPECIFICATIONS.

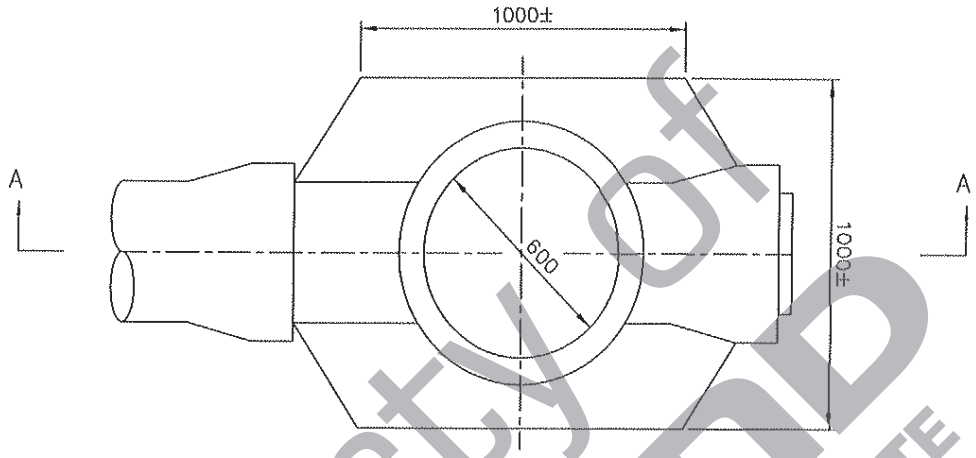
NOT TO SCALE

2008

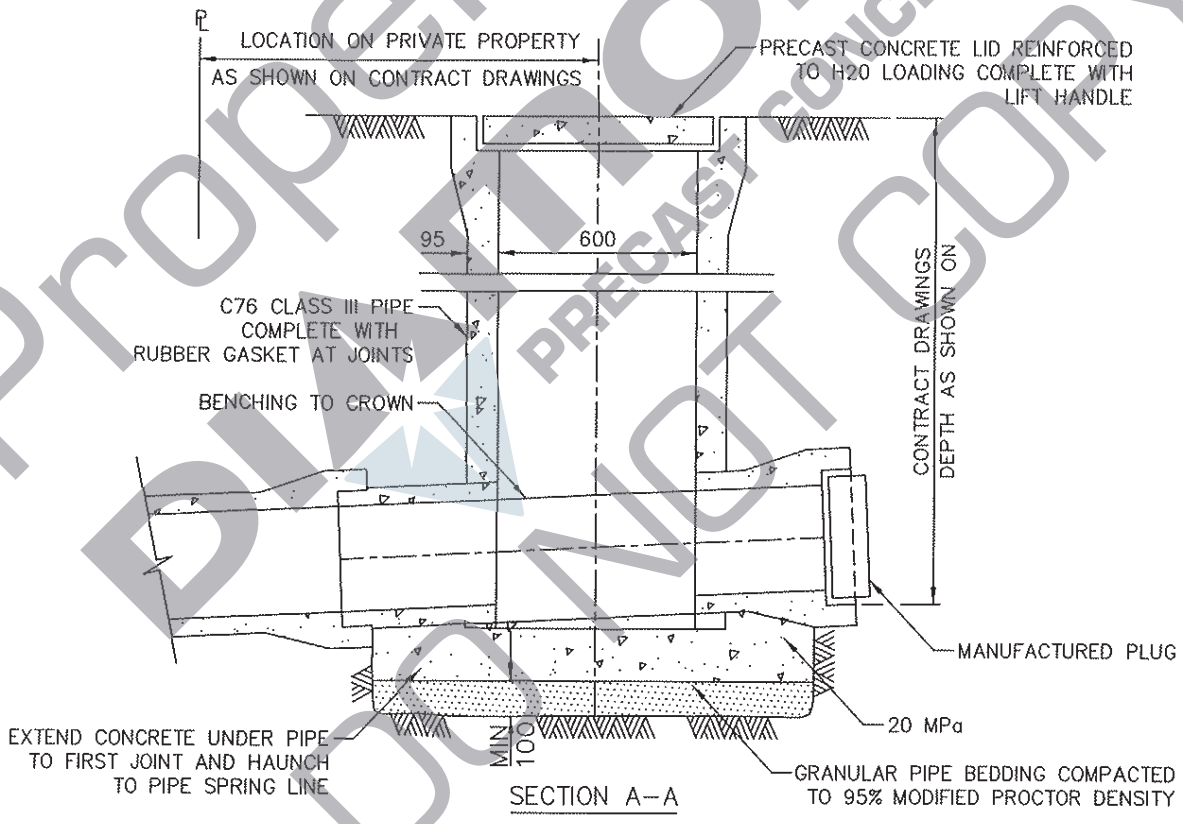
INSPECTION CHAMBER FOR 100 TO 200 SANITARY SEWER CONNECTION

DRAWING NUMBER:

S9



PLAN



SECTION A–A

NOTE: 1. REFER TO CONTRACT DRAWINGS FOR LOCATION WITH RESPECT TO PROPERTY LINES.

2. PRECAST UNIT MAY BE PROVIDED AS ALTERNATIVE WITH CONTRACT ADMINISTRATOR'S PRIOR APPROVAL.

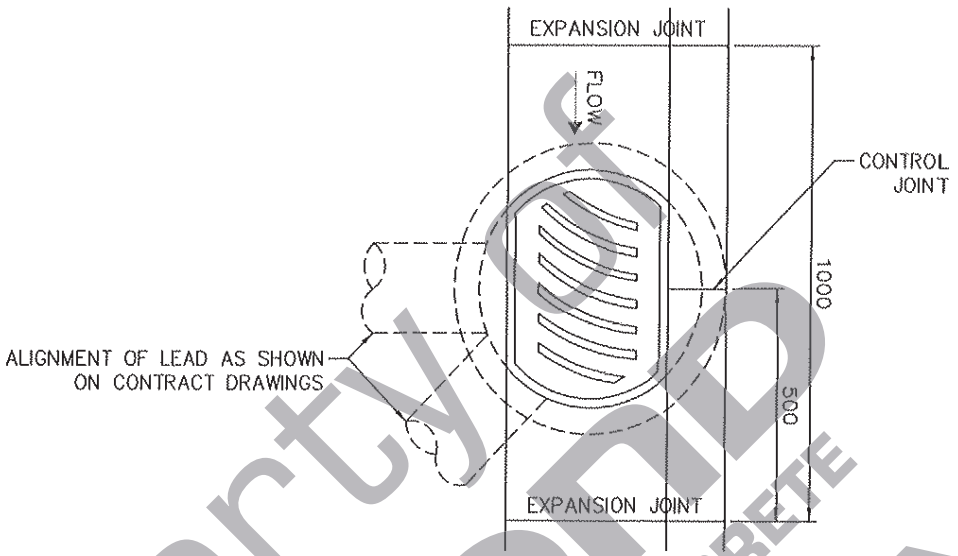
3. REFER TO CONTRACT DRAWINGS, SECTION 33 40 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

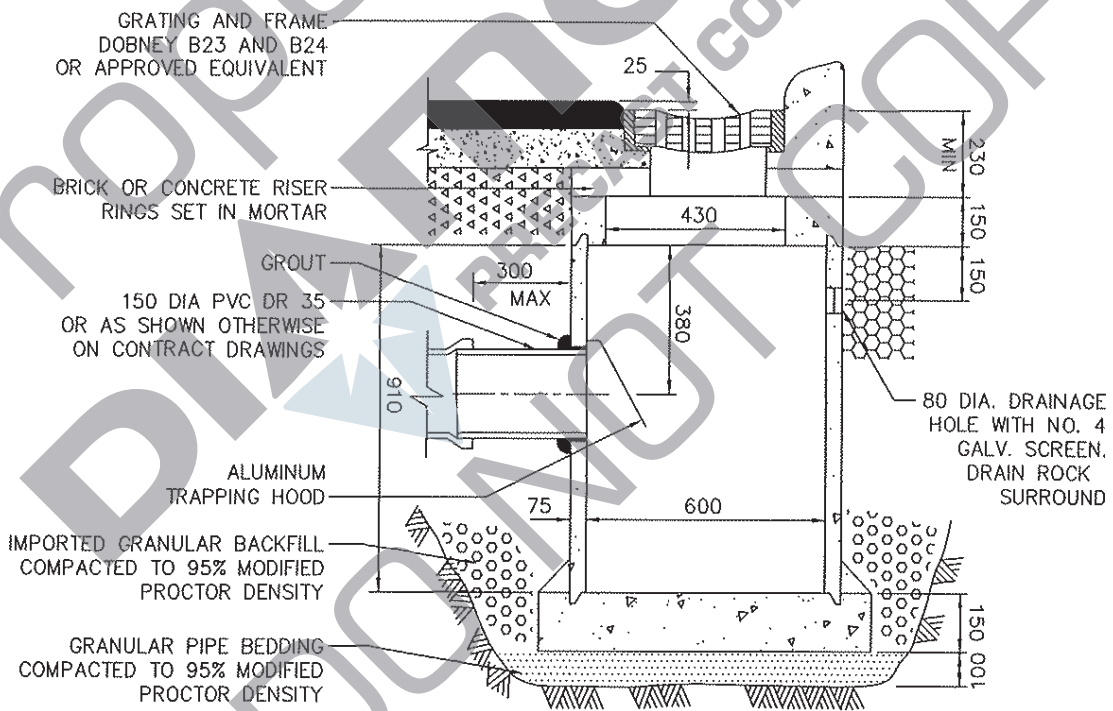
2008

INSPECTION CHAMBER FOR 250 TO 375 STORM SEWER CONNECTION

DRAWING NUMBER: **S10**



FRAME AND COVER DETAILS



STANDARD CATCHBASIN

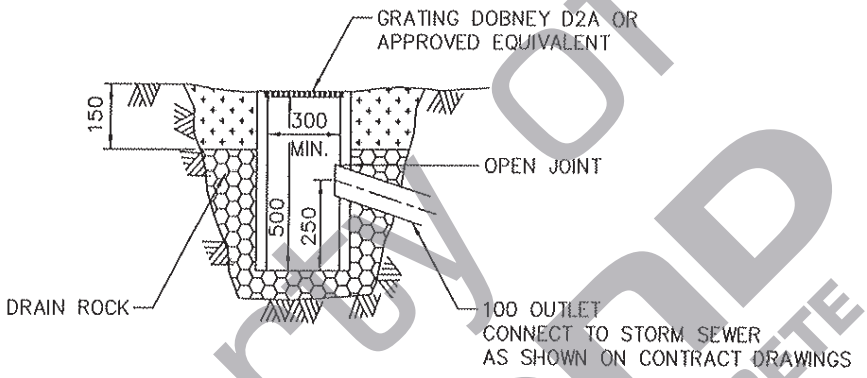
NOTE: 1. PRECAST UNITS c/w BASE, APPROVED BY CONTRACT ADMINISTRATOR, ARE ACCEPTABLE.
2. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

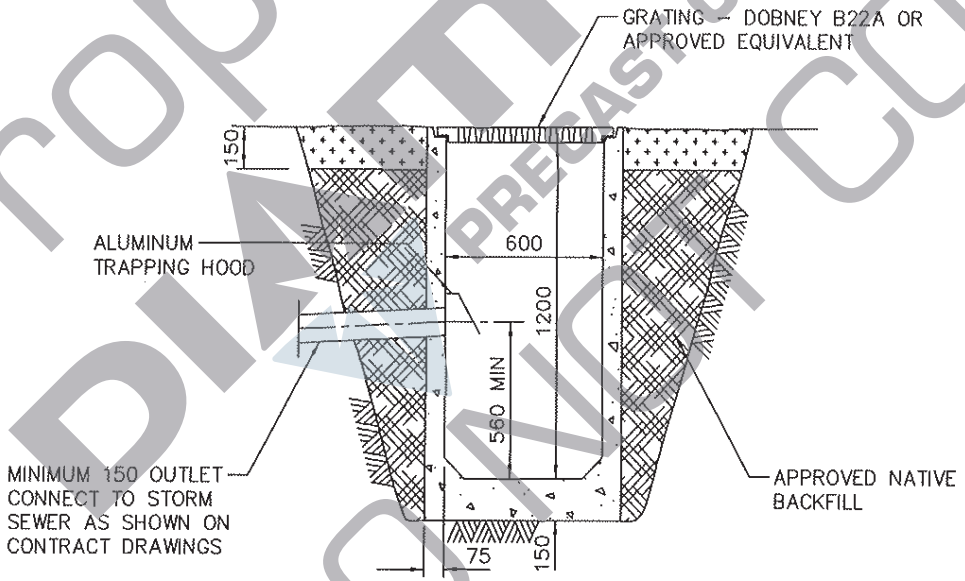
2008

TOP INLET CATCHBASIN

DRAWING NUMBER:
S11



TYPE 1



TYPE 2

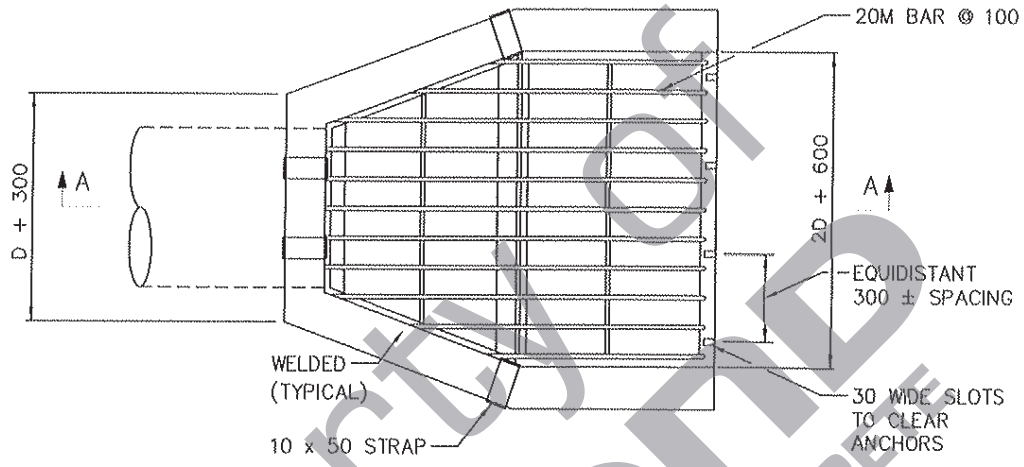
NOTE: 1. REFER TO CONTRACT DRAWINGS, SECTION 33 44 01 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

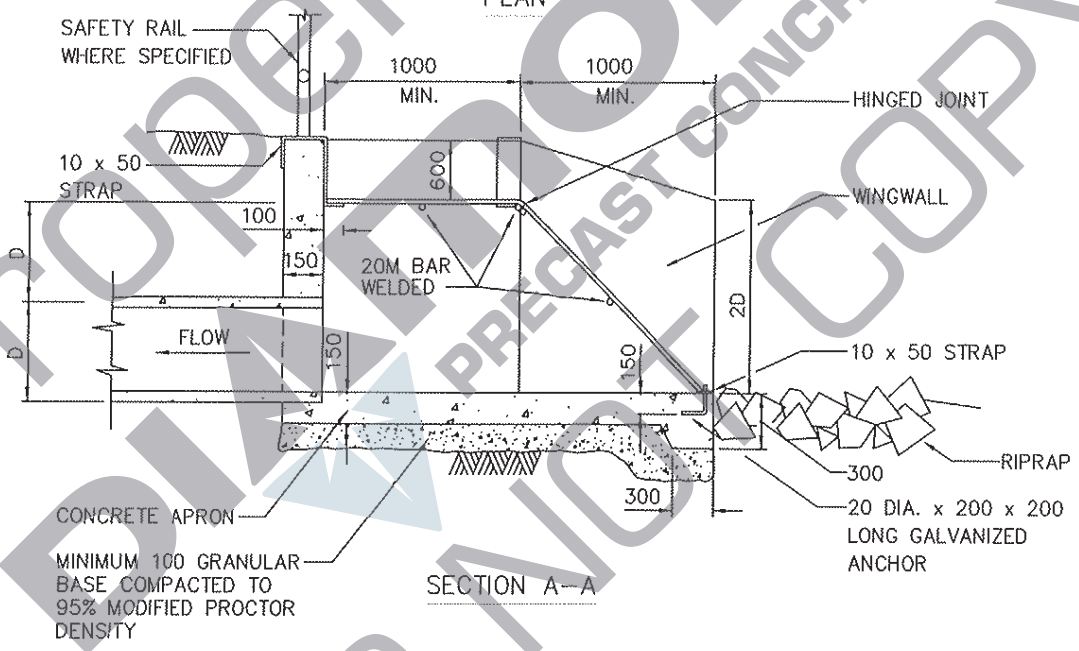
2008

LAWN DRAINS

DRAWING NUMBER:
S12



PLAN



SECTION A–A

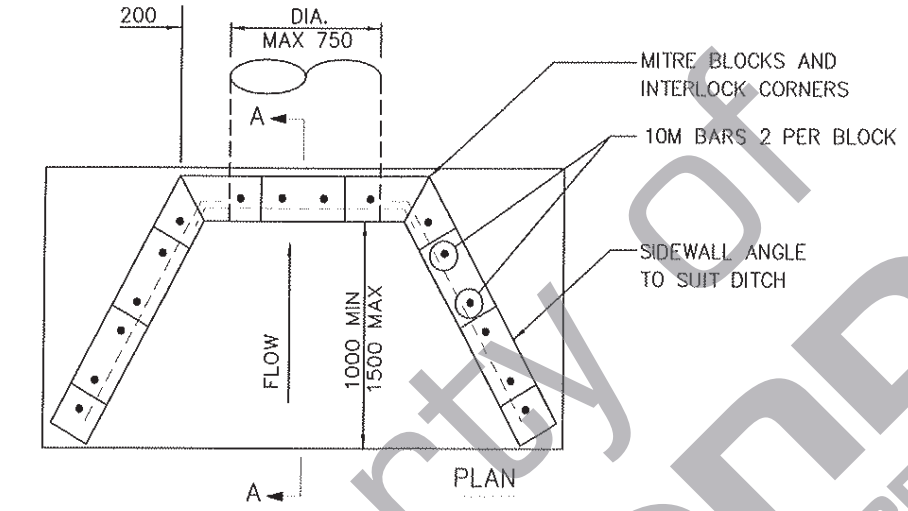
NOTE:
1. INSTALL SAFETY HANDRAIL IF SPECIFIED ON CONTRACT DRAWINGS.
2. PRECAST UNIT MAY BE PROVIDED AS ALTERNATIVE WITH CONTRACT ADMINISTRATOR'S PRIOR APPROVAL.
3. ALL STEEL COMPONENTS TO BE HOT DIPPED GALVANIZED AFTER FABRICATION.
4. SAFETY GRILLAGE TO BE WELDED AT ALL JOINTS AND CONNECTIONS EXCEPT AT ANCHOR BOLTS.
5. REFER TO CONTRACT DRAWINGS FOR LOCATIONS AND SITE SPECIFIC DIMENSIONS. REFER TO SECTIONS 03 20 01 AND 03 30 53 FOR DETAILED SPECIFICATIONS.

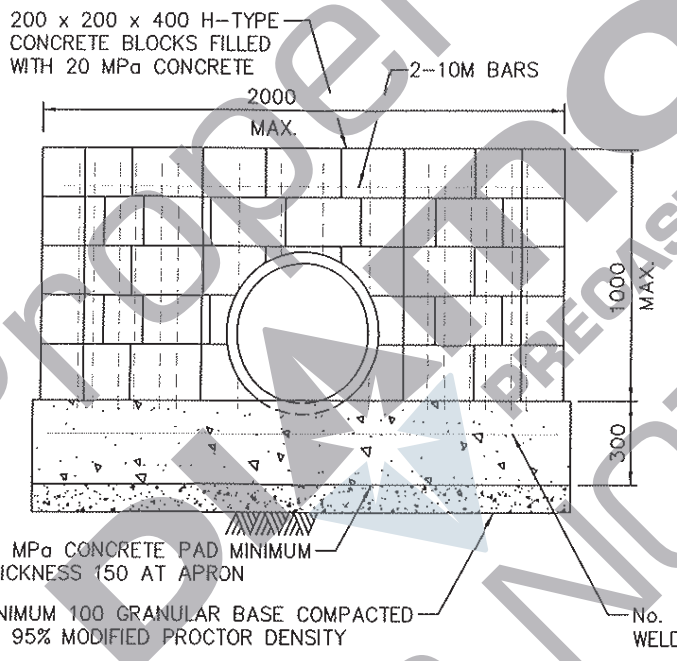
NOT TO SCALE

2008

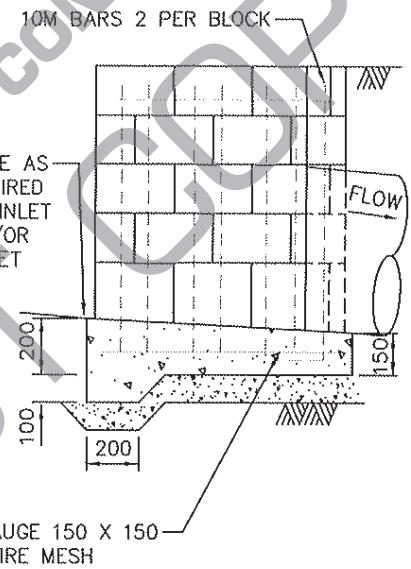
STORM SEWER INLET WITH SAFETY GRILLAGE

DRAWING NUMBER:
S13





FRONT ELEVATION



SECTION A-A

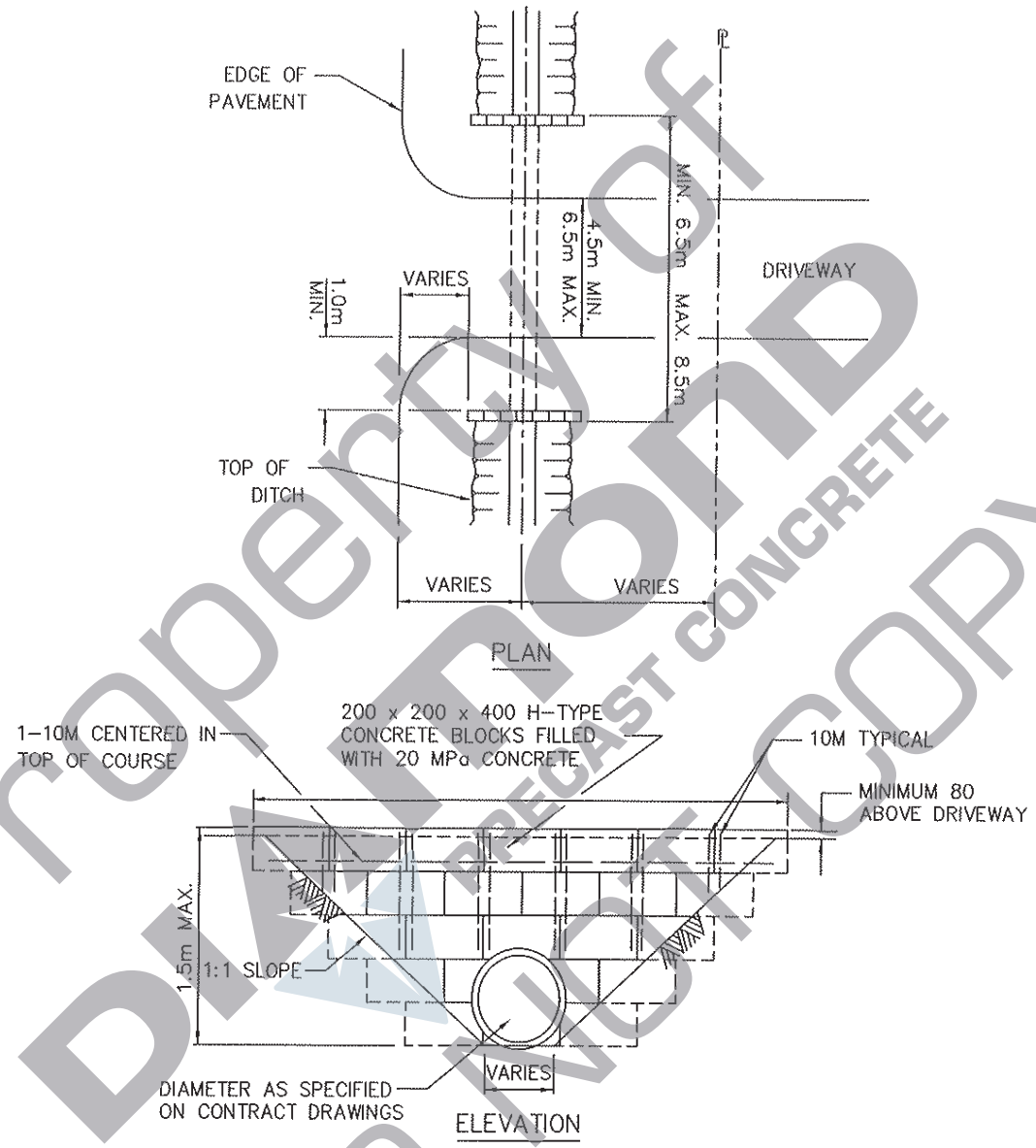
NOTE:
1. PRECAST UNIT MAY BE PROVIDED AS ALTERNATIVE WITH CONTRACT ADMINISTRATOR'S PRIOR APPROVAL.
2. INSTALL SAFETY HANDRAIL AND / OR SAFETY GRILLAGE IF SPECIFIED ON CONTRACT DRAWINGS.
3. DETAIL MAY BE MODIFIED FOR USE AS OUTLET STRUCTURE.
4. WHEN SAFETY GRILLAGE IS SPECIFIED INSTALL SIMILAR TO DRAWING S13.
5. REFER TO CONTRACT DRAWINGS FOR LOCATIONS AND SITE SPECIFIC DIMENSIONS. REFER TO SECTIONS 03 20 01 AND 03 30 53 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

2008

CONCRETE BLOCK ENDWALL

DRAWING NUMBER:
S14



NOTE:
1. FILL BETWEEN ENDWALLS TO BE IMPORTED GRANULAR BACKFILL OR APPROVED NATIVE BACKFILL. WITH 150mm GRANULAR BASE SURFACE.
2. SPIGOT END OF PIPE (WHERE APPLICABLE) TO FACE DOWNSTREAM AND TO BE CLEAR OF ENDWALLS.
3. ENDWALLS MAY BE CAST IN PLACE USING 20 MPa CONCRETE WITH REINFORCING OF 10M @ 200 BOTH WAYS.
4. REFER TO CONTRACT DRAWINGS FOR SITE SPECIFIC DIMENSIONS. REFER TO SECTIONS 33 42 13 AND 03 30 53 FOR DETAILED SPECIFICATIONS.

NOT TO SCALE

2008

DRIVEWAY CULVERT WITH CONCRETE BLOCK ENDWALLS

DRAWING NUMBER: **S15**

Certificate of Compliance

Certificate: 70055917 **Master Contract:** 260881

Project: 70055917 **Date Issued:** March 2, 2016

Issued to: **Diamond Precast Concrete Ltd.**
7520 Conrad Street,
Burnaby, BC, V5A 2H7
Canada
Attention: Mr. Jed Friesen, President

The products listed below are eligible to bear the CSA Mark shown

Issued by: *Justin Billey*
Justin Billey Justin Billey

PRODUCTS

CLASS - C808306 - PRECAST CONCRETE – Reinforced Circular Manhole Sections and Catch Basins-Certified to ASTM Standards for Canada

For details related to rating, size, configuration, etc. reference should be made to the CSA Certification Record or the descriptive report.

Certification of prefabricated circular reinforced concrete manhole sections and catch basins including the followings:

1) **Grade rings** used for final adjustment of manholes to grade;
2) **Flat slab tops** used in the construction of manholes for use in sewer, drainage, and water works;
3) **Risers and Conical Tops** used in construction of manholes for use in sewer, drainage, and water works;
4) **Base Sections** used in the construction of manholes used in sewer, drainage, and water works; and
5) **Steps and Ladders** used for providing access through manholes for use in sewer and water works.

CSA certification covers the manufacturing and performance requirements of products used for the assembly and construction of circular vertical precast reinforced concrete manholes and structures used in sewer, drainage, and water works under the following conditions:

a) This certification program covers the manufacturing requirements in the factory and does not include requirements for site backfill, or the relationship between field load conditions and the strength requirements of the manhole & catch basin products and appurtenances.
b) This certification program does not include certification to CSA A257 Standard.

c) This certification program does not include concrete pipes.

d) Some provinces in Canada reference ASTM standards as the compliance standards for these products, this report covers certification in Canada for the ASTM standards referenced below.

APPLICABLE REQUIREMENTS

ASTM Standard C478M – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM Standard C139 – Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes

MARKINGS

The manufacturer is required to apply the following markings:

- Products shall be marked with the markings specified by the particular product standard.
- Products certified for Canada shall have all Caution and Warning markings in both English and French.

Additional bilingual markings not covered by the product standard(s) may be required by the Authorities Having Jurisdiction. It is the responsibility of the manufacturer to provide and apply these additional markings, where applicable, in accordance with the requirements of those authorities.

Individual circular reinforced concrete manhole sections and catch basins shall be legibly marked with the following information, in a permanent manner, either on the product or on a tag attached to the product, or on the documentation accompanying the product (provided the latter is cross-referenced with the documentation), or by any other means acceptable to CSA Group:

1) Manufacturer's name, trade name, trademark, or CSA file number;
2) Specification and product designation: MH for manhole base, riser, conical tops, and grade rings;
3) Date of manufacturing; and
4) CSA Mark.

Marking shall be indented into the concrete at the time of manufacturing or shall be painted thereon with waterproof paint or ink. Certain jurisdictions in Canada require the use of French language in markings. It is the responsibility of the manufacturer to determine where this is required

Supplement to Certificate of Compliance

Certificate: 70055917 **Master Contract:** 260881

The products listed, including the latest revision described below, are eligible to be marked in accordance with the referenced Certificate.

Product Certification History

Project	Date	Description
70055917	March 2, 2016	Certification of Reinforced Circular Manhole Sections and Catch Basins, Certified to ASTM Standards for Canada

CSA Group

Certificate of Qualification
Pre-cast Concrete Products
Certification Program

This is to certify that

Diamond Precast Concrete Ltd.
at
7520 Conrad Street, Burnaby, BC, V5A 2H7

has been qualified by CSA Group, Certification and Testing, as a manufacturing facility of pre-cast concrete products under the CSA Pre-cast Concrete Products Certification Program in accordance with CSA Standard A23.4-09 – Precast Concrete, Materials and Construction; in the following categories:

Group D – Standard Drainage Products: D1
Group S – Standard Products without Architectural Finish

Issued by: Richard A. Frederick

Authorized by: Neil Forsyth

Date Issued: March 24, 2015
Date Expires: March 24, 2017

1707-94 Street NW
Edmonton, Alberta
T6N- 1E6
Ph: 780-451-2111
Fax: 780-461-5322
www.csagroup.org

CSA Group

July 17, 2015

Diamond Precast Concrete Ltd.
Attention: Jed Friesen
7520 Conrad Street
Burnaby, BC V5A 2H7

Subject: **CSA Certification to CSA A23.4 Standard for Precast Concrete, Materials and Construction.**

Dear Mr. Friesen:

This letter is to confirm that Diamond Precast Concrete Ltd. is certified to the CSA A23.4 standard for precast concrete.

The CSA certification program is a quality based program, where CSA reviews and approves the manufacturing facility's quality control system and actual work procedures conducted in the facility and confirms that the facility complies with A23.4 requirements. Part of this review includes verifying that the products being constructed in the manufacturing facility are manufactured in compliance with the shop drawings for that product.

The CSA certification program requires every manufacturing facility to have a full time or retained licensed professional engineer to verify that products meet the CSA A23.4 and CSA certification requirements on a continuing basis and issue a statement of compliance(s). The engineering and design of the product is left to a licensed professional engineer.

CSA A23.4 standard contains compliance requirements for (but is not limited to),
- materials used in the construction of the product;
- forms, including preparation;
- reinforcement and hardware placement;
- concrete casting, placing, finishing, and curing;
- pre-pour and post-pour inspections during the construction phase;
- concrete testing;
- stripping, handing, storage, and transportation of the finished products; and
- product markings.

1707-94 Street NW
Edmonton, Alberta
T6N- 1E6
Ph: 780-451-2111
Fax: 780-461-5322
www.csagroup.org

When CSA certifies a precast manufacturing facility to the A23.4 standard, a CSA engineer visits the facility and conducts an onsite review and approval of the facility's quality system and actual production procedures. This review includes (but is not limited to),

- Reviewing the factory's Quality manual and work instructions;
- observing actual work processes to ensure the procedures in the quality manual are properly implemented;
- reviewing material data sheets, mill certificates and material test records;
- reviewing equipment calibrations;
- reviewing shop drawings;
- witnessing fabrication of reinforcement cages and placement of hardware;
- witnessing concrete batching, placement, finishing, and curing;
- witnessing pre-pour and post-pour inspections conducted by the factory;
- verifying that the products are being manufactured as detailed on shop drawings;
- witnessing concrete testing and reviewing test data; and
- witnessing stripping, handling, storage and transportation operations.

Once the manufacturing facility has been certified, a CSA engineer visits the facility regularly to conduct follow up audits to verify ongoing compliance to the CSA A23.4 standard.

CSA has the A257 standard for circular manholes, however, we do not offer a certification program to this standard at this time.

Sincerely,

Richard A. Frederick

Richard A. Frederick M.Eng., P.Eng.
Certifier
CSA Group – Edmonton
Phone: 780-490-2057
Fax: 780-461-5322
E-mail: richard.frederick@csagroup.org

PROFILE OF REPORTS

File No:260881

Submittor:
(Contact ID)

Date: March 24, 2015
Replaces: New
Main File: Edmonton

Diamond Precast Concrete Ltd.
7520 Conrad Street
Burnaby, BC V5A 2H7
Canada

Attention: Mr. Ramesh Nathani
Tel: 604-415-5181
Fax: 604-415-5185

Factories

Contact No.	Name & Address	Inspection Office	Master Contract No/ Factory Contract No
4861119 (F1)	Diamond Precast Concrete Ltd. 7520 Conrad Street Burnaby, BC V5A 2H7 Canada	Edmonton	MC 260881 FC 263508

Report	Project	Contact No.	Subject
2784857	-	F1	March 24, 2015– Class 8083-02 - Certification of Group D1 and Group S in compliance with CSA A23.4-09 standard.

/jc

Descriptive Report and Test Results

MASTER CONTRACT: 260881
REPORT: 2784857
PROJECT: 2784857

Edition 1: March 24, 2015; Project 2784857 – Edmonton
Issued by Richard A. Frederick; Reviewed by Justin Billey

Contents: Certificate of Qualification - Page 1 to 1
Description and Tests – Pages 1 to 7

PRODUCTS

CLASS 8083-02 PRECAST CONCRETE PRODUCTS

Certification of precast concrete products under the following group classifications:

1) Group D (Drainage Products): reinforced, non-pre-stressed concrete structural elements with a primary function of drainage.

   a) Group D1, Standard Precast Concrete Drainage Products

      This group includes the following products: box units with span greater than 3m, open footing (3-sided) precast units with flat top slab or arch top – all sizes, Precast components for culverts such as wing walls, retaining walls, headwalls, parapet walls, strip footings, pile caps, load distribution slabs, etc., rectangular manholes and chambers – all sizes

2) Group S (Standard Products): products without an architectural finish.

   This group includes the following products: plain or reinforced concrete elements, without architectural finishes that are not included in Groups A, B, BA, C, or CA and are required to be manufactured in accordance with the provisions of CSA A23.4 Standard.

   Products in Group S are often manufactured for a particular application in custom built forms on demand or kept in inventory.

APPLICABLE REQUIREMENTS

CSA Standard A23.4-09 – Precast Concrete, Materials and Construction

1707-94 Street N.W., Edmonton, AB, Canada T6N 1E6
Telephone: 780.450.2111 1.800.463.6727 Fax: 780.461.5322 www.csagroup.org

MARKINGS

The manufacturer is required to apply the following markings:

- Products shall be marked with the markings specified by the particular product standard.
- Products certified for Canada shall have all Caution and Warning markings in both English and French.

Additional bilingual markings not covered by the product standard(s) may be required by the Authorities Having Jurisdiction. It is the responsibility of the manufacturer to provide and apply these additional markings, where applicable, in accordance with the requirements of those authorities.

Individual pre-cast concrete elements shall be marked with the following information, in a permanent manner, either on the product or on a tag attached to the product, or on the documentation accompanying the product (provided the latter is cross-referenced with the documentation), or by any other means acceptable to CSA International:

1) manufacturer's name, trade name, trademark, or CSA file number;
2) identification, as shown on the shop drawings;
3) date of casting; and
4) CSA Mark or the letters "CSA".

ALTERATIONS

Edition 1 Project: 2784857
This Report is issued on the condition that any alterations herein listed shall be made and certification of the subject products shall apply only where these alterations have been effected.

1) Markings as noted above.
2) Concrete uniformity testing has been conducted on all mixers used to produce concrete for precast operations.
3) Scales are calibrated every 180 days and records are on file.
4) Traceability records of certified weights used to calibrate scales are on file.
5) Factory is breaking cylinders to verify stripping strength has been achieved.
6) Factory is monitoring temperatures during the curing cycle.
7) Aggregate complete physical analysis report conducted by a CCIL certified laboratory within the last 12 months is on file.
8) Cylinders representing concrete that is steam cured are stored with the concrete elements during the steam cure cycle.
9) Planeness of compression machine platens is checked monthly and records are on file.
10) Compression machine rate of loading is checked weekly and records are on file
11) Curing tank temperatures are monitored 2 times per day and records are on file.
12) Field thermometers are calibrated before being put into use and annually thereafter, and records are on file.
13) Neoprene pad usage count records are on file.
14) Initial curing temperature of concrete cylinders are monitored, and records are on file.

FACTORY TESTS

1) **Air content of freshly mixed plastic concrete**
   a) The air content of each concrete mix shall be tested at the start of production and periodically during daily operation when the variation in slump exceeds 30 mm or the temperature of the concrete varies by more than 5°C.
   b) The air content of plastic concrete shall be tested with every strength test.

c) The air content of plastic concrete shall be tested, as part of the uniformity tests, prior to a decision on the acceptance of the mixing equipment.
d) The air content of freshly mixed plastic concrete shall be determined in accordance with CSA A23.2-4C.

2) **Compressive strength testing of concrete cylinders**
   a) Compliance with the specified compressive strength shall be determined by the following:
      i) Testing a minimum of two cylinders from each type of concrete mix each day, or a minimum of two cylinders for each 30 m^3 of any one mix when daily production exceeds 30 m^3.
      ii) When daily quantities are small, one test shall be performed for every 3 m^3.
      iii) When daily quantities are smaller than 3 m^3, two tests shall be performed each week.
      iv) Cylinders for determining handling strengths shall be made from each new mix until the manufacturing facility has correlated the cylinder strength to the maturity of the concrete in accordance with ASTM C1074.

   b) Compressive strength of concrete cylinders shall be determined in accordance with CSA A23.2-9C.

3) **Temperature of freshly mixed plastic concrete**
   a) The temperature of plastic concrete shall be measured with every strength test.
   b) The temperature of freshly mixed plastic concrete shall be determined in accordance with CSA A23.2-17C.

4) **Slump of freshly mixed plastic concrete**
   a) A sufficient number of tests shall be made to ensure uniform slump of the concrete.
   b) A slump test shall be made with every strength test and every second or third air test.
   c) Slump of freshly mixed plastic concrete shall be determined in accordance with CSA A23.2-5C.

WARNING

The factory tests specified herein may present a hazard of injury to personnel and/or property and should only performed by persons knowledgeable of such hazards and under conditions designed to minimize the possibility of injury.

SPECIAL INSTRUCTIONS FOR FIELD SERVICES

1) Component descriptions marked with either the "(INT)" or "(INT*)" identifiers may be substituted with other components providing the requirements specified under the notes in the "Description" are complied with.

COMPONENT SPECIAL PICKUP

1) Component descriptions marked with the identifier "(CT)" are subject to annual pickup and Conformity Testing.

CONDITIONS OF ACCEPTABILITY

1) Design basis
   a) The structural design of precast concrete shall be in accordance with CAN/CSA-A23.3 or CAN/CSA-S6.
   Note: Users may contact the authority having jurisdiction for further information.

b) A professional engineer licensed to practice in a jurisdiction in Canada shall be responsible for the design; a P. Eng. Stamp/seal is required for the structural design for every Pre-cast Concrete Product.
c) The design of specialty precast products shall be in accordance with other applicable Standards, as specified by the owner.

2) **Manufacturer's engineer**
Every certified facility shall have a structural engineer authorized by the manufacturer to ensure the adequacy of the structural aspects of the shop drawings, manufacture, and installation for which the manufacturer is responsible.

3) **Welding of reinforcement**
The welding of reinforcement (including tack welding) for precast concrete shall comply with CSA W186.

PLANT COMPLIANCE CONTROL (QUALITY ASSURANCE) PROGRAM

A quality assurance program shall be implemented at the manufacturing facility to ensure continuing compliance of certified products with applicable codes, standards and CSA Group requirements. The quality assurance program shall include, but not be limited to, the following:

1) Quality policy and objectives, reflecting management commitment to quality;
2) An organization chart wherein any change/update shall be promptly brought to the attention of the CSA representative for approval;
3) List of reference codes and standards against which the products are to be manufactured, evaluated, tested and certified;
4) Document initiation and control system to cover, as a minimum, the following;
   a) Clear and complete shop drawings;
   b) Control of dimensional tolerances in formwork and mould construction;
   c) Adequate bonding, placing and securing of reinforcement;
   d) Proper manufacturing and placing of all hardware items;
   e) Correct mix design, batching and mixing of concrete;
   f) Inspection of forms and moulds prior to concreting (pre-pour inspection);
   g) Proper handling, placing and consolidation of concrete;
   h) Suitable, adequately monitored and safe curing of concrete;
   i) Proper dimensioning and stripping procedures;
   j) Established finishing procedures;
   k) Final inspection of pre-cast concrete elements (post-pour inspection);
   l) Handling and storage;
   m) Repairs to maintain the quality of the elements;
   n) Transportation; and
   o) Installation.
5) Procedures for contract review;
6) Procedures for in-plant production inspection and testing; ensuring that items, construction and installation, comply with applicable technical requirements;
7) The use of quality program forms and checklists, including design checklists and production checklists documenting incomplete items and quality control deficiencies;
8) Guidelines dealing with purchasing and receiving of components and materials; making sure they comply with codes, standards and CSA requirements;
9) Customer complaint forms:
10) Instrument calibration records;
11) A system of record retention for a minimum of five (5) years;
12) A method for the disposition of nonconforming items including root cause analysis and follow-up system for reviewing the effectiveness of the corrective actions implemented.; and

13) Training records of staff and production personnel.

The plant QC Manual was reviewed and found to be in compliance with CSA requirements; a copy is maintained on CSA file and the original is maintained in the manufacturing facility, available for CSA review upon request.

PRODUCT RECORD (CSA INTERNATIONAL DOCUMENT PACKAGE)

The following records must be retained for pre-cast concrete elements manufactured under this certification program. One set of the following records shall be maintained at the manufacturing facility, available to CSA representative upon request:

1) A full set of shop drawings for each pre-cast concrete element produced in the manufacturing facility imprinted with the stamp or seal of a Professional Engineer licensed in the province where the pre-cast concrete element is destined;
2) Project specifications, owner's requirements, Concrete mix design, batching and mixing of concrete;
3) Record of factory tests completed on each pre-cast concrete element, specifying the date, applicable tests, equipment calibration information and the qualification of the person(s) who conducted the tests along with their signature;
4) Pre-pour and post-pour inspection forms completed for each pre-cast concrete element produced in the manufacturing facility;
5) Quality control deficiencies recorded on the quality control production checklist and maintained on file for each pre-cast concrete element. The list shall include a sign-off portion adjacent to each item with adequate space to allow for full details to be provided and recorded (along with a signature) indicating what corrective measures were taken to bring those items to compliance
6) One set of installation instructions or drawings indicating how pre-cast elements are installed, including the installation sequence of pre-cast elements and sequence for installation and removal of temporary shoring, bracing, supports, and guys;
7) A "Statement of Compliance" signed by the professional engineer who is designated as the manufacturer's engineer; confirming that the pre-cast concrete element is in compliance with the applicable Standards and CSA Group requirements.

DESCRIPTION

Notes:
1) Component Substitution
   a) Critical components (those identified by mfr name, cat no), which are NOT identified with either "INT" or "INT*" are not eligible for substitution without evaluation and report updating.
   b) The term "INT" means a "Certified" and/or "Listed" (or a "Recognized" and/or "Accepted") component may be replaced by one "Certified" and/or "Listed" by an organization (accredited by OSHA/SCC), for the same application; providing the applicable country identifiers are included and requirements in item "d" below are complied with.
   c) The term "INT*" means a "Recognized" and/or "Accepted" component may be replaced by one "Recognized" and/or "Accepted" by an organization (accredited by OSHA/SCC), for the same application, providing the applicable country identifiers are included, the component is **also** CSA Certified, the requirements in item "d" below are complied with and any "conditions of suitability" for the component (as recorded in this descriptive report) are complied with.
   d) Components which have been substituted, must be of an equivalent rating, configuration (size, orientation, mounting) and the applicable minimum creepage and clearance distances are to be maintained from live parts to bonded metal parts and secondary parts.

e) Substitution of a "Certified" and/or "Listed" component with a component that is "Recognized" or "Accepted" is not permitted without evaluation and report updating.

Group D1, Standard Precast Concrete Drainage Products

This group includes the following products: box units with span greater than 3m, open footing (3-sided) precast units with flat top slab or arch top – all sizes, Precast components for culverts such as wing walls, retaining walls, headwalls, parapet walls, strip footings, pile caps, load distribution slabs, etc., rectangular manholes and chambers – all sizes

The evaluation was conducted on representative samples of produced products, a full set of drawings of these prototype elements that were the subject of CSA site evaluation is kept on file along with the plant Quality Control Manual. Evaluations for compliance were conducted at different stages of production and included the following:

1) Plant quality control manual;
2) Shop drawings;
3) Mix proportions;
4) Forms;
5) Fabrication and placement of reinforcement and hardware;
6) Pre-pour inspection;
7) Placing of concrete;
8) Protection and curing; (conventional curing)
9) Concrete quality;
10) Post-pour inspection;
11) Stripping and handling; and
12) Storage, transportation and installation

Group S (Standard Products)

This group includes the following products: plain or reinforced concrete elements, without architectural finishes that are not included in Groups A, B, BA, C, or CA and are required to be manufactured in accordance with the provisions of CSA A23.4 Standard.

Products in Group S are often manufactured for a particular application in custom built forms on demand or kept in inventory.

The evaluation was conducted on representative samples of produced products, a full set of drawings of these prototype elements that were the subject of CSA site evaluation is kept on file along with the plant Quality Control Manual. Evaluations for compliance were conducted at different stages of production and included the following:

1) Plant quality control manual;
2) Shop drawings;
3) Mix proportions;
4) Forms;
5) Fabrication and placement of reinforcement and hardware;
6) Pre-pour inspection;
7) Placing of concrete;
8) Protection and curing; (conventional curing)
9) Concrete quality;
10) Post-pour inspection;
11) Stripping and handling; and
12) Storage, transportation and installation

TEST HISTORY

Project 2784857

The following tests were conducted on representative prototypes at the manufacturing facility at 7520 Conrad Street, Burnaby, BC, V5A 2H7 and witnessed by CSA International. These tests are outlined in the Factory Test Section of this report and the results for each prototype model are on file at the manufacturing facility.

Air content of freshly mixed plastic concrete – results are satisfactory
Compressive strength testing of concrete cylinders – results are satisfactory
Temperature of freshly mixed plastic concrete – results are satisfactory
Slump of freshly mixed plastic concrete – results are satisfactory

Result of the tests were satisfactory

END OF REPORT

CERTIFICATION RECORD

The company named below has been authorized by CSA International to represent the products listed in this record as "CSA Certified" and to affix the CSA Mark to these products according to the terms and conditions of the CSA Service Agreement and applicable CSA program requirements (including additional Markings).

File No: 260881

Class No: 8083 02 PRECAST CONCRETE Structural

SUBMITTOR

4861119
Diamond Precast Concrete Ltd.
7520 Conrad Street
Burnaby, BC V5A 2H7
Canada

FACTORIES

4861119
Diamond Precast Concrete Ltd.
7520 Conrad Street
Burnaby, BC V5A 2H7
Canada

March 24, 2015 (Replaces:)

Certification of precast concrete products in compliance with CSA A23.4-09 standard as categorized below.

1) Group D (Drainage Products): reinforced, non-pre-stressed concrete structural elements with a primary function of drainage.

a) Group D1, Standard Precast Concrete Drainage Products
This group includes the following products: box units with span greater than 3m, open footing (3-sided) precast units with flat top slab or arch top – all sizes, Precast components for culverts such as wing walls, retaining walls, headwalls, parapet walls, strip footings, pile caps, load distribution slabs, etc., rectangular manholes and chambers – all sizes

2) Group S (Standard Products): products without an architectural finish.
This group includes the following products: plain or reinforced concrete elements, without architectural finishes that are not included in Groups A, B, BA, C, or CA and are required to be manufactured in accordance with the provisions of CSA A23.4 Standard.

Products in Group S are often manufactured for a particular application in custom built forms on demand or kept in inventory.

CANADIAN STANDARDS ASSOCIATION

A23.4-09

Precast concrete — Materials and construction

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CANADIAN STANDARDS ASSOCIATION

Update No. 1
A23.4-09
July 2010

Note: *General Instructions for CSA Standards are now called Updates. Please contact CSA Information Products Sales or visit* ***www.ShopCSA.ca*** *for information about the* ***CSA Standards Update Service****.*

Title: *Precast concrete — Materials and construction* — originally published November 2009

The following revisions have been formally approved and are marked by the symbol delta (Δ) in the margin on the attached replacement pages:

Revised	Preface
New	None
Deleted	None

CSA A23.4-09 originally consisted of **69 pages** (ix preliminary and 60 text), each dated **November 2009**. It now consists of the following pages:

November 2009	iii–viii and 1–60
July 2010	ix

- Update your copy by inserting these revised pages.
- Keep the pages you remove for reference.

Δ Preface

This is the fifth edition of CSA A23.4, *Precast concrete — Materials and construction.* It supersedes the previous editions, published in 2005, 2000, 1994, and 1978.

This Standard has been revised to include all necessary technical requirements for precast concrete. This Standard refers extensively to CSA A23.1. To make it easier to navigate between the two Standards, Annex D lists the clauses of CSA A23.1 that contain provisions relating to clauses in this Standard.

CSA acknowledges that the development of this Standard was made possible, in part, by the financial support of the Canadian Precast/Prestressed Concrete Institute.

This Standard was prepared by the Technical Committee on Precast Concrete, under the jurisdiction of the Strategic Steering Committee on Concrete and Related Products, and has been formally approved by the Technical Committee.

November 2009

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*

Requests for interpretation should

(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;

(b) provide an explanation of circumstances surrounding the actual field condition; and

(c) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update*, which is available on the CSA Web site at www.csa.ca.*

CSA Standards Update Service

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CSA Standard

A23.4-09
Precast concrete — Materials and construction

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A23.4-09
Precast concrete — Materials and construction

0 Introduction

0.1 Referencing this Standard in contract documents
Because this Standard references all of the applicable requirements of CSA A23.1, contract documents for precast concrete construction may reference this Standard without referencing CSA A23.1 as well.

0.2 Use of Annex A
Annex A provides a recommended division of responsibilities between the owner and the manufacturer. Table A.1 outlines three options that may be adopted by the owner when contract documents are prepared. Consideration should be given to including the text of Annex A in the contract documents, but if this is done, the owner should clearly specify which option has been adopted.

0.3 Use of Annex B
Annex B deals with the scope of the work and is intended to assist owners preparing contract documents. The text of Annex B may be included in whole or in part in contract documents.

0.4 Use of Annex C
Annex C provides a comprehensive listing of the capabilities manufacturers should possess to manufacture precast concrete products for different applications.

0.5 Use of Annex D
Annex D lists the clauses of CSA A23.1 that correspond to the clauses of this Standard to assist users in locating topics common to both Standards.

1 Scope

1.1 General
This Standard specifies requirements for materials and methods for the manufacture, transportation, and installation of architectural, structural, and specialty precast concrete products.
Note: *This Standard should be specified for precast concrete elements used in segmental construction.*

1.2 Shop drawings
This Standard specifies the requirements, in addition to those specified in CAN/CSA-A23.3, for precast concrete shop drawings.

1.3 Architectural precast concrete
This Standard deals with the structural adequacy and architectural finishes of architectural precast concrete.

1.4 Precedence

Where this Standard states that the content of a clause is required to conform to a referenced Standard and to additional clauses of this Standard and there is a conflict between the referenced Standard and the requirements of this Standard, the requirements of this Standard take precedence.

1.5 Terminology

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

A23.1-09/A23.2-09
Concrete materials and methods of concrete construction/Test methods and standard practices for concrete

CAN/CSA-A23.3-04
Design of concrete structures

CAN/CSA-S6-06
Canadian Highway Bridge Design Code

CAN/CSA-S269.3-M92 (R2008)
Concrete formwork

S413-07
Parking structures

W47.1-03 (R2008)
Certification of companies for fusion welding of steel

W186-M1990 (R2007)
Welding of reinforcing bars in reinforced concrete construction

ACI (American Concrete Institute)

309R-05
Guide for Consolidation of Concrete

ASTM International (American Society for Testing and Materials)

A416/A416M-06
Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

A780/A780M-09
Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

A881/A881M-05
Standard Specification for Steel Wire, Deformed, Stress-Relieved or Low-Relaxation for Prestressed Concrete Railroad Ties

A911/A911M-05
Standard Specification for Uncoated, Stress-Relieved Steel Bars for Prestressed Concrete Railroad Ties

C42/C42M-04
Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C330-05
Standard Specification for Lightweight Aggregates for Structural Concrete

C457-09
Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

C512-02
Standard Test Method for Creep of Concrete in Compression

C641-07
Standard Test Method for Iron Staining Materials in Lightweight Concrete Aggregates

C957-06
Standard Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane With Integral Wearing Surface

C1074-04
Standard Practice for Estimating Concrete Strength by the Maturity Method

C1202-09
Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

C1231/C1231M-09
Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

E4-09
Standard Practices for Force Verification of Testing Machines

CGSB (Canadian General Standards Board)
CAN/CGSB-19.13-M87
Sealing Compound, One Component, Elastomeric, Chemical Curing

CAN/CGSB-19.24-M90
Multicomponent, Chemical-Curing Sealing Compound

CAN/CGSB-37.50-M89 (withdrawn)
Hot Applied, Rubberized Asphalt for Roofing and Waterproofing

CPCI (Canadian Precast/Prestressed Concrete Institute)
Architectural Precast Concrete Colour & Texture Selection Guide
http://www.cpci.ca/downloads/ectionbrochure.pdf

CPCI Design Manual, 4th ed. (2007)

Fire Resistance Ratings for Prestressed and Precast Concrete (1978)

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RD108 (1992)
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JR-271 (1983)
Fabrication and Shipment Cracks in Prestressed Hollow-Core Slabs and Double Tees

JR-316 (1985)
Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns

MNL-116-99
Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, 4th ed.

MNL-117-96
Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products, 3rd ed.

MNL-122-07
Architectural Precast Concrete, 3rd ed.

MNL-127-99
Erectors' Manual: Standards and Guidelines for the Erection of Precast Concrete Products

MNL-135-00
Tolerance Manual for Precast and Prestressed Concrete Construction

Manual for the Design of Hollow Core Slabs, 2nd ed. (1998)

Other publications
Concrete Technology Associates. 1974. "Composite Systems Without Roughness". In *Technical Bulletin*, 74-B6.

3 Definitions

In addition to the definitions in CSA A23.1, the following definitions shall apply in this Standard:

Bond breaker — a substance placed on materials to prevent concrete from bonding to them.

Bonding agent — a substance used to bond existing concrete to a subsequent application of concrete, mortar, or grout.
Note: *Examples of bonded concrete are patches and composite topping.*

Bowing — an overall out-of-plane curvature of a surface whose edges remain parallel.

Camber —
(a) the upward deflection caused by prestressing (does not include dimensional inaccuracies); and
(b) a built-in upward curvature to compensate for anticipated deflection.

Clearance — interface space (distance) between two elements.
Note: *Clearance is normally specified to allow for the effects of product and erection tolerances and for anticipated movement (e.g., deflection, thermal movement).*

Concrete cover — the distance from the concrete surface to the nearest deformation (or surface for smooth bars or wires) of the reinforcement.

Connection — a device for attachment of precast concrete elements to each other or to a building structure.

Construction joint — a surface where two successive placements of concrete join.

Corrosion inhibitor — a chemical added to concrete to delay the onset and reduce the rate of corrosion of reinforcement by chlorides by chemically influencing the kinetics of the electrochemical corrosion reaction at the reinforcement surface.
Note: *See Annex C in CSA S413 for information on corrosion inhibitors.*

Creep — a time-dependent deformation under sustained stress.
Note: *In some cases, creep is also known as plastic flow.*

Curing — the maintenance of the humidity and temperature of freshly placed concrete during a definite period following placing, casting, or finishing to ensure satisfactory hydration of the cementitious materials.
Note: *When the curing temperature remains in the normal environmental range (generally between 10 and 30 °C), this Standard uses the term "normal curing". When the curing temperature is increased to a higher range, this Standard uses the term "accelerated curing".*

Debonded tendon — a stressed tendon that is permanently prevented from bonding to the concrete in the end zone.
Note: *This is achieved by use of a bond breaker or ducts.*

Detensioning of tendon or **wire** — the transfer of tension from the bed anchorage to the concrete.

Differential camber — the difference in elevation between slabs of identical size, length, and prestressing force.

Documented — written technical substantiation of the use of a particular material, design practice, or construction method that satisfies the intent of this Standard.

Draft — the slope of a concrete surface in relation to the direction in which the precast element is withdrawn from the form.
Note: *Draft is provided to facilitate stripping with a minimum of form breakdown.*

Draped tendon — a tendon that is held up at specific points and held down at others to form a desired profile.
Note: *This practice can be referred to as harping, deflecting, or depressing a tendon.*

Dunnage — materials used for keeping concrete elements from touching each other or other materials during storage and transportation.

Engineer — a person in the engineering profession with specific expertise in precast concrete who is licensed to practice in a jurisdiction in Canada.

Exposed aggregate concrete — concrete manufactured so that the aggregate on the face protrudes from the paste.

Face mix — the exposed (visible) face of an architectural component behind which is a different type of concrete which may be a less costly or less visually attractive mix.

Flatness — the degree to which a surface approximates a plane.

Form — a structure or mould supporting of concrete while it is setting and gaining sufficient strength to be self-supporting.
Note: *The word "form" is used throughout this Standard and can refer to a mould (see **Mould**).*

Form release agent — a substance applied to a form to prevent bond between the form and the concrete cast in it.

Formed surface — a concrete surface that has been cast against formwork.

Grout — a mixture of cementitious materials and water, with or without sand. It can also contain admixtures.

Hardware — items used to connect precast units or attach other materials or equipment.
Note: *Hardware may be classified as follows:*
(a) Contractor's hardware: items placed in a structure to receive precast concrete units (e.g., anchor bolts, angles, or plates with suitable anchors). These items are usually marked "C" on shop drawings.
(b) Plant hardware: items embedded in the concrete units themselves, either for connections and precast installer's work or for other trades (e.g., mechanical, plumbing, glazing, miscellaneous iron, masonry, or roofing trades). These items are usually marked "P" on shop drawings.
(c) Installation hardware: all loose hardware necessary for installing precast concrete units. These items are usually marked "E" on shop drawings.

Holding period — the time from the placing of concrete to the commencement of accelerated curing.

Installation drawings — all drawings prepared by the manufacturer for installation.

Jig — a device to align parts of an assembly, usually for preassembling reinforcing steel and hardware cages with a minimum of measurement and consistent accuracy from one cage to the next.

Joint — the space between two adjacent precast concrete elements, used in the context of installation.
Note: *Other types of joints include control joints, construction or casting joints, expansion joints, and cold joints.*

Machine-cast product — a product produced by slip-form or extrusion.

Manufacturer — the party that produces (and usually installs) the precast concrete elements.

Manufacturer's engineer — the structural engineer authorized by the manufacturer to ensure the adequacy of the structural aspects of the shop drawings, manufacture, and installation for which the manufacturer is responsible.

Membrane — an impermeable material meeting the test requirements of ASTM C957 or CAN/CGSB-37.50, as applicable.
Note: *This definition is consistent with the definition in CSA S413.*

Mould — a custom-made form for specific products.
Note: *See **Form**.*

No-slump concrete — concrete designed with a low water/cementing materials ratio and a low slump that is compacted by special consolidation methods such as tamping or extrusion.

Owner — the administrator of the requirements of this Standard or the designated representative.
Note: *This role is usually performed by an engineer or an architect.*

Prestressing bed — the platform and abutments needed to support the forms and maintain the tendons in a stressed condition during placing and curing of the concrete.

Quirk — a reveal or false joint between two adjoining corner surfaces to mask mitred or cold joints.

Sandwich wall panel — a wall element consisting of two wythes of concrete separated by a layer of insulation.

Sealer (protective coating) — a material for coating precast concrete elements to improve resistance to water penetration or improve weathering qualities.

Set-up — the preparation of forms or moulds for casting, including placing of materials before placing of concrete.

Shop drawings — all drawings prepared by the manufacturer for production.
Note: *See Clause A.3.3.*

Smoothness — the degree to which a surface is locally flat.

Strand — a group of wires laid helically over a central core-wire.
Note: *A seven-wire strand consists of six outer wires laid over a single wire core.*

Strand anchor — a device for holding a strand under tension.
Note: *Sometimes called a "chuck" or "vice".*

Stress-resistant form — a form provided with suitable end bulkheads and sufficient strength to resist the total prestressing force.

Stripping — removing a precast concrete element from the form in which it was cast.

Supplier — the party supplying materials or components to the manufacturer.

Surface retarder — a material used to retard or prevent hardening of the cement paste at a concrete surface, thereby facilitating removal of the paste after curing.

Sweep — a variation in horizontal alignment from a straight line parallel to centreline of a concrete member.
Note: *Also called "horizontal bowing".*

Tendon — a high-strength steel element consisting of one or more wires, strands, or bars or a bundle of such elements, used to impart prestress to the concrete.

Tolerance — the permissible variation from the specified requirements.

Transfer strength — the minimum concrete strength specified for the individual concrete elements before the prestressing force can be transferred to them.
Note: *Sometimes called "detensioning strength" or "release strength".*

Veneered construction — the application of two different concrete mixes in one element.
Notes:
(1) *An example is a special architectural face mix and a standard backup mix.*
(2) *This term can also refer to the attachment of other materials (e.g., cut stone pieces, to a concrete panel).*

Warping — the twisting of a concrete member, resulting in an overall out-of-plane curvature of surfaces, characterized by non-parallel edges

4 Categories, certification, design basis, and project samples and reviews

4.1 Categories

In this Standard, precast concrete products are divided into one of the following three categories and each category is divided into two subcategories:

(a) architectural:
  (i) non-prestressed; and
  (ii) prestressed;
(b) structural:
  (i) non-prestressed; and
  (ii) prestressed; and
(c) specialty:
  (i) non-prestressed; and
  (ii) prestressed.

Note: *See Annex C for a comprehensive listing of the capabilities manufacturers must possess to manufacture precast concrete products for different applications.*

4.2 Certification

Precast concrete elements produced and installed in accordance with this Standard shall be produced by certified manufacturers, with certification demonstrating the capability of the manufacturer to fabricate precast concrete elements to the requirements of this Standard.

Note: *Users may request that conformity assessment of precast concrete products or elements to this Standard be performed by an organization accredited to do so. In Canada, the accrediting body is the Standards Council of Canada. Purchasers of precast concrete products may accept certification from other organizations that are equivalent.*

4.3 Design basis

4.3.1

The structural design of architectural and structural precast concrete shall be in accordance with CAN/CSA-A23.3 or CAN/CSA-S6.

Note: *Users may contact the authority having jurisdiction for further information.*

4.3.2

The design of specialty precast products shall be in accordance with other applicable Standards, as specified by the owner.

4.3.3

Sandwich wall panels shall be designed as composite or non-composite.

Note: *See the* CPCI Design Manual.

4.4 Project samples and reviews

4.4.1

The appearance of architectural precast concrete shall be determined by review of samples before production. The finishes shall be defined by the samples and by specifications for performance requirements such as durability, strength, and water absorption.

Note: *Samples for architectural precast concrete should be regarded only as providing a standard for performance within the variation of materials and quality of work to be expected. If the colour or appearance of the cement or aggregates is likely to vary significantly, samples showing the expected range of variations should be supplied for review by the owner. For further information, see Commentary C1.5.4 of PCI MNL-117.*

4.4.2
Project samples shall be submitted with sufficient information for the owner to assess the quality and expected performance of the concrete in the sample.

4.4.3
All finishes shall be carefully assessed and detailed with regard to controlling the effects of weathering.
Note: *For special weathering considerations, see PCI MNL-122.*

4.4.4
The shape of a sample shall resemble the shape of the actual casting. Flat samples shall be used only for flat castings. The size of a sample shall represent the maximum size of the aggregate to be used and shall allow for realistic placing of the concrete and the accurate expression of detail.
Note: *Unavoidable segregation in finishes that use mixes with a large colour difference between the coarse aggregate and the sand and cement matrix will produce noticeable colour and texture variations.*

4.4.5
The concrete placement and consolidation method used to make samples shall be representative of the intended production method.

4.4.6
Samples shall be supplied for each of the finishes for a project and all samples shall be clearly identified. A reference sample shall be cast using formwork, concrete, and vibration typical for the project. The reference sample shall be viewed from a distance of 6 m. Once accepted, the reference sample shall be identified and used for comparison in assessing compliance with the specified finish.
Note: *Samples with special architectural features representative of items that are installed and viewed at eye level might require review at closer distances.*

4.4.7
The first production units shall be reviewed by the owner before regular production continues. Such units shall be properly marked and serve as acceptance criteria for the balance of the project. They shall remain identifiable, even on the building, until final acceptance of the project.

5 Cements, supplementary cementing materials, and colouring materials

5.1 General
Cements and supplementary cementing materials shall comply with Clause 4.2.1 of CSA A23.1 and Clause 5.2 of this Standard.

When uniformity of colour for all or part of a project is desired, each cementing material used shall be of one type and from the same mill. This requirement shall apply whether a single cement or a mixture of cementing materials is used.

Notes:
(1) *The characteristics of special cements should be investigated before use.*
(2) *Some suppliers will provide cement that falls within guaranteed percentage colour variations.*
(3) *When a mixture of white and grey cements is used, uniformity is normally improved by increasing the percentage of white, but the grey tends to dominate.*

5.2 Colouring materials

Pigment used in the concrete mix or as a surface colourant shall have a proven history of colourfastness and shall not reduce the durability of the concrete.

Notes:

(1) *Suitable tests or performance records are used to establish colour stability in the actual concrete mix and compatibility with possible retarders and finish treatments.*

(2) *Except for exposed surfaces, dark pigments should be avoided.*

(3) *The effect of colouring agents on air content, mixing water requirements, and water absorption of the face mix should be established before use.*

6 Water

Water for use in precast concrete and curing shall comply with Clause 4.2.2 of CSA A23.1.

Water for architectural concrete mixtures and curing shall be free of impurities or colour that could affect the concrete finishes.

7 Aggregates

7.1 General

Aggregates for use in precast concrete shall comply with Clause 4.2.3 of CSA A23.1 and Clause 7.2 of this Standard.

7.2 Special aggregate

Special aggregate for architectural concrete (e.g., ceramics, glass, and plastics) shall not be used unless tests have proved, to the satisfaction of the owner, that they are acceptable with respect to strength, density, durability, and appearance for a minimum of 5 years.

Notes:

(1) *Investigation of special aggregates should cover the material itself and its interaction with the concrete materials and any other materials with which it could come in contact in service.*

(2) *Where elements have exposed aggregate finishes, care should be taken in selecting the aggregate so that it can withstand the environment to which it will be exposed.*

7.3 Fine aggregate

7.3.1 General

Fine aggregate for architectural concrete shall comply with Clauses 7.3.2 to 7.3.4.

Note: *When fine aggregate is likely to be a major colouring agent in architectural concrete, it should be controlled even more closely by using manufactured one-size fine aggregate.*

7.3.2 Grading

To control the uniformity of the appearance of architectural concrete, the amount of material passing a 160 µm sieve shall be limited to a maximum of 2% or maintained within ±1% of the amount established in the mix design.

Note: *For low absorption, the percentage of aggregate passing a* 315 µm *sieve, when tested in accordance with Test Method A23.2-2A in CSA A23.2, might need to be lower than the limit specified in CSA A23.1.*

7.3.3 Limits for deleterious substances

Fine aggregate for architectural concrete with exposed aggregate finishes exposed to the weather shall conform to the limits specified in the following table when tested in accordance with Test Methods A23.2-3A, A23.2-4A, and A23.2-5A in CSA A23.2, unless an exposure for at least 5 years under similar environmental conditions indicates acceptable durability and appearance:

Substance	Maximum % by mass of total sample
Clay lumps	1.0
Coal or lignite particles	0.5
Material passing an 80 µm sieve	2.0

Note: *See also Table 12 of CSA A23.1.*

7.3.4 Organic impurities

Fine aggregate tested in accordance with Test Method A23.2-7A in CSA A23.2 shall not produce a colour darker than the standard colour.

7.4 Coarse aggregate

7.4.1 General

Coarse aggregate for architectural concrete shall comply with Clauses 7.1 and 7.4.2 to 7.4.5.

7.4.2 Grading

Coarse aggregate for architectural concrete shall comply with the grading requirements of CSA A23.1, except when a special architectural appearance is required or exposure for at least five years under similar environmental conditions indicates satisfactory performance of the concrete mix.

7.4.3 Limits for deleterious substances and physical properties

Coarse aggregate for architectural concrete with exposed aggregate finishes exposed to the weather shall conform to the limits specified in the following table when tested in accordance with the test methods specified in Clause 4 of CSA A23.1 unless exposure of at least 5 years under similar environmental conditions indicates acceptable durability and appearance:

Substance or physical property	Maximum % by mass of total sample
Clay lumps	0.25
Coal particles	0.5
Material passing an 80 µm sieve	1.0
Magnesium sulphate soundness loss	12
Abrasion loss	35

Note: *See also Table 12 of CSA A23.1.*

7.4.4 Staining materials

Aggregates with iron compounds or other potentially staining materials shall not be used in architectural concrete that will be exposed to the weather unless the owner has been informed of the potential risks and consequences associated with the use of such aggregates. When tested in accordance with ASTM C641, such aggregates shall have a stain index of less than 20.

7.4.5 Structural low-density aggregate

Absorption of structural low-density aggregate, as defined in ASTM C330, shall not exceed 11% when such aggregate is used in architectural face mixes exposed to the weather.

Note: *Low-density aggregate should not be used in exposed finishes in cold or humid climates unless the performance of such aggregate has been verified by tests or the aggregate has demonstrated satisfactory performance under similar climatic conditions.*

8 Admixtures

8.1 General

Admixtures for use in precast concrete shall comply with Clause 4.2.4 of CSA A23.1 and Clause 8.2 of this Standard.

Note: *Some admixtures can affect the colour tone of concrete; therefore, the same admixture should be used throughout any part of a project where colour uniformity is required.*

8.2 Calcium chloride

Calcium chloride shall not be used in precast concrete.

9 Reinforcement

Reinforcement and prestressing tendons for use in precast concrete shall comply with Clause 6.1 of CSA A23.1 and, for concrete railroad ties, ASTM A881/A881M and ASTM A911/A911M.

10 Hardware and miscellaneous materials

10.1 General

Hardware and miscellaneous materials for use in precast concrete shall comply with Clause 6.2 of CSA A23.1 and Clauses 10.2 and 10.3 of this Standard.

Note: *To prevent rust staining on finished surfaces, all exposed metal inserts, anchorages, and other hardware should be protected with a rust-preventing material.*

10.2 Hardware

10.2.1 Connections

Precast connection hardware shall be identified and located on the shop drawings. The owner shall specify corrosion protection adequate for the type of exposure and the design service life.

Note: *Types of exposure for which measures such as hot-dip galvanizing or the use of stainless steel should be considered include the following:*

(a) exposure to corrosive environments;
(b) exposure to the weather, condensation, or other sources of moisture; and
(c) exposure within the air or insulation space outside the air barrier of a building.

10.2.2 Tendon deflectors

10.2.2.1

Tendon deflectors shall maintain the tendon location (bundled or spaced) in accordance with the design criteria and as shown on the shop drawings.

10.2.2.2
Tendon deflectors shall comply with the requirements of the design criteria and shall be of a type suitable for their intended use. When specified by the owner and furnished by a supplier, test and performance data shall be documented. When tendon deflectors are manufactured by the precast concrete plant's own personnel, the design shall be reviewed by the owner. Welding of hardware shall comply with Clause 6.7.4 of CSA A23.1.

10.2.2.3
Tendon deflectors used for holding tendons in the deflected position during stressing shall have pin and roller fixtures to minimize friction at all deflection points.

10.2.3 Pipes, conduits, and other hardware
Pipes, conduits, and other hardware shall be identified and located on the shop drawings.

10.2.4 Tendon anchors

10.2.4.1
Tendon anchors shall be capable of anchoring the tendon positively without slippage after seating.

10.2.4.2
Steel casings for tendon anchors shall be proof-tested by the supplier to at least 95% of the ultimate specified tensile strength of the tendon without permanent deformation of the casing.

10.2.4.3
Proper performance and maintenance data for the anchors shall be documented by the supplier.

10.2.4.4
Anchors for reuse shall be of a type designed for reuse. Anchors that are used only once and remain in the product may be of the one-use-only type.

10.2.4.5
Tendon anchors used repeatedly shall be removed from the beds and maintained regularly in accordance with the supplier's recommendations and with the use of proper tools and materials. The frequency of maintenance shall depend on the type of anchor and its exposure during use, but the same anchor shall never be used more than five times without checking and maintenance.

10.3 Miscellaneous materials

10.3.1 Special facing materials
When alternative facing materials such as brick, cut stone slabs, ceramic and glass products, plastics, oversized aggregates, metal sheets or sections, or wood are used as an integral part of the precast concrete element, such materials shall have a performance record that has been acceptable for at least 5 years under similar exposure conditions or shall be designed, tested, and proved to the satisfaction of the owner.

10.3.2 Bearing materials
Bearing materials shall have a record of satisfactory performance; alternatively, test results that prove the adequacy of such materials shall be made available to the owner upon request. Bearing materials shall be identified on the shop drawings and shall be adequate for the expected loads and movements. The owner shall specify the bearing materials for any bearings considered to have particularly high structural significance.

10.3.3 Joint materials
Materials for joints between precast concrete elements shall comply with CAN/CGSB-19.13 or CAN/CGSB-19.24, unless other standards are specified by the owner.
Note: *See PCI MNL-122.*

10.3.4 Weather-sealing materials
If weather-sealing materials are used, they shall be as specified or reviewed by the owner.
Note: *See PCI MNL-122.*

10.3.5 Insulation for sandwich wall panels
The owner shall specify the insulation material or the insulating properties (required R value) for sandwich wall panels. Plastic foam insulation shall have a flame spread rating of less than 500.
Note: *Properties such as insulation value, vapour transmission, and volume stability under service conditions should be documented and this documentation should be available from the supplier.*

10.3.6 Manufacturing accessories
Form ties, inserts, bracing, spacers, and similar accessories for production of precast concrete elements shall be adequate for their intended use and shall not be detrimental to the finished product.

10.3.7 Other materials
Other materials used in the manufacture of precast concrete shall be documented. Such documentation shall be available at the plant.

11 Storage of materials

11.1 General
Materials for use in precast concrete shall be stored in accordance with Clause 6.3 of CSA A23.1 and Clause 11.2 of this Standard.

11.2 Hardware materials
Hardware materials shall be
(a) stored according to type, grade, and size;
(b) handled and stored in a manner that avoids distortion; and
(c) kept clean.

12 Tolerances

12.1 General

12.1.1 Basic requirements
The maximum variations specified in Clauses 12.2 to 12.5 shall apply to finished precast concrete work and the installation of such work. The tolerances for precast concrete work shall comply with Clause 12 unless otherwise specified by the owner.

12.1.2 Tolerances not specified elsewhere
For situations in which the maximum variation is not specified in Clauses 12.2 to 12.5, the maximum allowable dimensional variation shall be 1:800 or ±5 mm, whichever is greater.
Notes:
(1) *See Annex C of CSA A23.1 for tolerance-related definitions, principles, and preferred sizes.*

(2) *Precast concrete elements not within the production tolerances provided in Clauses 12.2 to 12.5 may be accepted by the owner if they can be repaired and/or installed to the installation tolerances specified and any variations have been checked and reviewed for structural implications. The production tolerances specified in Clauses 12.2 to 12.5 will serve to establish the responsibility of the precast manufacturer for having the elements repaired in accordance with Clause 33 and/or installed within the installation tolerances and to verify that structural performance is not impaired.*

12.2 Tolerances for architectural precast concrete elements

12.2.1
Element tolerances for architectural precast concrete members shall be in accordance with Article 10.1 of PCI MNL-135.

12.2.2
Erection tolerances for architectural precast concrete members shall be in accordance with Article 12.5 of PCI MNL-135. See Figures 3 and 4.

12.3 Tolerances for architectural trim elements

12.3.1
Element tolerances for architectural precast concrete trim members shall be in accordance with Articles 10.27, 10.28, and 10.29 of PCI MNL-135.

12.3.2
Erection tolerances for architectural precast concrete trim members shall be in accordance with Article 12.5 of PCI MNL-135.

12.4 Tolerances for structural precast concrete elements

12.4.1
Element tolerances for structural precast concrete members shall be in accordance with Article 10.0 of PCI MNL-135. Articles 10.1, 10.27, 10.28, and 10.29 of PCI MNL-135 shall not apply to this Clause.

12.4.2
Erection tolerances for structural precast concrete members shall be in accordance with Article 12.0 of PCI MNL-135. Article 12.5 of PCI MNL-135 shall not apply to this Clause.

12.5 Tolerances for structural precast concrete elements with special surface finishes

12.5.1
Element tolerances for structural precast concrete members with special surface finishes shall be in accordance with Article 10.0 of PCI MNL-135. Articles 10.1, 10.27, 10.28, and 10.29 shall not apply to this Clause.

12.5.2
Erection tolerances for structural precast concrete members with special surface finishes shall be in accordance with Article 12.0 of PCI MNL-135. Article 12.5 of PCI MNL-135. shall not apply to this Clause.

12.6 Panel warping
The maximum allowable panel warpage of one corner out of the plane of the other three at the bottom surface shall be in accordance with Articles 8.1.7 and 10.0 of PCI MNL-135. See Figure 1.

12.7 Panel bowing

The maximum allowable panel bowing shall be in accordance with Articles 8.1.7 and 10.0 of PCI MNL-135. See Figure 2.

12.8 Camber

The maximum variation of design camber shall be in accordance with Articles 8.9 and 10.0 of PCI MNL-135.

Notes:

(1) *When roofing insulation and roofing materials are applied directly to precast slabs, feathering-out between slabs can be necessary when the differential camber exceeds* 10 mm. *The owner should specify the minimum differential camber above which such feathering-out by the precast installer is required.*

(2) *For precast slabs without subsequent floor topping applied in the field, or where top surface conditions are otherwise important, the maximum allowable elevation difference should be specified.*

12.9 Other tolerances

The tolerances for placing of reinforcement, hardware, hold-down devices, and lifting points shall be as specified in Clauses 14 and 15.

12.10 Tolerances for joints between architectural wall elements

Precast wall elements shall be manufactured and installed in accordance with Articles 11.0, 12.4, and 12.5 of PCI MNL-135.

Notes:

(1) *The maximum deviation in joint width from the specified width should be either* 8 mm *or* 12 mm. *The choice depends on the specified clearance between the structure and the panels and on whether the tolerances for length and height of elevations are to be accommodated solely in the joints.*

(2) *Small variations in the width of adjacent joints can be achieved by setting out joint centrelines equally spaced along an elevation and centring the panels between them.*

(3) *The maximum deviation in joint widths from the specified width may be limited to* 5 mm *in projects where tolerances for length and height at elevations have been designed to be accommodated as part of the corner details, in expansion joints, and in overlapping details with other wall materials.*

13 Forms

13.1 Forms for precast concrete

13.1.1

The design and materials for forms shall comply with CAN/CSA-S269.3 and Clauses 13.1.2 to 13.3 of this Standard. In addition, the design and materials shall comply with the quality requirements for the finished product with respect to materials and dimensional controls.

13.1.2

Forms shall be able to withstand the consolidation of the concrete by external and internal vibration, the hydrostatic concrete pressure, and thermal stresses during the complete cycle for either normal or accelerated curing and shall be made so that water and cement paste are not lost from the concrete.

Notes:

(1) *Where empty forms or forms containing concrete are to be handled during the production cycle, the forms should be designed to maintain the dimensional controls of the element*

(2) *Where external vibration is used, special design of the forms is necessary to maintain the specified tolerances. If the vibrators are fastened to the form, their position and the construction of the form should be such that uniform vibration is transmitted along any surfaces that are to be exposed.*

(3) *When the form is assembled from several components, compressible seals between components should be used or the joints should be sealed before the concrete is placed.*

13.1.3
Parts such as bulkheads, side or top forms, or form modification pieces shall be well fitted and secured and joints shall be sealed to prevent leakage.

13.1.4
Forms shall be fabricated to allow stripping without damage to the precast element.

13.1.5
Form braces shall not touch the concrete for any finish better than smooth form finish, as described in Clause 6.5 of CSA A23.1, unless reviewed by the owner.

13.1.6
Forms shall be clean, well maintained, and checked to ensure that elements of the required quality are produced.

Notes:

(1) *The manufacturer should identify the specific form or forms in which an element was cast so that appearance and dimensional problems can be identified.*

(2) *Tolerances for forms should be one-half those specified for the dimensions of the finished element in Clause 12.*

13.1.7
Joints in the form material shall be made in such a manner that they will not be reflected in the concrete surface and mar the appearance of the product.

13.1.8
Repeated casting, consolidation of concrete, and stripping of elements shall not affect the dimensions or the planes of the elements beyond the allowable tolerances.

Notes:

(1) *It is important that window openings be made accurately. For glazing directly to the concrete, the plane of the opening should meet the tolerance requirements during the entire casting and curing cycle.*

(2) *Corners of precast concrete elements that are exposed to view should normally be rounded. Lines and shapes should be true and uniform.*

(3) *Whenever possible, forms should have sufficient draft to facilitate stripping with a minimum of form breakdown.*

(4) *It is often advantageous to precast architectural elements with large returns in stages in order to cast exposed surfaces horizontally and thus obtain a more uniform texture.*

13.1.9
Forms shall permit fixed positioning or jigging of hardware and allow for accurate positioning of the reinforcing cage while maintaining the specified cover to the reinforcement. In architectural concrete, spacers shall not be used between the reinforcing and those surfaces that will be exposed to view.

Notes:

(1) *When spacers are necessary for unusual products, their use and type should be reviewed by the owner.*

(2) *Forms may be made of wood, steel, concrete, plastic, rubber, or a combination of these materials. The choice of material should be the manufacturer's, provided that this does not compromise the quality of the finished product specified by the owner.*

13.1.10
When forms are being prepared for concrete, form-release agents and surface retarders shall be applied uniformly.

13.1.11
Forms shall allow for shortening and movement of the precast elements during the transfer of prestress and for the application of heat when accelerated curing is used.

13.1.12
Forms shall be sufficiently strong and stiff to carry concentrated loads resulting from cambering of prestressed elements following the release of the prestress force.

13.1.13
Butt joints between form units making up the length of a casting bed shall match closely to minimize form break lines on the elements.

13.1.14
Proper alignment of all form units shall be maintained during the entire casting operation.

13.1.15
Stress-resistant forms shall be designed and constructed in such a way that they are sufficiently stiff and strong to withstand the prestressing forces and still maintain the required dimensional tolerances.

13.2 Forms for internal voids

13.2.1
Forms for internal voids shall have sufficient strength and stiffness to provide stability during handling and placing of concrete and to withstand hydrostatic pressures and other forces during the production cycle. However, the forms shall not be so stiff as to cause the concrete to crack because of the restraint of shrinkage.

Notes:

(1) *Where new void designs are used, elements should be checked to ensure that void collapse or displacement has not taken place and that no stress raisers have been created. When voids cannot be visually checked, actual concrete quantities may be compared with theoretical quantities or the actual mass of an element may be compared with the theoretical mass.*

(2) *Storage conditions affect some void form materials and should be monitored so that a change in shape or a collapse can be prevented.*

13.2.2
The forming material shall not be adversely affected by moisture. The adequacy of the forms shall be established before use.

13.2.3
Forms for internal voids shall be held in place during the placing and consolidation of the concrete in such a way that their correct positions are maintained.

13.2.4
The anchoring devices to hold the voids in position shall be properly spaced to minimize the deflection between anchor points and shall not puncture or otherwise damage the forms. Where void anchors are attached to the reinforcement or prestressing tendons, displacement of the reinforcement shall be prevented. Where removable templates are used, they shall remain in place for sufficient time after concrete placement to ensure that the void is not displaced upon removal of the templates. However, the concrete shall be sufficiently plastic that holes left by the template removal can be filled and the concrete compacted into a homogeneous mass.

13.2.5
The ends and splices of void forms shall be sealed to prevent entry of cement paste or concrete.

13.2.6
When specified by the owner, void forms other than the solid type shall be drained. Where elements are subjected to freezing temperatures, the voids shall be provided with drains at appropriate points.
Note: *When accelerated curing is used, consideration should be given to providing vents in void forms.*

13.3 Preparation of forms

13.3.1
Forms shall be clean and shall be assembled within the dimensional controls established for the particular set-up and element.

13.3.2
Form-release agents shall be
(a) applied uniformly;
(b) of a type consistent with the required finish;
(c) used at a rate suitable for easy release and stripping of the element; and
(d) compatible with any further treatment of the concrete surface.
Note: *The choice of form-release agents or surface retarders should be based on the form configuration, planned production methods, the actual curing conditions, and any further treatment of the concrete surface.*

13.3.3
The prestressing tendons, anchorages for miscellaneous connections, and reinforcement shall not be contaminated by form-release agents, whether the form-release agent is applied before or after the placing of the reinforcement and hardware.

14 Fabrication and placement of reinforcement

14.1 General
Fabrication and placement of reinforcement and prestressing tendons shall comply with Clause 6.6 of CSA A23.1 and Clauses 14.2 to 14.6 of this Standard.

14.2 Placing of tendons
The location of individual pretensioning tendons shall be shown on the shop drawings. At the ends, the minimum clear spacing shall be 2-1/4 times the nominal diameter of the individual tendon, but not less than 1-1/2 times the nominal maximum size of the coarse aggregate.

14.3 Placing of reinforcement
The size, shape, and spacing of all reinforcement shall be checked against the shop drawings. The reinforcement shall be placed in the forms within the tolerances specified in Clause 14.4. Any variations in spacing of reinforcement exceeding allowable tolerances shall be corrected.
Note: *To maintain tolerances and concrete cover requirements in intricate shapes or small concrete sections, cages should be produced on a jig. Tack welding will normally result in additional cage rigidity and accuracy, but its use is restricted by CSA W186, which describes the procedures to be followed when tack welding is performed.*

14.4 Tolerances for placing

14.4.1
Reinforcement shall be placed within the following tolerances:
(a) for clear concrete protection or reinforcement: ±8 mm;

(b) for the position of primary flexural and compression reinforcement, where the depth of a flexural element, thickness of a wall, or smallest dimension of a column is
  (i) 400 mm or less: ±8 mm;
  (ii) more than 400 mm but less than 800 mm: ±12 mm; and
  (iii) 800 mm or more: ±20 mm;
(c) for the lateral position of flexural reinforcement, wall reinforcement, column ties, stirrups, temperature reinforcement, and other secondary reinforcement, where the depth of a flexural element, thickness of a wall, or smallest dimension of a column is
  (i) 400 mm or less: ±12 mm;
  (ii) more than 400 mm but less than 800 mm: ±20 mm; and
  (iii) 800 mm or more: ±30 mm;
(d) for longitudinal locations and ends of bars, except at ends of elements: ±50 mm; and
(e) for ends of bars at ends or edges of elements: ±20 mm.

Notes:

(1) *Tolerances different from those specified in Clause 14.4.1 should be specified by the owner in the contract documents and should be detailed on the shop drawings.*

(2) *Smaller tolerances should be specified only after a careful evaluation for feasibility, realistic control, and need.*

(3) *More precise tolerances for the location of prestressing tendons of* ±5 mm *are feasible for some precast prestressed concrete elements.*

14.4.2

Regardless of tolerance requirements, the concrete cover shall not be reduced by more than one-fourth of the specified cover (see Clause 14.6).

14.4.3

Deflection points in prestressed elements shall be located with a longitudinal tolerance of ±200 mm, unless otherwise specified by the owner.

14.5 Welding of reinforcement

The welding of reinforcement (including tack welding) for precast concrete shall comply with CSA W186.

14.6 Concrete cover

14.6.1

The specified cover to the reinforcement, tendon sheaths, and ducts in precast concrete shall be not less than the larger of the values specified in Table 1.

Note: *For textured architectural surfaces, the cover is measured from the deepest point of the surface. The distance between the form and the reinforcement therefore needs to be large enough to compensate for this reduction.*

14.6.2

In a corrosive environment, additional concrete cover shall be provided in accordance with CSA A23.1, CSA S413, or CAN/CSA-S6, as applicable.

Note: *Galvanized or stainless steel bars may be used where adequate cover cannot be provided.*

14.6.3

When a precast concrete member is required to have a fire-resistance rating, the minimum cover for reinforcement shall be specified by the owner.

Notes:

(1) *Information on fire resistance can be obtained from the CPCI* Fire Resistance Ratings for Prestressed and Precast Concrete.

(2) *For information on fire performance ratings, see the* National Building Code of Canada.

15 Fabrication and placement of hardware and other embedded items

15.1 General

Fabrication and placement of hardware and other embedded items shall comply with Clause 6.7 of CSA A23.1 and Clauses 15.2 to 15.5 of this Standard.

15.2 Handling of hardware

Care shall be taken during handling and placing of hardware to prevent damage to corrosion protection. All damage shall be repaired. For galvanized elements, repairs shall be performed in accordance with ASTM A780.

Notes:

(1) *The exposed metal surfaces of hardware should be adequately protected during storage.*

(2) *Additional protective measures for hardware after installation will depend on exposure and on how the hardware is handled.*

15.3 Shop drawings

Specified reinforcement, as shown on the shop drawings, shall not be modified, relocated, or eliminated to accommodate hardware. If hardware anchors or reinforcing steel cannot be located as shown on the shop drawings, the revisions shall be reviewed by the manufacturer's engineer. All revisions shall be recorded on the drawings for review by the owner.

15.4 Tolerances for placing hardware

Hardware shall be placed in accordance with Article 10.0 of PCI MNL-135.

Notes:

(1) *Immediately after consolidation of the concrete, hardware should be checked for position and, if necessary, realigned.*

(2) *The reason for more precise tolerances in the case of slope variations is the difficulty in compensating for such variations when a connection is made in the field. In the case of other dimensional variations, as covered by Clause 6.7.3 of CSA A23.1, it is relatively simple to compensate if the design has allowed for sufficiently large plates, ample clearances, and proper use of shim plates.*

15.5 Lifting and handling hardware

Permanent connection hardware shall not be used for handling unless designed and approved by the manufacturer's engineer. The connections shall be designed for such additional service to prevent damage to the connection or impairment of their performance. Any resulting damage to corrosion protection shall be repaired. In the case of hot-dip galvanized connections, repairs shall be performed in accordance with ASTM A780.

Notes:

(1) *Lifting devices made of prestressing tendon or wire cable are frequently used. If more than one tendon or wire cable is required to comply with the design requirements, special provisions should be used to ensure that the load is distributed evenly between all lifting devices. Proper rigging should be used to distribute the load in accordance with the design criteria.*

(2) *Threaded inserts and lifting devices with exposed threads should be protected.*

(3) *Precast elements designed to be demountable should have permanent protected connections to allow for the future relocation of the elements.*

16 Mix proportions

16.1 General

Mix proportioning for precast concrete shall comply with Clause 4.3.1 of CSA A23.1 and Clauses 16.2 and 16.3 of this Standard.

16.2 Architectural concrete

All architectural concrete exposed to the weather shall have a

(a) minimum compressive strength of 30 MPa;
(b) minimum air content of 5%; and
(c) maximum water/cementing materials ratio of 0.45.

16.3 Veneered construction

16.3.1

When two different concrete mixes are veneered in a precast concrete element, the two mixes shall be compatible as an integral unit. The mixes shall be within 10% of each other with respect to cementing materials and water/cementing materials ratio.

Note: *Because dissimilar expansion and contraction caused by thermal and moisture changes, and differential shrinkage and creep, can cause unacceptable cracking, bowing, or warping, any difference in behaviour between the face and the backup concrete should be minimized. Accordingly, the two mixes should be reasonably compatible with respect to cementing materials content and water/cementing materials ratio.*

16.3.2

When a separate face mix is used for precast concrete, the thickness of the face mix following consolidation shall be at least 25 mm or 1-1/2 times the maximum size of the aggregate, whichever is larger. In the case of large aggregates hand-laid in a mould, these dimensions shall apply to the concrete mix used as the matrix.

17 Durability

Precast concrete shall comply with Clause 4.1.1 of CSA A23.1. Care shall be taken to protect connections and exposed hardware.

Note: *Durable precast concrete structures are dependent on the protection of reinforcement and hardware, whether provided by concrete cover or other means.*

18 Specifying concrete

Alternative (1) of Table 5 in CSA A23.1 shall be used by the owner for specifying the concrete used in precast concrete.

In addition to the items specified in Alternative (1) of Table 5 in CSA A23.1, the owner shall specify

(a) the allowable percentage of water absorption for architectural concrete exposed to the weather;
(b) special additives (e.g., colour pigments for architectural concrete);
(c) the maximum allowable water/cementing materials ratio; and
(d) for special high-quality architectural concrete in severe or polluted environments or when improved weathering qualities are desirable, the limits for any concrete materials passing a 315 µm sieve.

Note: *For further information, see Clause 4.1.2 of CSA A23.1.*

19 Concrete quality

19.1 General

Evaluation of concrete quality for precast concrete shall comply with Clause 4.4 of CSA A23.1 and Clauses 19.2 to 19.9 of this Standard.

19.2 Air content — Frequency and number of tests

19.2.1
The air content of each concrete mix shall be tested at the start of production and periodically during daily operation if the variation in slump exceeds 30 mm or the temperature of the concrete varies by more than 5 °C.

Note: *When the air content is critical, it should be checked before the concrete is placed and again when strength samples are taken during the casting.*

19.2.2
When special consolidation methods make it difficult to predict the air content in the hardened concrete, the air content shall be verified by a test of the hardened concrete in accordance with ASTM C457. The test shall be performed periodically, whenever the placing or consolidation methods are modified and whenever the concrete materials are changed.

Note: *Manufacturing methods (e.g., machine-cast extrusion techniques) and some consolidation methods (e.g., use of spinning machines or impact tables) cause loss of air. This may be compensated for by increasing the initial air dosage unless other tests prove, to the satisfaction of the owner, that the additional strength and density eliminate the need for additional air.*

19.3 Compressive strength

19.3.1 Frequency and number of tests
For prestressed concrete production, the following minimum number of cylinders shall be taken each time a bed is used:

(a) two for determining compliance with the specified compressive strengths;
(b) two for determining compliance with the release strength at time of transfer. These cylinders shall be made from concrete placed during the latter half of bed casting; and
(c) one for each intermediate strength level, as necessary.

Note: *Where several beds are cast with the same concrete mix during one working day, the testing for the specified compressive strength may be reduced to a minimum of two beds.*

19.3.2 Test methods
For architectural and structural precast concrete production, compliance with the specified compressive strength shall be determined by testing a minimum of two cylinders from each type of concrete mix each day or a minimum of two cylinders for each 30 m^3 of any one mix when daily production exceeds 30 m^3. When the daily quantities are small, one test shall be performed for every 3 m^3. When the daily quantities are smaller than 3 m^3, two tests shall be performed each week.

Cylinders for determining handling strengths shall be made from each new mix until the plant has correlated the cylinder strength to the maturity of the concrete in accordance with ASTM C1074. If the plant has not conducted correlation tests, cylinders shall be made.

Note: *If more than one mix is in use, the cylinder tests may be performed on a rotating basis.*

19.3.3 Test cylinders
Standard 100 × 200 mm test cylinders shall be used.

19.3.4 In-house testing
When concrete cylinders are made for the purpose of in-house testing, methods other than those described in Test Method A23.2-9C in CSA A23.2 may be used, if acceptable to the owner.

19.3.5 Unbonded caps
Unbonded caps, if used, shall comply with ASTM C1231/C1231M. The number of uses of unbonded caps shall not be limited if the manufacturer can demonstrate that the strength results will not be affected by the reuse of the unbonded caps. Unbonded caps may be used to determine strength levels at any age.

19.4 Absorption — Frequency and number of tests

As an indication of potential weather staining and durability characteristics, the absorption of all face mixes subject to weathering shall be established as the average of three tests in accordance with Test Method A23.2-11C in CSA A23.2. The absorption shall be verified at the beginning of each production run, every 6 months thereafter, and whenever the materials or production methods are modified.

Notes:

(1) *Acceptable absorption varies in accordance with exposure conditions but normally should not exceed 6% (by mass).*

(2) *To obtain an absorption of 6% or less, thorough consolidation and curing are necessary, as well as a low water/cementing materials ratio and limitations on the percentage of aggregates passing a* 315 µm *sieve.*

19.5 Accelerated curing tests

19.5.1

During accelerated curing, temperatures within the concrete shall be monitored and recorded in accordance with Clause 23.2.2.5.

Note: *For standard production methods, air temperatures rather than concrete temperatures may be monitored.*

19.5.2

When accelerated curing of the concrete elements takes place in accordance with Clause 23.2.2, all test specimens shall be cured with the concrete elements during the accelerated curing, following which the specimens shall be cured under controlled laboratory conditions in accordance with Test Method A23.2-3C in CSA A23.2.

Notes:

(1) *Test specimens should be placed in such a way that the curing conditions simulate as closely as possible the condition of the concrete elements. Specimens should not be subjected to any concentration of heat or any heat exceeding what is likely to reach the products. During initial castings in new set-ups, the ambient temperature around the test specimens should be compared to the ambient temperature near the elements.*

(2) *The experience of precast producers indicates that the initial curing of* 28 d *cylinders with the elements during accelerated curing will normally result in* 28 d *strengths up to 8% below normally cured laboratory cylinders, depending on how closely the optimum curing temperature cycle is controlled. However, this curing method is important, as it is the only valid check that the accelerated curing has not been excessive or has otherwise resulted in significant strength losses of the actual concrete element below the potential* 28 d *strength.*

(3) *To verify the potential strength of the concrete mix, normal laboratory-cured cylinders should occasionally be made and tested.*

19.6 Intermediate strength levels

For intermediate concrete strength determination, such as strength at handling or transfer of prestress force, test specimens made in accordance with other Standards may be used if the tests are correlated to standard cylinder testing.

Note: *Tests for intermediate strength levels may use test samples cast horizontally if the moulds and casting procedures are in accordance with ASTM C512.*

19.7 Low-density concrete

19.7.1

The modulus of elasticity and the shrinkage and creep characteristics of a proposed concrete mix with low-density aggregate for architectural, prestressed, or precast concrete shall be determined before its use and reviewed by the owner to ensure that it meets the applicable requirements of this Standard. This requirement shall apply to concrete where all aggregates are low density and to concrete with only low-density coarse aggregate.

Note: *The modulus of elasticity, shrinkage, and creep characteristics for low-density aggregate concrete are different from those for normal-density aggregate concrete. To assess related design and performance requirements (e.g., prestress losses, deflection, and camber under the proposed production methods and application), it is necessary to know the modulus of elasticity of low-density aggregate concrete.*

19.7.2
The absorption of structural low-density aggregate, as defined in ASTM C330, shall not exceed 11% when such aggregate is used in architectural concrete face mixes exposed to the weather.

Notes:

(1) *Low-density aggregate should not be used in exposed finishes in cold or humid climates unless the performance of the finishes has been verified by tests or records of satisfactory usage under similar conditions.*

(2) *In consolidation of lightweight concrete, precautions should be taken to avoid aggregate flotation caused by over-vibration.*

19.8 No-slump concrete

19.8.1
Test specimens shall be made in accordance with one of the following methods to determine the 28 d strength:

(a) concrete cylinders made, cured, and tested in accordance with Test Method A23.2-12C in CSA A23.2;

(b) drilled cores obtained and tested in accordance with Test Method A23.2-14C in CSA A23.2; or

(c) cubes sawn from the products and tested in accordance with ASTM C42/C42M.

The number of tests shall be as specified in Clause 19.3.2.

19.8.2
Intermediate strength levels, such as the strength at handling or transfer of the prestress force, shall be determined by

(a) any of the methods specified in Clause 19.8.1; or

(b) rebound hammer or other non-destructive testing calibrated to a test specified in Clause 19.8.1.

Tendon slippage of pretensioned products shall be measured in accordance with Clause 28.2.7.2.

19.9 Low-permeability concrete
Low-permeability concrete shall be obtained by using exposure class C-1 concrete or, for added protection, exposure class C-XL concrete.

20 Production of concrete

20.1 General
Production of concrete shall comply with Clause 5.2 of CSA A23.1 and Clauses 20.2 to 20.6 of this Standard.

Note: *Many architectural finishes are now available and new ones are constantly being developed. The more common finishes and the means of achieving them are described in detail in publications such as PCI MNL-122 and the CPCI* Architectural Precast Concrete Colour & Texture Selection Guide.

20.2 Mixers
Only stationary mixers shall be used for

(a) architectural precast concrete mixes; and

(b) mixes with a slump of less than 50 mm.

Notes:

(1) *Force mixers are preferred for the mixes specified in this Clause to provide the required uniformity.*

(2) *Mixers should be provided with timing devices to prevent under- or over-mixing of the batch.*

(3) *Mixers should be considered excessively worn and due for adjustment if the gap between the pan (or drum) and blades exceeds one-fourth of the nominal maximum size of the coarse aggregate or* 6 mm, *whichever is smaller.*

20.3 Control of slump and air content

The time from start of mixing to placement shall not exceed 1 h. Retempering of concrete shall not be allowed.

Where truck mixers are used, air and slump tests shall be performed on every load and the mixer shall be adjusted as necessary until it complies with the uniformity requirements of Clause 5.2.3.5 of CSA A23.1, at which time the frequency of the tests may be reduced to once a day for each truck.

20.4 Colouring materials

Colouring materials shall be carefully measured to facilitate the colour uniformity of the finished product. Provisions shall also be made to ensure uniform dispersal of the material throughout the concrete.

Note: *When only small additions of powdered colouring materials are to be made, greater accuracy can be achieved by first dispersing the colouring material in a larger amount of an inert filler or cement.*

20.5 Facing materials

When facings of any suitable material (e.g., brick, cut stone slabs, ceramic and glass products, plastics, oversized aggregates, metal sheets or sections, or wood) are used as an integral part of the precast concrete element, they shall have an acceptable performance record or be tested to the satisfaction of the owner.

The design and dimensions of elements shall take into account any difference in shrinkage or thermal characteristics between the concrete and the facing material.

Notes:

(1) *When special facing materials are used, design and testing should be based on the expected environmental conditions. The test samples, preferably to full scale, should be produced, cured, and handled in a manner similar to the expected production procedures.*

(2) *Particular attention should be paid to the interaction of the concrete and the facing materials during humidity and temperature changes and to potentially detrimental reactions between the concrete and the facing material. If the materials do not have similar physical properties, the final design should include provisions for possible movement of the face material in relation to the backup concrete panel.*

(3) *If performance records for special climatic conditions (including severe corrosive atmospheres) have not already been established for the face materials, the materials should be tested for such conditions. The tests may be accelerated but should otherwise reflect the expected service condition.*

20.6 Multiple finishes

Elements with more than one finish shall have features incorporated into the casting to ensure proper demarcation between the finishes.

Note: *When a precast element is exposed to view from all sides (e.g., a column), it is impossible to completely match the colour and texture of the formed surfaces with the unformed surfaces. The difference can be made more acceptable by placing such elements in the finished structure in a way that hides the unformed surfaces or by orienting the surfaces so that they are viewed from one direction only. For the best possible match, a high degree of hand-finishing of the unformed surfaces should be specified to match the smoothness of formed and unformed surfaces. See also Clause 26.1.2.*

21 Placing of concrete

21.1 General

21.1.1

The methods of mixing, conveying, spreading, consolidating, finishing, curing, and protecting the concrete shall be established by the plant in conjunction with the plant engineer and shall be documented as part of the plant procedures.

Note: *Limits in height of drop can be important to prevent segregation and, in the case of mixes for architectural concrete, to maintain uniformity of appearance.*

21.1.2
The placing of concrete shall comply with Clause 7.2 of CSA A23.1 and Clauses 21.1.1 to 21.4 of this Standard.

21.2 Placing

21.2.1
The placing of concrete shall be scheduled in such a manner that each layer is placed against concrete that has not reached its initial set.

21.2.2
The face mix and the backup mix shall be placed in such a manner that the backup mix bonds to but does not penetrate the face mix.

Notes:

(1) *For the minimum thickness of face mix for precast concrete, see Clause 16.3.2.*

(2) *The use of separate face and backup mixes or of a uniform concrete mix throughout the element depends on economics, the type of finish required, the configuration of the element, and the practice of the precasting plant. Elements with intricate shapes and deep, narrow sections generally require one uniform concrete mix throughout. See Clause 16.3.1.*

(3) *The second mix should be placed before the evaporation of bleedwater from the first mix unless special bonding techniques are used.*

21.2.3
Concrete coating on reinforcement shall be cleaned off or the backup mix shall be placed before any concrete on the reinforcement hardens. Alternatively, the placement of the reinforcement may follow the consolidation of the face mix.

21.2.4
Two-stage precasting, as used for intricate elements such as column covers, corners with large returns, or elements with abrupt changes in concrete volumes, shall be performed with construction joints that comply with Clause 22.

21.2.5
In the construction of insulated concrete wall panels, the first wythe shall be carefully placed and consolidated to the correct thickness. The concrete shall be finished with a smooth surface to minimize air pockets between the insulation and the concrete. Any pockets showing along the edges of the insulation shall be filled with concrete.

Notes:

(1) *The correct wythe thickness is normally accomplished or checked by a special template riding on the sides of the form.*

(2) *Some sandwich wall panels are designed with an uninterrupted air space between the wythe exposed to the weather and the insulation. This air space should remain completely open to allow water to be drained from the building.*

21.3 Consolidation
Surface vibrators shall be of such a type and shape, and applied in such a manner, that suction action is prevented during use.

Note: *See ACI 309R.*

21.4 Removal of paste
Paste adhering to extended reinforcement shall be removed to ensure bonding of bars to concrete in a later placement.

22 Joints

22.1 General

22.1.1
If jointing materials are supplied and installed by the precast concrete manufacturer, the joints between precast elements and the jointing materials shall be as specified by the owner and shown on the installation drawings.

22.1.2
The following shall be shown on the installation drawings:
(a) joints between precast elements;
(b) joints between precast elements and other materials;
(c) jointing materials (if supplied and installed by the precast concrete manufacturer); and
(d) joint dimensions.

Note: *For information on the design of joints, see PCI MNL-122.*

22.1.3
Joint width shall be sufficient to accommodate volume change movement tolerances for precast elements, structure, and site placing of hardware. The owner shall specify the requirements for structure movement. Joint widths shall also be chosen to ensure proper performance of joint material.

Note: *An adequate joint width is particularly important where the joints are the only means for accommodating installation tolerances and building movements. See also Clause 12.*

22.2 Construction joints

22.2.1 General
When a construction joint is to be made, the surface of the set concrete shall be suitably roughened, thoroughly cleaned of foreign matter and laitance, saturated with water, and left damp, with no free water on the surface, immediately before new concrete is placed. When a bonding agent is used, the surface treatment shall be as recommended by the manufacturer.

Notes:

(1) *Precasting using multiple pours may be used when small parts intersect larger parts; such practices can decrease the danger of unacceptable cracking.*

(2) *When selecting a bonding agent, consideration should be given to the exposure conditions that will prevail during the life of the structure.*

22.2.2 Architectural joints
Joints between architectural precast concrete elements shall be constructed as shown on the shop drawings. Joint materials shall be specified or reviewed by the owner.

Notes:

(1) *Samples of the joint materials for architectural precast concrete should be reviewed at the same time as the concrete samples.*

(2) *It is often advantageous to precast architectural elements with large returns in stages in order to cast exposed surfaces horizontally and thus obtain a more uniform texture. The joints between exposed aggregate match-cast surfaces can be hidden by locating them in a groove or a quirk return (for mitred joints).*

23 Protection and curing

23.1 General

23.1.1
Except as specified in Clause 23.1.2, curing and protection shall comply with Clause 7.4 of CSA A23.1 and Clauses 23.1.3 to 23.3 of this Standard.

23.1.2
When the ambient temperature in the plant does not fall below 5 °C and the manufacturing facilities are protected from wind and the direct rays of the sun, curing and protection shall comply with Clause 7.4.1.5.3 of CSA A23.1 and Clauses 23.1.3 to 23.3 of this Standard.
Note: *CSA A23.1 specifies additional curing and protection measures for outside casting. An estimate of the moisture evaporation can be obtained from Annex D of CSA A23.1.*

23.1.3
Immediately after the concrete is placed and consolidated, provisions shall be made for moisture retention. The concrete shall not be subjected to rapid drying or excessive stresses during the curing cycle.

23.1.4
The curing process shall be well established and controlled and shall continue until the concrete has attained its specified transfer or handling strength.

23.1.5
Records of concrete strength and temperature shall be maintained during the curing cycle.

23.2 Initial curing

23.2.1 General

23.2.1.1
The minimum concrete strength for stripping precast elements shall comply with CAN/CSA-A23.3.

23.2.1.2
The strength of elements at the time of transfer of prestress and stripping shall be determined by test cylinders cured under temperature and moisture conditions that simulate as closely as possible the conditions under which the concrete in the precast forms is cured.

23.2.1.3
The strength of the concrete at transfer of prestress and stripping, as well as the 28 d concrete strength of precast elements, shall be specified on the shop drawings.

23.2.2 Accelerated curing and heated concrete

23.2.2.1 General
When a combination of accelerated curing and heated concrete is used, the requirements specified in Clause 23.2.2.3 shall apply.
Notes:
(1) *Concrete is heat treated to accelerate its strength development. Two types of heat treatment are recognized:*
(a) accelerated curing, which is heating of the concrete after it has been placed in the forms; and
(b) heated concrete, which is heating of the concrete before it is placed in the forms.

(2) *Clause 23.2.2 is broadly based on the recommendations of PCA RD108. The potential for expansion is believed to be primarily related to cement composition and curing temperature. Air entrainment can reduce expansion.*

23.2.2.2 Moisture categories

23.2.2.2.1
Based on the ambient conditions to which they will be exposed, concrete elements shall be classified as
(a) moisture category dry; or
(b) moisture category damp.

23.2.2.2.2
Moisture category dry shall apply to concrete elements that, after curing, will not be subjected to a moist environment during service. Unless such units are air entrained, they shall not be exposed to a moist environment for a period of more than 3 months prior to service.

23.2.2.2.3
Moisture category damp shall apply to concrete elements that, after curing, will be subjected to a moist environment during service or to non-air-entrained elements that will be exposed to a moist environment for a period of more than 3 months prior to service.

Note: *Examples of moisture category damp include*
(a) external elements of buildings or structures that are exposed to precipitation, surface water, or groundwater (e.g., bridge girders, unprotected roof slabs, building facades, basement walls, railway ties, and underground vaults);
(b) internal building elements subject to moist conditions (e.g., indoor swimming pool areas, laundries, and parking garages); and
(c) elements that have parts that can frequently drop below their dew point (e.g., chimneys, filter chambers, and internal voids in bridges).

23.2.2.3 Accelerated curing

23.2.2.3.1
Accelerated curing shall be achieved by one or more of the following means:
(a) Live steam shall be applied within an enclosure able to retain the steam. The steam jets shall distribute the steam uniformly and shall not discharge directly onto the concrete, forms, or test cylinders.
(b) Radiant heat or electric heat within an enclosure shall be able to effect an even distribution of heat. Pipes or electric heating units shall not be in direct contact with the concrete, forms, or test cylinders.
(c) Forced air within an enclosure shall be able to effect an even distribution of heat. Hot air shall not discharge directly onto the concrete, forms, or test cylinders.

23.2.2.3.2
Throughout the entire accelerated curing cycle, concrete surfaces shall be protected from moisture loss by covering the surfaces with tarpaulins or plastic sheeting, using a water spray, ensuring that 100% relative humidity is present in the curing enclosure, etc.

23.2.2.3.3
Concrete surfaces shall not be exposed to combustion gases during the accelerated curing cycle.

Note: *Unless exhaust flue gases from combustion heaters are vented outside the curing enclosure, concrete surfaces should be protected by formwork, tightly fitted tarpaulins, or plastic sheeting.*

23.2.2.3.4
The accelerated curing cycle shall be as specified in Table 2.

23.2.2.4 Heated concrete

23.2.2.4.1
Heated concrete shall be achieved by
(a) preheating the concrete materials;
(b) heating the concrete mixture using a means such as superheated steam; or
(c) a combination of Items (a) and (b).

Note: *The use of heated concrete can cause premature stiffening of the mix.*

23.2.2.4.2
During the heated concrete cycle, concrete surfaces shall be protected from moisture loss as specified in Clause 23.2.2.3.2.

23.2.2.4.3
During the heated concrete cycle, concrete surfaces shall not be exposed to combustion gases (see Clause 23.2.2.3.3).

23.2.2.4.4
The heated concrete cycle shall be as specified in Table 3.

23.2.2.5 Measuring and recording the heat treatment cycle

23.2.2.5.1
When accelerated curing or heated concrete methods are used, the governing concrete temperatures shall be those achieved within the concrete elements.

23.2.2.5.2
Temperatures shall be measured by one or more of the following means:
(a) devices, such as expendable thermometers or thermocouples, cast into the concrete; or
(b) temporary measuring devices placed against the concrete surface under a temporary cover of heavy insulation.

For standard elements, however, temperatures may be measured within the enclosure, in which case the correlation between the enclosure temperature and temperatures within the concrete shall be determined and documented and the temperature within the concrete shall be used to govern the cycle.

23.2.2.5.3
Concrete temperatures should be recorded continuously, but the interval between temperature readings shall not exceed 30 min.

23.2.2.5.4
The times at which concrete temperatures are measured shall be recorded.

23.3 Extended curing

23.3.1
Extended curing, as specified in Clause 7.4.2.1 of CSA A23.1, shall be used where it is important for durability. The concrete shall be kept in a surface-damp condition.

Note: *For architectural precast concrete panels, additional curing should continue until the hydration of the cement on the surface is sufficient to prevent unhydrated cement from streaking the panel surfaces or being carried by rainwater to window glass areas or other surfaces that could be affected.*

23.3.2
Extended curing, as specified in Clause 7.4.2.3.2 of CSA A23.1, shall be used when concrete strength levels exceeding those achieved following initial curing are required for structural safety.

23.4 High-performance concrete curing (Types C-1 and C-XL concrete)
The curing procedures specified in CSA A23.1 shall be followed. However, alternative curing procedures specific to a particular precast plant may be used if the procedures have been shown to produce a finished concrete product that meets or exceeds all of the performance requirements for C-1 or C-XL concrete, as applicable, specified in CSA A23.1. All testing and documentation shall be completed before the project begins and shall be reviewed by the owner before the start of precast production.
Note: *See Tables 1 and 2 of CSA A23.1.*

24 Treatment of unformed surfaces

24.1 General
The finishing of plastic concrete surfaces shall comply with Clause 7.5 of CSA A23.1 and Clauses 24.2 to 24.3 of this Standard.

24.2 Finishing
Concrete surfaces that are to have concrete placed on them shall be clean and free of laitance.

24.3 Composite construction
The requirement specified in Clause 7.5.6.2 of CSA A23.1 for producing 5 mm deep grooves may be waived for precast members, provided that interface shear is designed in accordance with CAN/CSA-A23.3 for surfaces not intentionally roughened or if it can be shown by tests that the required flexural and shear resistances can be developed without surface roughness.
Note: *See*
(a) PCI Manual for the Design of Hollow Core Slabs*; and*
(b) Concrete Technology Associates, Technical Bulletin *74-B6.*

25 Toppings

25.1
Bonded concrete toppings used for rehabilitating existing concrete structures shall comply with Clause 7.6 of CSA A23.1. Bonded concrete toppings for new precast concrete construction shall comply with Clause 7.6 of CSA A23.1, except as specified in Clauses 25.2 and 25.3.

25.2
The procedures for new precast construction specified in Clause 7.6.4.2.2 of CSA A23.1 for bonding toppings to the base may be waived, provided that engineering analysis shows that the required level of tensile or shear bond strength will be achieved.

25.3
Control joints shall comply with Clause 7.6.4.3.2 of CSA A23.1. Control joints, where required, shall be located over longitudinal and transverse joints between precast concrete members,
Note: *The layout of control joints should be shown on the shop drawings. Consideration should be given to the shrinkage characteristics of the topping mix when determining the number and spacing of control joints.*

26 Finishing of formed surfaces

26.1 General

26.1.1
The finish of formed surfaces shall be specified by the owner, in accordance with Clause 26.2, and shall be detailed on the shop drawings.

26.1.2
The finish shall be established from an assessment of previous production or from samples, as specified in Clause 26.2.

26.2 Finish grades

26.2.1 Reference sample
After the contract is awarded, a reference sample shall be cast using formwork, reinforcement, concrete, and vibration typical for the project. The reference sample shall be viewed from a distance of 6 m. Once accepted, the reference sample shall be identified and used for comparison in assessing compliance with the specified finish grade.

26.2.2 Commercial grade
For this finish, concrete may be cast in forms that impart a texture to the surface, but fins shall be removed and large surface voids exceeding 12 mm in diameter shall be filled. Faces exposed to view shall have well-defined outlines and all sharp edges visible in the finished structure shall be softened by sanding or grinding.

26.2.3 Standard grade
The finish shall be as specified in Clause 26.2.2, except that the forms shall not impart a pronounced texture to the finished concrete.

26.2.4 Finish Grade B
This finish shall be as specified in Clause 26.2.3, except that all surface blemishes shall be finished to provide a smooth surface of uniform appearance if painted. Form-release or other agents shall not leave a paint-rejecting coating or leave a caulking/sealant rejecting coating on the concrete.

26.2.5 Finish Grade A
This finish shall be as specified in Clause 26.2.4, except that repairs that are exposed to view shall be colour-matched within practical limits.

Note: *Because variations in cement, curing conditions, and other production procedures can influence the final colour, it is not reasonable to expect a uniform colour finish in large prestressed concrete elements. The purpose of this finish is to provide a smooth finish. Repairs and filling of surface defects to produce an acceptable finish should be established from an assessment of previous production or from representative samples.*

27 Surface sealers and joint sealants

27.1
Compatibility between surface sealers and joint sealants shall be established.

27.2
Surface sealers and joint sealants specified by the owner shall be applied in accordance with the manufacturer's instructions.

Notes:

(1) *PCI MNL-122 provides some information on the merits of sealers and the types of joint sealants.*

(2) *The application of some sealers and joint sealants should be delayed so that it follows the completion of installation and joints.*

(3) *Before actual application on the finished product, sealers and joint sealants should be tested on reasonably sized samples of varying ages and their performance verified over a suitable period based on experience under similar exposure conditions.*

28 Prestressing

28.1 Post-tensioning
Post-tensioning shall comply with Clause 6.8 of CSA A23.1.

28.2 Pretensioning

28.2.1 General
The prestress force to be applied to the tendon shall be calculated in accordance with Clause 18 of CAN/CSA-A23.3, taking into consideration the specified effective prestress force and prestress losses. The prestress force shall be shown on the shop drawings.

28.2.2 Facilities

28.2.2.1
Prestressing beds shall comply with the following requirements:

(a) Anchorages, abutments, stress-resisting forms, and deflecting equipment shall be designed by experienced engineers and reviewed by the manufacturer's engineer.

(b) The design shall be based upon a stated factor of safety in accordance with sound engineering principles, taking into account the maximum forces on the bed. Such forces shall be analyzed as to magnitude, position, and frequency of occurrence.

(c) Foundations shall be sufficiently firm to prevent undesirable movements.

Note: *For examples of pretensioning application, see the* CPCI Design Manual.

28.2.2.2
Information on the capacity of each bed and stress-resisting form, in terms of allowable prestress force and its corresponding height of application above the bed or base, shall be kept on record and made available when requested.

28.2.3 Equipment

28.2.3.1
The tensioning force shall be applied by equipment suitable for single-tendon tensioning.

28.2.3.2
Hydraulic gauges, dynamometers, tension meters, load cells, pressure transducers, digital indicators, or other suitable force-measurement systems shall be used for controlling and measuring the prestress force and shall comply with the following requirements:

(a) They shall have an accuracy of reading within ±2%.

(b) Each force-measurement system shall be capable of indicating loads directly or be accompanied by a chart by which the reading can be converted into units of force.
(c) The indicating dials of gauges for initial and final stressing shall be at least 150 mm in diameter.
(d) Each force-measurement system shall be calibrated for the jacks, hoses, and connections with which it is used or, alternatively, it shall be calibrated alone and friction losses in jacks, hoses, and connections established by other means shall be recorded.
(e) The calibration of each prestress force-measurement system shall be performed by a registered professional engineer or by a technician trained to perform such calibration by a registered professional engineer. A calibration certificate for each system shall be signed by the engineer.
(f) The calibration shall be repeated whenever the system provides erratic results and at intervals not longer than 6 months during regular usage and not longer than 12 months for other conditions of use.
(g) Stressing equipment shall be calibrated in accordance with ASTM E4.
(h) The loads to be gauged shall be not less than one-quarter or more than three-quarters of the total graduated capacity unless calibration data clearly establish accuracy over a wider range.
(i) Hydraulic gauge needles shall not fluctuate in such a way that reading becomes uncertain and shall remain steady until the jacking load is released.
(j) Force-measurement systems shall be mounted near eye level and within 2 m of the operator. Gauges shall be positioned so that readings can be obtained without parallax.

28.2.3.3
Manual hydraulic pumps shall not be allowed for stressing tendons.

28.2.3.4
Automatic hydraulic controls shall be capable of adjustment so that the jacking force will correspond to the required load. The setting accuracy of automatic cut-off valves shall be verified whenever the results are suspect.

28.2.4 Stringing of tendons

28.2.4.1
Contamination of tendons shall be prevented. After stringing and tensioning, the tendons shall be inspected and, if found to be contaminated, shall be cleaned.

28.2.4.2
The stressing sequence shall avoid entanglement of tendons and minimize unbalanced loads on the beds.

28.2.4.3
Binding of tendons shall not occur during the stressing operation.

28.2.4.4
Tendons cast into prestressed elements shall be free of grip marks and other damage.

Notes:

(1) *Care should be taken where lengths of tendon previously gripped by tendon vices are incorporated within the length to be stressed but outside of individual elements.*

(2) *Significant nicks create local stress concentrations that can result in failure of the tendon during stressing.*

28.2.4.5
Tendon anchors shall comply with Clause 10.2.4 and shall be capable of anchoring stressing loads positively and with a minimum of slippage.

28.2.5 Stressing

28.2.5.1 General

28.2.5.1.1
An initial load shall be applied to the individual tendons to straighten them, eliminate slack, and provide a starting or reference point for measuring elongation. The final load, for which elongation of tendons is computed and measured, shall then be applied.

28.2.5.1.2
The force in the tendons shall be measured by elongation and by pressure gauge.
Note: *Stressing may be done to a calculated elongation using the force reading as a check against the calculated force or vice versa.*

28.2.5.1.3
Discrepancies between the elongation measurement and force measurement shall not exceed 5%, except for jacking forces above 70% of the specified tensile strength, where the discrepancies shall not exceed 5 to 8%, varying proportionately between 70 and 80% of specified tensile strength. The elongation measurement and the force measurement shall not vary by more than 5 to 8% (as applicable) from the required design value.
Notes:
(1) *The force measurement should indicate that the proper force has been applied. A check of the elongation should indicate that the correct size of tendon has been used and that operational losses are within tolerance limits. It also provides a check on the force-measurement system.*
(2) *Inaccurate and variable stressing can result in differential camber, lateral bowing of members, and reduction of the cracking load.*
(3) *The rotation of a tendon during stressing should be limited to one turn per* 30 m.
(4) *See ASTM A416/A416M.*

28.2.5.2 Initial tensioning
Initial load shall be measured within a tolerance of ±200 N or 2%, whichever is larger.
Notes:
(1) *The same jack used for final stressing of single tendons may be used for initial tensioning if it has a proper system for measuring the initial force (see Clause 28.2.3.2).*
(2) *In single-tendon tensioning, the initial and final loads may be applied in immediate succession. When this is done, the initial load is applied and held momentarily while reference marks are made for measuring elongation and slippage; the load is then increased to its full value and the tendon is seated.*

28.2.5.3 Elongation corrections

28.2.5.3.1
Elongation calculations shall be based on the actual modulus of elasticity of the tendon determined from the stress-strain curve furnished by the tendon manufacturer.

28.2.5.3.2
Elongation calculations shall take into account the slippage of the tendon in the anchors and the seating of the chucks for both the dead and live ends. Slippage and seating adjustments shall be based on average values from tests. Testing shall be performed to determine average adjustment values.

28.2.5.3.3
Elongation calculations shall take into account the movement of anchorages and shortening of stress-resisting forms. Compensation for movements shall be based on tests that simulate the appropriate force and eccentricity.

28.2.5.3.4
Where rods under tension are used in multiple-tendon tensioning, an allowance shall be made for the elongation of the rods.

28.2.5.3.5
Elongation calculations shall take into account the effect of temperature variations if the temperature of the steel at the time it is stressed and at the time the concrete starts to set differs by more than 15 °C. The thermal coefficient of the expansion of steel shall be taken as 12×10^{-6}/°C.

28.2.5.4 Measurement of elongation

28.2.5.4.1
After completion of initial stressing, reference marks shall be established from which elongations resulting from final tensioning forces can be measured.

Reference marks shall be visible during the entire final stressing operation.

28.2.5.4.2
Elongation shall be measured and recorded to the nearest millimetre.

Note: *Stressing procedures and calculations should be the responsibility of the manufacturer's engineer.*

28.2.5.4.3
Where there are no intermediate bulkheads or friction points, elongation and tendon slippage shall be measured on the first and last tendon stressed and on at least 10% of the remaining tendons.

28.2.5.5 Force corrections
The following shall be taken into account in calculating the indicated hydraulic pressure:

(a) friction in the jacking system;

Note: *Because of the large jacking ram and the heavy sliding or rolling anchorage to which the tendons are attached, multiple-tendon tensioning methods usually used on post-tensioned construction are subject to substantial variations in friction that need to be overcome by the jack. Friction in single-tendon tensioning is small and can usually be ignored.*

(b) temperature variations (allowance shall be made in the stressing force for temperature variations of 15 °C or more between the ambient temperature and the concrete temperature at the time of placing); and

(c) live end seating (allowance shall be made for loss of force as the tendon seats into the anchor).

Note: *See PCI MNL-116 for assistance in stress corrections.*

28.2.5.6 Final stressing of straight tendons
After application of the initial load in single-tendon tensioning and the establishment of reference marks for measuring elongation and slippage, the full tendon load shall be applied and checked by at least two control measures. The frequency of elongation and tendon slippage measurement shall be as specified in Clause 28.2.5.4.3.

Note: *For multiple-tendon tensioning, see PCI MNL-116.*

28.2.5.7 Final stressing of draped tendons

28.2.5.7.1
After application of the initial load and the establishment of the reference mark for measuring elongation and slippage, the full tendon load shall be applied and checked by at least two control measures, as specified in Clause 28.2.5.6.

28.2.5.7.2

Final stressing shall be accomplished by one or more of the following methods:

(a) Deflection of stressed tendons: in order to distribute friction and restraint forces at tendon deflection points, tendon lifting and depressing shall be carried out either simultaneously or consecutively, commencing at the centre of the bed and progressing alternately at points equidistant from the centre to the end.

(b) Stressing in draped position: tendons shall be stressed to final value in their draped position for the full length, from either one or both ends of the bed. The tendons shall pass over pin and roller fixtures that effectively minimize friction at all deflection points. Support and hold-down devices shall be of sufficient rigidity and adequate support that the position of tendons will remain substantially unchanged under the induced loads.

Note: *If elongation is not obtained within the required tolerance, the tendon may be temporarily overstressed to overcome friction. Overstress should not exceed 80% of the specified tensile strength. Although the stress should not exceed 80% of the specified tensile strength, consideration should be given to lowering the stress due to the undetermined friction buildup and localized bending stress in the draped tendons, especially where tendon drape exceeds a slope of 1 to 6. See PCI MNL-116.*

28.2.5.8 Recording of stressing operations

28.2.5.8.1

Prestress force and elongations shall be checked and recorded during the stressing operations.

28.2.5.8.2

Stressing records shall include the following information applicable to the particular operation:

(a) date of tensioning;
(b) casting bed identification;
(c) description, identification, and number of elements;
(d) manufacturer, size, type, and ultimate strength of tendon;
(e) sequence of stressing (and detensioning, if critical);
(f) straight or draped tendons (possible compensations and possible stressing from either end);
(g) identification of jacking equipment;
(h) corrections for tendon slippage (including splices), anticipated abutment movement, thermal effects, etc.;
(i) required total load per tendon;
(j) initial tension;
(k) anticipated pressure for each tendon or for each group of tendons stressed in one operation;
(l) anticipated elongation for each different jacking load;
(m) actual elongation or actual force measurement, depending on which operation is chosen for checking (see Clause 28.2.5.1.2);
(n) for stressing of draped tendons:
    (i) sequence; and
    (ii) data and description; and
(o) any unanticipated problems encountered during tensioning (e.g., wire breakage, excessive slippage, restressing, or other factors that can have an influence on the net stress).

28.2.5.9 Debonded tendons

Bond breakers shall not alter the physical or chemical properties of the tendons or surrounding concrete. Grease or oil shall not be used.

28.2.5.10 Tendon splices

28.2.5.10.1

Tendon splices shall comply with the same requirements as tendon anchors (see Clause 10.2.4).

28.2.5.10.2
There may be a maximum of one splice per tendon.

28.2.5.10.3
The ends of tendons to be spliced shall be cut by shears or abrasive grinders.

28.2.5.11 Wire failure in strands
Failure of one wire in a seven-wire strand shall be acceptable if the 5% allowable variation in prestress force for all strands in the entire element is not exceeded and the total area of wire failure is not more than 2.5% of the total area of tendons in any member.

28.2.6 Detensioning

28.2.6.1
Before detensioning, the concrete strength shall be determined in accordance with Clause 19.8.2.

28.2.6.2
Where concrete curing has been accelerated, the detensioning shall be performed immediately following the curing period, while the concrete is still warm and moist.

Note: *If concrete is allowed to dry and cool before detensioning, volume changes can cause tension stresses and cracking in the concrete.*

28.2.6.3
Forms, ties, inserts, hold-downs, or other devices that would restrict longitudinal movement of the members along the bed shall be removed or loosened, or, alternatively, detensioning shall be performed in such a manner and sequence that longitudinal movement is precluded.

28.2.6.4
The prestressing forces shall be kept nearly symmetrical around the vertical axis of the element and shall be applied in a manner that will minimize sudden loading.

28.2.6.5
For draped tendons, the sequence of release of hold-down and anchorage forces shall be established to minimize cracking of the element.

Notes:

(1) *Cracks resulting from initial release of hold-downs will generally close upon release of anchorage forces; however, cracking of concrete members is undesirable and should be avoided.*

(2) *Computation of the hold-down forces and comparison with the weight of the member should always be performed if hold-downs are to be released before release of anchorage forces. Release of hold-downs without release of anchorage forces can result in concentrated vertical loads that can crack the top of the member.*

(3) *In general, if the sum of hold-down forces is not more than one-half the weight of the member, it is safe to release hold-downs before releasing anchorage forces. If the hold-down forces are less than three-fourths of the weight of the element and nominal reinforcing steel is contained in the top flange or slab, cracking is unlikely. If the hold-down forces approach the weight of the element, some cracking of upper surfaces immediately above the hold-downs is inevitable if hold-downs are released before the anchorage.*

(4) *Preloading of the element with weights or additional vertical restraint can minimize the effect of releasing hold-down forces.*

28.2.6.6
Tendons shall be detensioned by hydraulic jack or by heat applied to the tendons at both ends simultaneously to produce a gradual release of stress before cutting.

28.2.7 No-slump concrete products

28.2.7.1 General

Documented procedures for manufacturing no-slump concrete products shall be established by the precast concrete manufacturer.

Note: *In most cases, the supplier of equipment for no-slump concrete products will have established operational procedures and standards that should be followed.*

28.2.7.2 Detensioning

28.2.7.2.1

Before detensioning, the concrete strength shall be determined in accordance with Clause 19.8.2.

28.2.7.2.2

Tendon slippage shall be checked during detensioning by establishing a reference line close to the free end of the casting bed. Each tendon shall be marked at a fixed distance from the reference line so that slippage can be measured as each tendon is detensioned. Tendon slippage exceeding 6 mm at the time of detensioning shall be investigated and evaluated and all slabs on the bed shall be marked to identify the tendon location and the position of each slab on the casting bed.

28.2.7.2.3

Tendon slippage shall be checked at the sawn face of slab ends. Tendon slippage exceeding 3 mm shall be investigated and evaluated.

Note: *Tendons at the sawn face with no draw-in should be investigated to determine the level of prestress force in each of them.*

28.2.7.2.4

The manufacturer's engineer shall evaluate the adequacy of all pretensioned products having tendons with bond slippage exceeding the limits specified in Clauses 28.2.7.2.2 and 28.2.7.2.3.

29 Stripping and handling

29.1

Care shall be exercised in removing the elements from the forms. To prevent damage, initial lifting shall be gradual and equipment for initial release shall have controls allowing such operation.

Note: *Intricate shapes can require special equipment during removal from the form through the use of compressed air, vibration, hydraulic pressure, or screw jacks.*

29.2

The minimum concrete strength, the number and location of lifting points for handling of elements, and details of lifting devices shall be shown on the shop drawings. The number and location of the lifting points shall be compatible with the method of shipping (i.e., flat or on edge).

29.3

Lifting equipment shall be properly secured to the element being stripped and handled. Proper rigging procedures shall be documented and all lifting equipment shall conform to established safety practices.

29.4

All precast elements shall be handled in positions consistent with their shape and design. Care shall be exercised to retain the required condition, quality, and appearance of all elements until finally installed.

29.5
Individual precast concrete elements shall be clearly marked with identification as shown on the shop drawings, including date of casting. Alternatively, precast concrete elements shall be identified with individual mark numbers and a list provided with required information correlated to mark numbers. Marking shall be performed as soon as practical after stripping from forms and prior to yarding.

Notes:

(1) *Such markings may be made in the wet concrete, made by tagging (as long as the tags are securely fastened to the elements), or painted on the elements. In all cases, the markings should remain legible for the longest anticipated storage period.*

(2) *The approximate mass of the elements should be marked on them, particularly in cases where shipping or installation crews cannot easily identify the masses of the precast elements.*

(3) *For on-site quality control, markings should be readable following installation. Alternatively, the installation drawings may be marked with complete element identification, including date of production.*

30 Storage

30.1
Products awaiting delivery shall be stored to minimize twisting, racking, bowing, or warping and to avoid damage to the product. Manufacturer's procedures shall indicate how precast members will be stored and handled.

Notes:

(1) *Often the manner of storage depends on how the product is to be shipped and what limitations the element's cross-sections impose on handling.*

(2) *Wall panels should be stored in vertical storage racks carefully made so as to minimize bowing or warping of the panels.*

(3) *Panels with a large vertical dimension should be designed to be turned in the air using a double-crane hookup.*

30.2
Elements shall be stacked only when the lower elements in a stack will not be damaged and where the risk of warpage is small. Proper blocking and dunnage shall be used for separation.

30.3
All blocking, dunnage, and protective materials shall be of a type that will not cause damage or objectionable staining.

Note: *For exposed surfaces, care should be taken that such material does not cause uneven curing that can result in permanent colour variations.*

30.4
Elements that are exposed in the finished structure shall be protected from soiling, staining, and contact with objectionable matter (see Clause 30.6).

30.5
Prestressed elements shall be stored with due allowance for creep, shrinkage, and temperature effects.

Notes:

(1) *The location of supports and any external loading during storage can increase or decrease camber growth. Special conditions for storage should be shown on the shop drawings.*

(2) *Preloading a pretensioned element in the plant can be used to control excessive camber growth.*

30.6
Any soiling or weathering of architectural concrete panels that would result in a pattern different from normal weathering shall be avoided during storage.

31 Transportation

31.1
All materials and products shall be satisfactory for delivery before loading. The manufacturer's procedures shall indicate how units shall be transported.

Note: *The responsibility for transporting precast elements should be clearly established in the contract documents (see Annex A).*

31.2
Elements shall be supported and braced during transportation to ensure that they are not subjected to stresses for which they are not designed.

Notes:

(1) *Significant vibration, impact, and lateral forces occur during transportation.*

(2) *Particular care should be taken with slender elements to minimize excessive twisting or whipping. Lateral stability during transportation should be investigated.*

31.3
All precast elements shall be delivered to the site clearly marked in accordance with Clause 29.5. The mass of the unit shall be provided.

Note: *All orientation and identification marks should be located on the element in such a way as to be visible during loading and unloading.*

32 Installation

32.1
Installation procedures or drawings shall include

(a) the installation sequence;

(b) temporary shoring, bracing, supports, and guys; and

(c) the sequence for installation and removal of temporary shoring, bracing, supports, and guys.

Note: *For further information, see PCI MNL-127.*

32.2
All elements shall be installed as shown on the installation drawings to the tolerances specified in Clause 12. Precast elements shall be positioned in such a way that cumulative dimensional errors shall not exceed allowable tolerances.

Note: *For example, a 9 m long slab adjacent to a 3 m long slab having a different upward deflection is not considered to constitute differential camber. Such situations should be addressed through proper installation procedures.*

32.3
Elements shall be installed in a sequence that takes into account the actual loading on the building, the loading on previously installed elements, attachments, weather-sealing, and tolerances. Elements shall not be stacked temporarily on other elements during installation unless allowance has been made for this in the design of the elements and the connections.

32.4
Installation shall not impose undue stresses or overloads on the structure, elements, or connections.

Note: *Panels with a large vertical dimension should be designed to be turned in the air using a double-crane hookup.*

32.5
Connections and bearings shall be set within specified tolerances (see Clause 12 and see CSA A23.1). Elements shall be positioned to avoid any eccentric application of forces not considered in the design.

Note: *It is important that bearing surfaces make proper contact with the supports in accordance with the design criteria; otherwise, it is possible that the structure will be built with serious structural deficiencies.*

32.6
Connections shall not be modified unless reviewed by the engineer responsible for the connection design.

32.7
All bolted or welded connections shall be made in accordance with the installation drawings. Where welded connections are required, all welds shall be made in accordance with CSA W47.1.

32.8
Temporary lifting and handling devices cast into the elements shall be removed, retained, and protected as specified on the installation drawings.

32.9
Where elements in partially completed structures might be damaged by the effects of weather, such as freezing water in ducts, holes, and inserts, adequate temporary protection shall be provided.

32.10
All discontinuities in corrosion protection on permanent connections shall be repaired. The repair method shall be specified or reviewed by the engineer responsible for the design of the connections.
Note: *Discontinuities in corrosion protection can result from welding or other installation procedures.*

33 Repairs

33.1 General
Defects in and damage to precast concrete elements shall be repaired in a manner that will restore the specified quality of the product.
Notes:
(1) *This Standard distinguishes between repairs of minor defects or damage, normally referred to as aesthetic repairs (see Clause 33.2), and repairs of extensive defects or damage, normally referred to as structural repairs (see Clause 33.3).*
(2) *Guidance on the prevention, significance, effect, and suggested method of repair of cracks can be found in PCI JR-271 and PCI JR-316.*

33.2 Aesthetic repairs

33.2.1
Holes left by lifting or hold-down devices or other temporary inserts shall be repaired where necessary. Patches on the underside of elements, near the centre, or in the area of variable tensile stresses shall be bonded by an epoxy resin or other reviewed bonding material.

33.2.2
Bonding agents shall have a proven record of durability and shall be applied under conditions and by methods specified by the manufacturer.

33.2.3
Where it is necessary to fill surface voids in vertical concrete surfaces or under top forms, these surfaces shall be sack-rubbed in accordance with Clause 7.7.4.4 of CSA A23.1.

33.2.4
Damaged areas that will be exposed to view and other areas specified by the owner shall be repaired.
Notes:
(1) *When repairs have to match specified architectural finishes, repair mixes should be developed early, following review of the initial sample. A trial-and-error process is normally required for each newly developed face mix to effectively match colour and texture. Such trials should allow several weeks for curing and should include outdoor exposure.*

(2) *When repairs of grey concrete have to be colour-matched, white cement normally has to be included in the repair batch, especially when curing of elements has been accelerated.*

33.2.5

The repair mix shall be proportioned to provide at least the strength and durability of the original mix. When appearance is important, proportions may be adjusted to obtain the best match, but the strength and durability shall not be less than that of the original mix.

Notes:

(1) *It is possible that the repair mix will need an altered cement content (see Clause 33.2.4) or that some of the larger aggregate pieces will have to be eliminated or hand-placed in the patch.*

(2) *When colour-matching is desired for elements exposed to the weather, care should be taken to obtain similar absorption characteristics so that patches do not become too obvious in alternating dry and wet weather. For this reason, bonding agents should normally not be included in the repair mix.*

33.2.6

Preparation of the repair area and the actual repair shall consist of the following steps:

(a) All loose material shall be removed and chipped back to sound concrete.

(b) Cut-outs shall be at least 6 mm deep. For exposed aggregate finishes, cut-outs shall be a minimum of 6 mm plus the maximum size of the exposed aggregate. Feather edges shall not be permitted.
Note: *A slight undercut should be used.*

(c) The repair area shall be cleaned by brushing or with compressed air.

(d) The repair area and surrounding concrete shall be saturated with water to prevent absorption of water from the patching mix and to facilitate bonding.

(e) When surface water has evaporated, but before complete drying, the repair mix shall be placed by vibration or hand tamping for consolidation and for proper contact with the old concrete surface.
Note: *For larger repair areas, placement of the repair batch should be preceded by brushing a bond coat (cement and fine sand) onto the repair surface.*

(f) Proper curing shall be provided and care shall be taken to retain moisture and avoid excessively high or low ambient temperatures (see Clause 23).
Note: *The curing procedure should be part of the development of the trial mix, particularly where colour-matching is important (see Clause 33.2.4.)*

(g) The area shall be finished as required, depending on the particular finish treatment.

33.3 Structural repairs

33.3.1 General

Repairs of a structural nature shall not be undertaken until the manufacturer's engineer has

(a) investigated the structural implications of the defect or damage;

(b) established the cause of the defect or damage; and

(c) received approval of the proposed repair procedures from the owner.

33.3.2 Conditions

A defect or damage shall be deemed to be of a potentially structural nature when one or more of the following conditions occur:

(a) main reinforcement or tendons are exposed;

(b) connection hardware anchorage is exposed;

(c) cracking occurs in bearing areas;

(d) cracking extends from one face of the element through to the opposite face; and

(e) cracks are wider than 0.3 mm or more than 300 mm long.

33.3.3 Repair procedures

The procedures for repairs shall include the requirements of Clause 33.2.6 or additional methods, such as drypacking, pressure grouting, or injection of epoxy under pressure or by vacuum. The procedures shall also state whether any load test is required following repairs.

33.3.4 Drypacking

Drypacking shall be used for deep holes or any hole that has a relatively high ratio of depth to area. Drypack (approximately 1 part of cement to 2.5 parts of sand passing a 1.25 mm sieve) shall have the correct amount of water to make a sound, solid pack. It shall be placed in layers having a compacted thickness of about 10 mm. Each layer shall be compacted with a tool (hardwood stick) that will not produce too smooth a surface for proper bonding of successive layers.

33.3.5 Pressure grouting

Pressure grouting shall comply with the requirements for the grouting of post-tensioning ducts in CSA A23.1.

33.3.6 Epoxy injection

Injection of a low-viscosity epoxy under pressure or by vacuum shall be performed by personnel skilled in working safely with epoxies. For treatment other than treatment of horizontal surfaces, cracks shall be sealed, except for entry and vent points, and care shall be taken not to trap air pockets.
Note: *It can be necessary to examine concrete cores to verify structural bond.*

33.3.7 Load test

If a load test is required following repairs, it shall be performed in accordance with Clause 20 of CAN/CSA-A23.3.

Table 1
Cover to reinforcement, tendon sheaths, and ducts*

(See Clause 14.6.1.)

	Exposure						
			Chlorides, sulphates, manure, sewage, and industrial effluents				
					Protection systems†		
	Not exposed‡	Earth or weather	Unprotected concrete		A	B, C, D, E	F, G, H, J, K
Exposure condition (see Table 2 of CSA A23.1)	N	F-1, F-2	C-1, C-3, A-1, A-2, A-3, S-1, S-2, S-3	C-XL	C-1, C-3, A-1, A-2, A-3, S-1, S-2, S-3	C-1, C-3, A-1, A-2, A-3, S-1, S-2, S-3	C-1, C-3, A-1, A-2, A-3, S-1, S-2, S-3
Piles	—	40 mm	50 mm	40 mm	—	40 mm	40 mm
Beams, girders, and columns	20 mm	30 mm	50 mm	40 mm	—	40 mm	30 mm
Slabs, walls, joists, shells, and folded plates	20 mm	25 mm	50 mm	40 mm	40 mm	40 mm	35 mm
Ratio of cover to nominal bar diameter§	1	1.5	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)
Ratio of cover to nominal maximum aggregate size	1.0**	1.5	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)	1.5 (cover ≤ 60)
Cover to mesh reinforcing in all precast products	20 mm	25 mm	40 mm	35 mm	30 mm	35 mm	30 mm

**The cover for precast concrete is reduced from the cover used in cast-in-place concrete because of greater dimensional control of formed concrete, tighter tolerances on placement of reinforcing, and better quality of concrete in plant-controlled conditions.*

†*A = membrane*

†*B = concrete with a rapid chloride permeability test result (ASTM C1202) of less than* 1000 coulombs *within* 56 d *and black reinforcing within* 100 mm *of the exposed surface*

†*C = corrosion inhibitor and black reinforcing within* 100 mm *of the exposed surface*

†*D = sealer and black reinforcing within* 100 mm *of the exposed surface*

†*E = corrosion inhibitor and black reinforcing within* 100 mm *of the exposed surface*

†*F = sealer and galvanized reinforcing within* 100 mm *of the exposed surface*

†*G = concrete with a rapid chloride permeability test result (ASTM C1202) of less than* 1000 coulombs *within* 56 d *and galvanized reinforcing within* 100 mm *of the exposed surface*

†*H = corrosion inhibitor and galvanized reinforcing within* 100 mm *of the exposed surface*

†*J = sealer and corrosion inhibitor*

†*K = stainless steel reinforcing within* 100 mm *of the exposed surface*

‡*Refers only to concrete that will be continually dry within a conditioned space (i.e., members entirely within the vapour barrier of a building envelope).*

§*The cover for a bundle of bars shall be determined from a circle circumscribing the perimeter of the bundle.*

***The specified cover from screeded surfaces shall be at least 1.5 times the nominal maximum aggregate size to reduce interference between aggregate and reinforcement where variations in bar placement can result in a cover smaller than specified.*

Note: *Greater cover or protective coatings can be necessary where there is exposure to industrial chemicals, food processing chemicals, and other corrosive materials. See CSA A23.1 and PCA IS001.*

Table 2
Accelerated curing cycle
(See Clause 23.2.2.3.4.)

	Moisture category	
Heat treatment cycle	**Dry**	**Damp**
Minimum holding period (delay) before application of heat and maximum concrete temperature during the holding period	1 h at 30 °C	3 h at 30 °C or 4 h at 40 °C
Maximum heating rate of concrete, °C/h*	20	20
Maximum concrete temperature, °C	70	60
Maximum cooling rate of concrete, °C/h†	15	15

**For structural low and semi-low-density concrete, the heating rate shall be limited to 10 °C/h.*
†Cooling shall continue until the concrete temperature is not more than 20 °C above the ambient temperature.

Table 3
Heated concrete cycle
(See Clause 23.2.2.4.4.)

	Moisture category	
Heat treatment cycle	**Dry**	**Damp**
Maximum temperature of the compacted fresh concrete in the form, °C	50	40
Maximum concrete temperature, °C	70	60
Maximum cooling rate of concrete, °C/h*	15	15

**Cooling shall continue until the concrete temperature is not more than 20 °C above the ambient temperature outside the enclosure.*

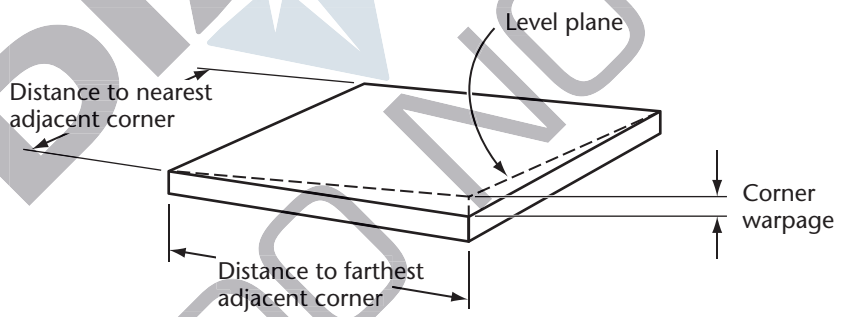

Figure 1
Warpage of one corner of slab or panel
(See Clause 12.6.)

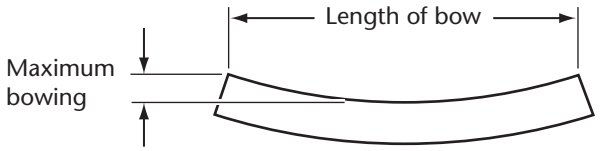

Figure 2
Measuring of bowing in panel
(See Clause 12.7.)

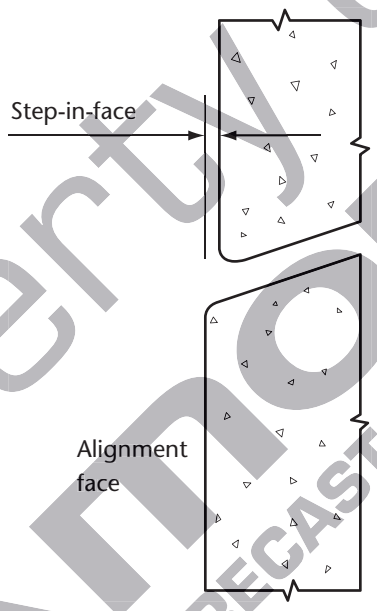

Figure 3
Section through face
(See Clause 12.2.2.)

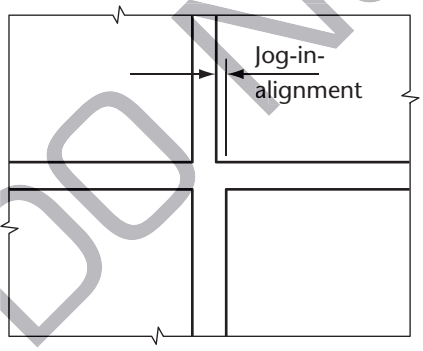

Figure 4
View of elevation
(See Clause 12.2.2.)

Annex A (informative)
Responsibilities

Note: *This informative Annex has been written in mandatory language to facilitate adoption by anyone wishing to do so.*

A.1 Outline of responsibilities

Table A.1 outlines the responsibilities of the owner and the manufacturer. It specifies three options and, within Options II and III, two alternatives for the manufacturer. The owner shall clearly state in the contract documents for a project which option and (if applicable) which alternative shall apply.

A.2 Responsibility of the owner

A.2.1

The basic responsibility for the structural and aesthetic design of precast concrete, whether used architecturally or structurally, shall rest with the owner (see Table A.1).

A.2.2

The owner shall, as applicable (see Table A.1), carry out the following responsibilities:

(a) provide clear and concise working drawings and specifications, with any exemptions from current Canadian standards clearly identified;

(b) establish standards of acceptability;
Note: *The owner's right to review work encompasses checking for defects and rejecting elements that would render the building or structure, or any portion of it, unusable in the manner and for the purpose intended.*

(c) identify the precast concrete elements used to resist vertical and lateral loads on the structure;

(d) allow for the effects of material properties, stiffness, temperatures, and other characteristics or qualities that can influence the interaction of precast concrete elements with other elements of the structure;

(e) determine all load reactions that bear on precast elements;

(f) evaluate thermal movements;
Note: *Thermal movements can affect requirements for joints, connections, reinforcement, and compatibility with adjacent materials.*

(g) determine the watertightness of exterior precast concrete wall panel systems by
  (i) detailing joint treatment, including the performance of adjacent materials; and
  (ii) specifying the joint treatment and the proper sealing of the precast concrete to windows, doors, and other openings;

(h) design the supporting structure so that it will carry the mass of the precast concrete, as well as any superimposed loads, including provisions for deflection and rotation of the supporting structure during and after installation of the precast concrete;

(i) design the supporting structure to withstand any temporary loading conditions;
Note: *Temporary loadings can result from the sequence of installation and/or the sequence of loading of the structure.*

(j) select the surface finishes and define the area of exposure;
Note: *This necessitates recognizing the limitations inherent in natural materials and production techniques in regard to uniform colour, texture, and performance.*

(k) specify the required structural and insulating performance of sandwich wall panels;

(l) review all drawings as required in the specifications in time to meet project schedule requirements; and

(m) specify any dimensional and installation tolerances for the precast concrete and tolerances for the supporting structure that exceed the requirements of this Standard and CSA A23.1.

A.3 Responsibility of the manufacturer

A.3.1 Design capability

A.3.1.1
A manufacturer producing precast concrete elements in accordance with this Standard shall have established design capability.

A.3.1.2
The responsibilities of the manufacturer's engineer in relation to the owner shall be established in the contract documents (see Table A.1).

A.3.1.3
The manufacturer's engineer shall be responsible for preparing and obtaining the owner's review of shop drawings and installation drawings (see Clauses 1.2 and 16.3 of CAN/CSA A23.3) and for translating the requirements for each project into procedures that will allow the finished project to be of the required quality.

A.3.1.4
The manufacturer shall be responsible for the following design items, if applicable:
(a) design of all loading conditions for precast concrete elements;
(b) shop drawings, layout, connection details, and related calculations (see Clause A.3.3);
(c) design of structural precast concrete elements; and
(d) design for loads for handling, transportation, and installation.

A.3.1.5
The manufacturer shall be responsible for the following items during the preparation of shop drawings, the fabrication of precast concrete elements, and the installation of precast concrete elements, if applicable in accordance with this Standard:
(a) design, protection, and location of lifting hardware;
(b) modifications to reinforcement and hardware;
(c) conduits, pipes, wiring, and/or other appurtenances or fixtures embedded in the precast concrete;
(d) determination of the stripping strength of the concrete;
(e) curing procedures;
(f) establishment of concrete strength for shipping; and
(g) assessment of structural damage and repairs.

A.3.1.6
The manufacturer shall clearly identify the owner's fire-rating requirements and verify that the design and shop drawings contain materials and details sufficient for attaining these ratings (see Clause 14.6.3).

A.3.1.7
The manufacturer shall review the design of all precast concrete elements designed by others for structural soundness and feasibility with respect to applied loads, finishes, connections, handling stresses, joint treatment, and tolerances, both for manufacturing and installation. Any deficiencies shall be reported to the owner.

Note: *This review should not be interpreted as relieving the owner of any applicable responsibilities (see Table A.1).*

A.3.2 Manufacturer's engineering capability

A.3.2.1
A manufacturer that produces prestressed concrete shall have an engineer on staff unless application is made to the certification agency to retain an independent engineer to carry out and supervise the design and production.

A.3.2.2
The manufacturer shall be responsible for fabricating and installing the precast concrete in accordance with this Standard, the shop drawings, and sound engineering principles.

A.3.3 Shop, installation, and setting drawings
Shop and installation drawings and related documents prepared by the manufacturer and reviewed by the manufacturer's engineer shall provide the information required by Clause 16.3 of CAN/CSA-A23.3 and shall include the following:

(a) shop and installation drawings showing the layout and general arrangement of the precast elements, their location in the building or the structure, their relation to adjacent materials, the connections, and the joint and sealing details, if within the scope of the work. Drawings shall show the markings of individual elements and special installation methods and shall indicate the sequence of installation where this is critical;

(b) shop and setting drawings showing the location of hardware supplied by the precast manufacturer to be installed by the general contractor; and

(c) shop and installation drawings that detail the dimensions and shape of individual elements, masses, reinforcement, finishes, and special handling instructions, stressing information, and individual mark numbers. Such drawings shall also show special embedments (e.g., plant and installation hardware and fastening details, such as reglets, cut-outs, and pipe sleeves and openings) required by other trades. Shop drawings for the production of individual elements shall contain enough views and sections to ensure clear interpretation by workers, including, information on special materials, the concrete mix, finishes (including wet finishing), and special tolerances.

Also, information listed in Clause 1.2 of CAN/CSA-A23.3 should be indicated.

Table A.1
Outline of responsibilities of owner and manufacturer

(See Clauses 0.2, A.1, A.2, A.3.1.2, and A.3.1.7.)

Contract information supplied by the owner	Responsibility of the manufacturer
Option I	
The owner shall provide complete drawings and specifications for the precast concrete, detailing all of the aesthetic and functional requirements plus all of the dimensions.	The manufacturer shall make shop and installation drawings with details as shown by the owner. The manufacturer may suggest modifications that would improve the economics, structural soundness, or performance of the precast installation. The manufacturer shall obtain specific approval for such modifications. Full responsibility for the precast design, including such modifications, shall remain with the owner.
Option II	
The owner shall detail all aesthetic and functional requirements but specify only the required structural performances of the precast units. In specifying performances, the owner shall include all limiting combinations of loads and their points of application. This shall be supplied in such a way that all details of a unit can be designed without reference to the behaviour of other parts of the structure.	The manufacturer shall (a) submit drawings showing installation and element configurations, with all necessary details and design information for the review and ultimate responsibility of the owner; or (b) submit drawings showing installation and element configurations for general review and assume responsibility for the manufacturer's part of the structural design (i.e., the individual units but not their effect on the building). Precast manufacturer to provide drawings sealed by an engineer. The choice between alternatives (a) and (b) shall be decided by the owner before bidding, with either approach clearly stated in the specifications for proper allocation of the design responsibility.
Option III	
The owner shall cover the required structural performance of the precast units as in Option II and cover all or parts of the aesthetic and functional requirements by performance specifications. The owner shall define all limiting factors (e.g., minimum and maximum thickness, depth, masses, and limiting dimensions). The owner shall specify acceptable limits for any other requirements not detailed.	The manufacturer shall submit drawings and assume the responsibilities under alternative (a) or (b) in Option II.

Note: *In all cases, the owner shall clearly assign in the contract documents the responsibility for the transportation and installation of the precast concrete (see Clause B.1.2).*

Annex B (informative)
Scope of work

Note: *This informative Annex has been written in mandatory language to facilitate adoption by anyone wishing to do so.*

B.1 General

B.1.1
The owner's specifications shall include all items that are to be included in the contract documents for the precast concrete work.
Note: *The owner should stipulate that the general contractor provide the name of the precast concrete subcontractor in the tender documents for each project involving architectural and structural precast concrete.*

B.1.2
Transportation to and installation at the job site of the precast concrete elements shall be the responsibility of the precast concrete manufacturer and executed by the manufacturer's employees or by a qualified specialist firm acting as subcontractor to the precast concrete manufacturer.
Note: *Exemption from responsibility for delivery and/or installation may be made for small precast elements such as window sills, lintels, stair treads, benches, covers, pavement slabs, and specialty items. Other exemptions may be made where the usage of concrete products ties in with other site operations not controllable with respect to scheduling by the precast manufacturer, such as the incorporation of precast elements into masonry work.*

B.1.3
Items relating to other trades shall be described in the precast concrete specifications and in the other related trade sections.
Note: *The general inclusion or exclusion of specific items has been outlined in this Annex so that early budget estimates supplied to the owner can be judged on a more uniform basis. The owner should clearly outline which items are to be included for bidding purposes. These will depend on the individual job, local trade practices, and the precast manufacturer's recommendations.*

B.1.4
The cost of any specified materials testing and/or inspection, beyond the cost of the manufacturer's quality control required by this Standard, shall be the responsibility of the owner. The manufacturer shall provide, at no extra cost, all materials required for testing and allow inspectors reasonable access to the manufacturer's premises.

B.1.5
The owner shall specify procedures for the submission of shop drawings for review, including the number of prints required of the installation (or layout) drawings, setting drawings for contractor's hardware, drawings of all installation details, and drawings of all typical elements.
Note: *Submission of production shop drawings may be limited to typical elements.*

B.2 General contractor's work

B.2.1
A schedule of installation shall be mutually agreed upon between the precast manufacturer and the general contractor.

B.2.2
The general contractor shall provide and maintain site access and operating space for the trucks and equipment used by the precast concrete installer. The general contractor shall provide safety fences, rails, gates, and site security.

Notes:

(1) *Such access may include roads, ramps, and crossings capable of supporting cranes and trucks that are normally used in installation operations of the type in question and move under their own power.*

(2) *Foundation and utility excavations should be backfilled by the general contractor when necessary.*

B.2.3
The general contractor shall coordinate the work of other trades with the precast concrete manufacturer. The general contractor shall coordinate the placement of embedded items and their locations as well as the sizing and locating of openings required by the trades.

B.2.4
The general contractor shall establish and permanently mark, at convenient locations, benchmarks and building lines for the use of the precast manufacturer in the layout and installation of the precast concrete elements. If the building frame is not precast, the general contractor shall provide benchmarks and building lines at each floor.

B.2.5
The general contractor shall assume responsibility for protecting the manufacturer's work during and after the final installation of the precast work, including all connections and joints.

Note: *Any cleaning or repairs of the precast concrete work should be carried out by the precast manufacturer.*

B.3 Hardware

B.3.1 General contractor's hardware

B.3.1.1
Precast connection hardware to be placed by the general contractor, as well as setting drawings for properly locating and placing the hardware, shall be supplied to the job site by the precast manufacturer. The hardware shall be placed in the structure to the tolerances specified in Clauses 6.7.2 and 6.7.3 of A23.1.

Notes:

(1) *This practice is the most economical and practical for most projects. A different approach can be advantageous only when precast concrete elements are being fastened to structural steel buildings that are not fireproofed by structural concrete encasement. Brackets, angles, etc., which need to be fastened to the structural steel, can be more economically supplied and shop-welded to supporting members by the structural steel supplier.*

(2) *The contractor's hardware should be delivered to the general contractor in sufficient time to be incorporated into the structure in accordance with setting drawings supplied by the precast manufacturer and in accordance with a predetermined and agreed-upon schedule.*

(3) *The precast manufacturer should check the location of the contractor's hardware before actual installation of the precast elements. This should not, however, relieve the general contractor of the responsibility for properly positioning such hardware.*

B.3.1.2
The general contractor shall maintain and suitably protect the contractor's hardware (e.g., by capping inserts and keeping threads clear of concrete).

B.3.1.3
If anchors or other structural items shown on the precast manufacturer's reviewed drawings cannot be accommodated, the general contractor shall obtain approval for any modifications from both the owner and the precast manufacturer to ensure the required structural adequacy of the hardware.

B.3.2 Plant hardware

B.3.2.1

B.3.2.1.1
All plant hardware necessary for connecting precast elements shall be supplied by the precast manufacturer. Plant hardware that is cast into precast concrete elements at the plant shall not be modified by the general contractor at the site.

B.3.2.1.2
Plant hardware or inserts intended to support a force of more than 500 N that are shown on the contract drawings or described in the specifications shall be supplied by the trade in question, installed by the precast concrete manufacturer, and shown on the reviewed shop drawings.

Connections that are required for the work of other trades and result in forces of less than 500 N shall be installed at the site by the trade in question in accordance with Clauses B.3.2.3 and B.4.2.

B.3.2.2
Other plant hardware to be placed by the precast manufacturer (e.g., dovetail slots for masonry anchors or inserts for flashings) shall be specified by the owner. The anchors or the flashings shall be supplied by the respective trades. Specially manufactured hardware shall be supplied by the trade requiring it. Hardware shall be sealed to exclude concrete and shall have suitable lugs for fastening to the forms.

B.3.2.3
Installation of inserts and fastenings by explosive-actuated or power-driven tools shall be allowed only where such installation will not damage the structural integrity of the elements by being too close to reinforcement or tendons and where such installation will not mar the concrete finish by spalling or chipping.

B.3.3 Installation hardware
Installation hardware shall be supplied by the precast manufacturer when it is used in the connections or is an integral part of the precast installation.

B.3.4 Other materials

B.3.4.1
Temporary bracing stays and guy wires for supporting precast elements shall be considered installation equipment and be supplied by the precast manufacturer. Inserts or connections for such equipment may be either general contractor's hardware or plant hardware and shall be treated accordingly.

B.3.4.2
Sealant, backer rod, and insulation specified for joints between precast concrete wall panels shall be supplied and installed by the precast manufacturer.

B.3.5 Joint materials

B.3.5.1
Joint materials between precast concrete elements and adjacent materials shall not be included in the precast concrete work.
Note: *This work is generally more efficiently carried out by the subsequent trade installing such adjacent materials.*

B.3.5.2
The contract drawings and project specifications shall clearly show the responsibility for the supply and installation of materials at the joints between precast concrete elements and other materials installed before the precast installation (e.g., cast-in-place structures and steel members).

B.4 Holes and openings

B.4.1
All openings for services and equipment, with their approximate size and location shown on the contract drawings, and the same holes subsequently detailed with respect to size and location by the trades requiring the openings, shall be coordinated by the general contractor and noted on the first issue of the precast manufacturer's shop drawings. The openings shall be provided by the precast manufacturer, except as specified in Clause B.4.2.
Note: *Sizes and locations of openings should be adjusted to avoid major reinforcing bars, prestressing tendons, supporting beams, and double Tee legs.*

B.4.2
Holes of small diameter (80 mm or less) or holes for fastenings intended to carry less than 500 N shall be made at the site by the trade requiring the opening, in locations reviewed by the precast manufacturer.
Note: *Holes made by other trades should not be located in areas of structural importance (e.g., reinforcement and tendon locations).*

B.4.3
The procedures specified in Clause B.4.1 shall be followed whether the precast manufacturer provides openings at the plant or elects to cut and drill openings on site.

B.4.4
Openings requested after review of the shop drawings and production of precast elements shall be cut only if the openings can be structurally accommodated.
Notes:
(1) *These modifications should be carried out by the precast manufacturer, which will have the equipment and expertise needed to cut new openings.*
(2) *Holes in architectural wall panels for other trades should be made at the manufacturing plant and consequently should be detailed and located on the contract drawings.*

B.5 Roof and floor fill

B.5.1
If roof or floor slab joints have grout keys that form part of the slab design, the grouting shall be executed by the precast installer and the areas made ready for roofing or floor fill as necessary.

B.5.2

Where the joints between slabs do not have grout keys, they may be taped for roofing or topping applications. This taping shall be performed by the trade or general contractor who subsequently carries out the roofing or floor topping operations.

B.5.3

Where differential camber exceeds the values specified in Clause 12.8, the joint might have to be feather-grouted to a slope of 1:12. This work shall be performed by the precast concrete installer.

Annex C (informative)
Product group classifications

Note: *This informative Annex has been written in mandatory language to facilitate adoption by anyone wishing to do so.*

C.1 General
Manufacturers may be certified in up to four of the product group classifications, as specified in Clauses C.2 to C.5.

C.2 Group A (architectural products)
Group A includes products that are decorative and establish the aesthetic character of a structure. These products shall be produced in accordance with the requirements of this Standard. Group A is divided into two categories:

(a) Architectural trim units (AT), which are non-prestressed products with a high standard of finish quality and of relatively small size, can be installed with equipment of limited capacity. Products include sills, lintels, coping, cornices, quoins, medallions, bollards, benches, planters, and pavers. This category also includes specialty products specifically designed for a project but not commodity or ornamental units produced for wholesale or retail purposes.

(b) Architectural cladding and load bearing units (A1) are precast concrete building elements (e.g., exterior cladding, load bearing and non-load bearing wall panels, spandrels, beams, mullions, columns, column covers, and other miscellaneous shapes). Elements may be conventionally reinforced and/or pretensioned or post-tensioned. This category includes category AT.

Note: *Group A does not include structural products that exhibit a high degree of finish or texture, including unique colouration. Such products are included in Groups B and C.*

C.3 Group B (bridge products) and Group BA (bridge products with architectural finishes)

C.3.1 General
Both Group B and Group BA products shall be produced in accordance with the requirements of this Standard.

C.3.2 Group B
Group B is divided into four categories:

(a) Precast concrete bridge products (B1) are conventionally reinforced precast concrete elements that include some types of bridge beams or slabs, piling, sheet piling, pile caps, retaining wall elements, median barriers, parapet walls, sound barriers and box culverts.

(b) Prestressed miscellaneous bridge products (B2) are any precast concrete and pretensioned or post-tensioned elements, excluding superstructure beams. This category includes Category B1.

(c) Prestressed straight-strand bridge members (B3) include all precast concrete superstructure elements, such as box beams, segmental components, I-girders, bulb tees, stemmed members, solid slabs, and full- or partial-depth bridge deck slabs pretensioned or post-tensioned with straight strands. This category includes Categories B1 and B2.

(d) Prestressed deflected-strand bridge members include the same class of products as category B3 and which are pretensioned or post-tensioned with deflected strands. This category includes Categories B1, B2, and B3.

C.3.3 Group BA

Group BA products are produced with the additional requirements for architectural finishes. Group BA is divided into the same four categories as Group B and are designated Categories BA1, BA2, BA3, and BA4. The category descriptions are identical with the category descriptions for Group B except that the manufacturer shall have the capability to apply architectural finishes in accordance with the provisions of this Standard. Each BA category includes the preceding BA categories and supersedes the equivalent Group B category.

C.4 Group C (commercial [structural] products) and Group CA (commercial [structural] products with architectural finishes)

C.4.1 General

Groups C and CA include structural and non-structural elements of buildings and other structures, excluding bridges. These products shall be produced in accordance with the requirements of this Standard.

C.4.2 Group C

Group C is divided into four categories:

(a) Precast concrete products (C1) are conventionally reinforced precast concrete elements, including piling, sheet piling, pile caps, retaining wall elements, slabs, joists, stairs, seating members, columns, spandrels, beams, walls, or other similar products.

(b) Prestressed hollow core and repetitive products (C2) are precast concrete products with standard shapes that are generally produced by a repetitive process that may be mechanized and pretensioned or post-tensioned with straight strands. Examples are hollow core slabs, railroad ties and piling. This category includes Category C1.

(c) Prestressed straight-strand structural members (C3) are precast concrete structural members pretensioned or post-tensioned with straight strand, including stemmed members, beams, columns, joists, and segmental components. This category includes Categories C1 and C2.

(d) Prestressed deflected-strand structural members include the same class of products as Category C3 and which are pretensioned or post-tensioned with deflected strands. This category includes Categories C1, C2, and C3.

C.4.3 Group CA

Group CA products are produced with the additional requirements for architectural finishes. Group CA is divided into the same four categories as Group C and are designated Categories CA1, CA2, CA3, and CA4. The category descriptions are identical with the category description in Group C, except that the manufacturer will have demonstrated the capability to apply architectural finishes in accordance with the provisions of this Standard. Each CA category includes the preceding CA categories and supersedes the equivalent Group C category.

C.5 Group S (standard products)

Group S includes plain or reinforced concrete elements, without architectural finishes, not included in Groups A, B, BA, C, or CA that are required to be manufactured in accordance with the provisions of this Standard. Products in Group S are often manufactured for a particular application in custom built forms on-demand or kept in inventory.

Proposition de modification

N'hésitez pas à nous faire part de vos suggestions et de vos commentaires. Au moment de soumettre des propositions de modification aux normes CSA et autres publications CSA prière de fournir les renseignements demandés ci-dessous et de formuler les propositions sur une feuille volante. Il est recommandé d'inclure

- le numéro de la norme/publication
- le numéro de l'article, du tableau ou de la figure visé
- la formulation proposée
- la raison de cette modification.

Proposal for change

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Standard Specification for Circular Precast Reinforced Concrete Manhole Sections (Metric)[1]

This standard is issued under the fixed designation C478M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

PART I—GENERAL

1. Scope

1.1 This specification covers the manufacture and purchase requirements of products used for the assembly and construction of circular vertical precast reinforced concrete manholes and structures used in sewer, drainage, and water works.

1.2 Part I, Sections 1 – 11, of this specification presents general requirements and requirements which are common to each precast concrete product covered by this specification.

1.3 Part II of this specification presents specific requirements for each manhole product in the following sections:

Product	Section
Grade Rings	12
Flat Slab Tops	13
Risers and Conical Tops	14
Base Sections	15
Steps and Ladders	16

NOTE 1—Future products will be included in Part II in a future revision of this specification.

1.4 This specification is the SI companion to C478.

NOTE 2—This specification is a manufacturing and purchase specification only, and does not include requirements for backfill, or the relationship between field load conditions and the strength requirements of the manhole products and appurtenances. Experience has shown, however, that the successful performance of this product depends upon the proper selection of the product strength, type of foundation and backfill, and care in the field installation of the manhole products and connecting pipes. The owner of the project for which these products are specified herein is cautioned to require inspection at the construction site.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

C33 Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C150 Specification for Portland Cement

C260 Specification for Air-Entraining Admixtures for Concrete

C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C494/C494M Specification for Chemical Admixtures for Concrete

C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile

C595 Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C822 Terminology Relating to Concrete Pipe and Related Products

C989 Specification for Slag Cement for Use in Concrete and Mortars

C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

2.2 *ACI Standard:*

ACI 318 Building Code, Requirements for Reinforced Concrete[3]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to concrete pipe, see Terminology C822.

[1] This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.06 on Manholes and Specials.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.

4. Materials and Manufacture

4.1 General material requirements for precast reinforced concrete manhole products are presented in 4.1.1 – 4.1.9. Other materials or additional requirements for a product, if any, are covered in the Part II section for that specific product.

4.1.1 *Reinforced Concrete*—Reinforced concrete shall consist of cementitious materials, mineral aggregates, and water, in which steel reinforcement has been embedded in such a manner so that the steel reinforcement and concrete act together.

4.1.2 *Cementitious Materials:*

4.1.2.1 *Cement*—Cement shall conform to the requirements for portland cement of Specification C150, or shall be portland blast-furnace slag cement or portland-pozzolan cement conforming to Specification C595, except that the pozzolan constituent of the Type IP portland-pozzolan cement shall be fly ash.

4.1.2.2 *Fly Ash*—Fly ash shall conform to the requirements of Class F or Class C of Specification C618.

4.1.2.3 *Slag Cement*—Slag cement shall conform to the requirements of Grade 100 or 120 of Specification C989.

4.1.3 *Allowable Combinations of Cementitious Materials*—The combination of cementitious materials used in the concrete shall be one of the following:

4.1.3.1 Portland cement only,

4.1.3.2 Portland blast-furnace slag cement only,

4.1.3.3 Portland pozzolan cement only,

4.1.3.4 A combination of Portland cement and slag cement,

4.1.3.5 A combination of Portland cement and fly ash, or

4.1.3.6 A combination of Portland cement, slag cement (not to exceed 25 % of the total cementitious weight) and fly ash (not to exceed 25 % of the total cementitious weight).

4.1.4 *Aggregates*—Aggregates shall conform to Specification C33, except that the requirements for gradation shall not apply.

4.1.5 *Admixtures and Blends*—The following admixtures and blends are allowable:

4.1.5.1 Air-entraining admixture conforming to Specification C260;

4.1.5.2 Chemical admixture conforming to Specification C494/C494M;

4.1.5.3 Chemical admixture for use in producing flowing concrete conforming to Specification C1017/C1017M;

4.1.5.4 Chemical admixture or blend approved by the owner.

4.1.6 *Steel Reinforcement*—Reinforcement shall consist of wire and welded wire conforming to Specification A1064/A1064M; or of bars conforming to Specification A615/A615M, Grade 280 or 420, or Specification A706/A706M, Grade 420.

4.1.7 *Water*—Water used in the production of concrete shall be potable or non-potable water that meets the requirements of Specification C1602/C1602M.

4.1.8 *Secondary Synthetic Fiber*—Collated fibrillated polypropylene virgin fibers shall not be prohibited when used in steel reinforced concrete manholes as a non-structural manufacturing enhancement. Only fibers designed and manufactured specifically for use in concrete and so certified by the manufacturer shall be accepted.

4.1.9 *Other Materials*—Other materials required for a product and not covered in Section 4 will be covered in the Part II section for that specific product.

5. Design

5.1 Design requirements for a product are prescribed in the specific Part II section for that product.

5.1.1 The minimum compressive strength of concrete manhole products covered by this specification shall be 27.6 MPa unless specified otherwise in Part II of this specification.

5.2 *Modified or Special Design:*

5.2.1 Manufacturers are not prohibited from submitting to the owner, for approval prior to manufacture, designs other than those prescribed in the specific section for a product. If such approval is obtained, then the product shall meet all the tests and performance requirements specified by the owner in accordance with the appropriate sections on manufacture and physical requirements.

5.2.2 If permitted by the owner, the manufacturer is not prohibited from requesting approval of designs of special sections, such as reducers, tees, and bases.

6. Reinforcement

6.1 This section presents requirements for reinforcement cover, continuity, laps, welds and splices. Other reinforcement requirements are presented in Section 4 and any additional requirements are given in the Part II section for a specific product.

6.2 *Cover*—The exposure of the ends of reinforcement, stirrups or spacers used to position the reinforcement during placement of the concrete shall not be cause for rejection.

6.3 *Continuity*—The continuity of the circumferential reinforcement shall not be destroyed during the manufacture of the product, except when lift holes or pipe openings are provided in the product.

6.4 *Welded Steel Cage Laps. Welds, and Splices:*

6.4.1 If splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars, and 40 diameters for plain bars and cold-drawn wire. In addition, where lapped cages of welded wire fabric are used without welding, the lap shall contain a longitudinal wire.

6.4.2 When splices are welded and are not lapped to the minimum requirements in 6.4.1, there shall be a minimum lap of 50 mm and a weld of sufficient length such that pull tests of representative specimens shall develop at least 50 % of the minimum specified tensile strength of the steel. For butt welded splices in bars or wire, permitted only with helically wound cages, pull tests of representative specimens shall develop at least 75 % of the minimum specified tensile strength of the steel.

6.5 *Steel Hoop Splices*—When splices are welded and not lapped to the minimum requirements in 6.4.1, there shall be a minimum lap of 50 mm and a weld of sufficient length such that pull tests from representative specimens shall develop at least 50 % of the minimum specified tensile strength of the

steel. For butt welded splices, pull tests from representative specimens shall develop at least 75 % of the minimum specified tensile strength of the steel.

7. Precast Concrete Manufacture

7.1 *Mixture*—The aggregates shall be sized, graded, proportioned, and mixed with such proportions of cementitious materials and water as will produce a thoroughly-mixed concrete of such quality that the products will conform to the test and design requirements of this specification. All concrete shall have a water-cementitious ratio not exceeding 0.53 by mass. Cementitious materials shall be as specified in 4.1.2 and shall be added to the mix in a proportion not less than 280 kg/m^3, unless mix designs with a lower cementitious materials content demonstrate that the quality and performance of the product meet the requirements of this specification.

7.2 *Curing*—Concrete products shall be subjected to any one of the methods of curing prescribed in 7.2.1 – 7.2.4 or to any other method or combination of methods approved by the owner that will give satisfactory results.

7.2.1 *Steam Curing*—Concrete products are placed in a curing chamber, free of outside drafts, and cured in a moist atmosphere maintained by the injection of steam for such time and such temperatures as may be needed to enable the products to meet the strength requirements. The curing chamber shall be so constructed as to allow full circulation of the steam around the entire product.

7.2.2 *Water Curing*—Concrete products are water-cured by covering with water-saturated material, or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the products moist during the curing period.

7.2.3 *Sealing Membrane*—A sealing membrane conforming to the requirements of Specification C309 is applied and shall be left intact until the required concrete strength requirements are met. The concrete at the time of application of the membrane shall be within 6°C of the atmospheric temperature. All concrete surfaces shall be kept moist prior to the application of the membrane and shall be damp when the membrane is applied.

7.2.4 The manufacturer is not prohibited from combining methods prescribed in 7.2.1 – 7.2.3 provided the required concrete compressive strength is attained.

8. Acceptance

8.1 *Acceptance Procedures:*

8.1.1 Unless otherwise designated by the owner at the time of, or before, placing an order, acceptance procedures for precast reinforced concrete manhole products shall be as specified in the Part II section for a particular product, and shall not be prohibited from consisting of one or more of the following:

8.1.1.1 Acceptance of a product on the basis of tests of materials, including concrete compressive strength and absorption.

8.1.1.2 Acceptance of a product on the basis of inspection of the finished product, including amount and placement of reinforcement to determine conformance with the design prescribed under this specification, and freedom from defects.

8.2 *Test Methods:*

8.2.1 *Concrete Compressive Strength Test:*

8.2.1.1 *Type of Specimen*—Compression tests for satisfying the minimum specified concrete strength requirement shall be made on either concrete cylinders or, at the option of the manufacturer, on cores cut from the concrete manhole product.

8.2.1.2 *Compression Testing of Cylinders*—Cylinders shall be made in accordance with Test Methods C497, and shall be tested in accordance with Test Method C39/C39M. For manhole products, an owner shall not be prohibited from requiring concrete compressive tests on cylinder specimens numbering in the amount of 5 % of the total order of a manhole product, but not to exceed two cylinders for each day's production. The average compressive strength of all cylinders tested shall be equal to or greater than the specified strength of the concrete. Not more than 10 % of the cylinders tested shall fall below the specified strength of the concrete. In no case shall any cylinder tested fall below 80 % of the specified strength of the concrete.

8.2.1.3 *Compression Testing of Cores*—Cores shall be cut from the concrete manhole product and tested in accordance with Test Methods C497, except that the requirements for moisture conditioning shall not apply. One core shall be taken from a manhole product selected at random from each day's production run of a single concrete strength. When the concrete compressive strength of the core is equal to or greater than 80 % of the specified strength of the concrete, the concrete strength of the production run is acceptable. If the core does not meet the preceding concrete strength requirement, another core from the same manhole product may be taken and tested.

8.2.1.4 If the concrete compressive strength of the recore is equal to or greater than 80 % of the specified strength of the concrete, the concrete strength of the production run is acceptable. If the recore does not meet the preceding concrete strength requirement, that manhole product shall be rejected. Two manhole products from the remainder of the day's production run shall be selected at random and one core taken from each manhole product and tested. When the average concrete strength of the two cores is equal to or greater than 80 % of the specified strength of the concrete with no core below 75 % of the specified strength of the concrete, the concrete strength of the day's production run shall be acceptable.

8.2.1.5 If the concrete strength of the two cores does not meet the preceding concrete strength requirement, then the remainder of the day's production run shall be either rejected, or, at the option of the manufacturer, each manhole product of the remainder of the day's production run is not prohibited from being cored and accepted individually.

8.2.1.6 *Plugging Core Holes*—Core holes on accepted manhole sections shall be plugged and sealed by the manufacturer in a manner such that the manhole products will meet all of the requirements of this specification. Manhole sections so sealed shall be considered as satisfactory for use.

8.2.2 *Absorption Test:*

8.2.2.1 The absorption of a specimen from a concrete product, as determined in Test Methods C497, shall not exceed

9 % of the dry mass for Test Method A procedure or 8.5 % for Test Method B procedure. All specimens shall be free of visible cracks and shall represent the full thickness of the product.

8.2.2.2 Specimens for Test Method B shall meet the requirements of Test Methods C497.

8.2.2.3 Each specimen tested by Test Method A shall have a minimum mass of 1.0 kg.

8.2.2.4 When the initial absorption specimen from a concrete product fails to conform to this specification, the absorption test shall be made on another specimen from the same product and the results of the retest shall be substituted for the original test results.

8.2.3 *Retests*—When not more than 20 % of the concrete test specimens tested under either 8.2.2.1 or 8.2.2.2 fail to pass the requirements of this specification, the manufacturer is not prohibited from culling his stock and eliminating whatever quantity of product he desires and shall so mark the culled product that they will not be shipped for the order. The required tests shall be made on the balance of the order and the products shall be accepted if in conformance with the requirements of this specification.

8.3 *Test Equipment*—Every manufacturer furnishing manhole products under this specification shall furnish all facilities and personnel necessary to carry out the tests required for acceptance.

9. Repairs

9.1 Repair of manhole products shall not be prohibited, if necessary, because of imperfections in manufacture or damage during handling, and will be acceptable if, in the opinion of the owner, the repaired products conform to the requirements of this specification.

10. Inspection

10.1 The quality of materials, the process of manufacture, and the finished manhole products shall be subject to inspection and approval by the owner.

11. Product Marking

11.1 The following information shall be legibly marked on each precast concrete product:

11.1.1 Specification and product designation: MH for manhole base, riser, conical tops, and grade rings,

11.1.2 Date of manufacture, and

11.1.3 Name or trademark of the manufacturer.

11.2 Marking shall be indented into the concrete or shall be painted thereon with waterproof paint.

PART II—PRODUCTS

12. Grade Rings

12.1 *Scope*—This section covers precast reinforced concrete grade rings used for final adjustment of manholes to grade.

12.2 *Acceptance*—Acceptability of grade rings covered by this specification shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by 12.4, 12.5 and 12.6, to determine its conformance with the design prescribed under this specification and its freedom from defects.

12.3 *Design*—The minimum wall thickness shall be one twelfth of the internal diameter of the grade ring or 100 mm, whichever is greater.

12.3.1 *Joints*—Grade rings are not required to have the joint formed with male and female ends.

12.4 *Circumferential Reinforcement:*

12.4.1 The circumferential reinforcement shall have an equivalent area of not less than 150 mm^2/vertical m, but not less than 15 mm^2 in any one grade ring.

12.4.2 The circumferential reinforcement shall be one line in the center third of the wall of the grade ring.

12.5 *Permissible Variations:*

12.5.1 *Internal Diameter*—The internal diameter of grade rings shall not vary more than ±1 %.

12.5.2 *Wall Thickness*—The wall thickness of grade rings shall be not less than that prescribed in the design by more than 5 % or ±5 mm, whichever is greater. A wall thickness greater than that prescribed in the design shall not be cause for rejection.

12.5.3 *Height of Two Opposite Sides*—Variations in laying heights of two opposite sides of grade rings shall be not more than 6 mm.

12.5.4 *Height of Grade Ring*—The underrun in height of a grade ring shall be not more than 20 mm/m of height.

12.5.5 *Position of Reinforcement*—For grade rings with a 100-mm wall thickness, the maximum variation in the design position of circumferential reinforcement from that described in 12.4.1 shall be ±10 % of the wall thickness or ±6 mm, whichever is greater. For grade rings with a wall thickness greater than 100-mm, the maximum variation from the design position of reinforcement shall be ±10 % of the wall thickness or ±16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of the joint.

12.5.6 *Area of Reinforcement*—Steel reinforcement areas that are 10 mm^2/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

12.6 *Rejection*

12.6.1 Grade rings shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual grade ring shall be subject to rejection because of any of the following:

12.6.1.1 Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

12.6.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honeycombed or open texture that would adversely affect the function of the grade ring.

12.6.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the grade ring, within the limits of permissible variations prescribed in 12.5.

12.6.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

12.6.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the wall.

13. Flat Slab Tops

13.1 *Scope*—This section covers precast reinforced concrete flat slab tops used in the construction of manholes for use in sewer, drainage, and water works.

13.2 *Acceptance:*

13.2.1 Acceptability of flat slab tops shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by 13.4 and 13.6, to determine its conformance with the design prescribed under this specification and its freedom from defects.

13.2.2 Unless otherwise designated by the owner at the time of, or before, placing an order, two separate and alternative methods of acceptance are permitted for flat slab top manufacturer designs, in addition to tests of materials and inspection required in 13.2.1.

13.2.2.1 *Acceptance on the Basis of Proof-of-Design Test*—Acceptance of flat slab tops on the basis of the results of a proof-of-design test performed in accordance with 13.5 in lieu of submission of design calculations and detailed drawings.

13.2.2.2 *Acceptance on the Basis of Rational Design*—Acceptance of flat slab tops on the basis of design calculations by a rational method and detailed drawings.

13.3 *Design:*

13.3.1 The basis of flat slab top designs shall be the appropriate sections of the latest edition of ACI 318.

13.3.2 Flat slab tops shall have a minimum thickness of 150 mm for risers up to and including 1200 mm in diameter and 200 mm for larger diameters.

13.3.3 The flat slab top access opening shall be a minimum of 600 mm in diameter.

13.3.4 *Joint*—The reinforced concrete flat slab top shall be formed with or without a male or female end so that when the manhole base, riser and top section are assembled, they will make a continuous and uniform manhole compatible with the tolerances given in Section 13.6.

13.3.4.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

13.4 *Reinforcement:*

13.4.1 Flat slab tops manufactured with a joint or with other indication of the top or bottom of the slab shall be manufactured with one layer of reinforcement placed near the bottom surface so that the protective cover over the reinforcement shall be 25 mm.

13.4.2 Flat slab tops manufactured without a joint or without other indication of the top or bottom of the slab shall be manufactured with two layers of steel reinforcement, one located near the bottom surface and one near the top surface so that the protective cover over each layer is 25 mm.

13.4.3 A layer of reinforcement shall have a minimum area of 250 mm^2/linear m in both directions.

13.4.4 Openings in flat slab tops shall be additionally reinforced with a minimum of the equivalent of 130 mm^2 of steel at 90°. Straight rods used to reinforce openings shall have a minimum length equal to the diameter of the opening plus 50 mm.

13.5 *Physical Requirements*—Physical requirements for tests shall conform to the requirements of Section 8.

13.5.1 *Proof-of-Design Test:*

13.5.1.1 If 13.2.2.2 has been designated as the basis of acceptance, one flat slab top for each design shall be tested unless the owner has indicated otherwise.

13.5.1.2 The flat slab top proof-of-design test procedures shall be in accordance with Test Methods C497.

13.5.1.3 The ultimate test load shall be the sum of at least 130 % of the dead load on the slab plus at least 217 % of the live-plus impact load on the slab. Dead load is the mass of the column of earth over the slab plus the mass of the riser supported by the slab. Live load is the maximum anticipated wheel load that may be transmitted through the riser to the slab.

13.5.1.4 The flat slab top shall be acceptable if it supports the required ultimate test load without failure. Ultimate strength failure is defined as the inability of the slab to resist an increase in the applied load.

13.5.1.5 When agreed upon by the owner and manufacturer, the flat slab top shall be acceptable based on certified copies of the results of tests performed on identical flat slab tops instead of requiring new proof-of-design acceptance tests.

13.6 *Permissible Variations:*

13.6.1 *Internal Diameter*—The internal diameter of the flat slab tops entrance hole shall not vary more than ±1 %.

13.6.2 *Thickness*—The thickness of flat slab tops shall be not less than that prescribed in the design by more than 5 % or ±5 mm, whichever is greater. A thickness greater than that prescribed in the design shall not be cause for rejection.

13.6.3 *Length of Two Opposite Sides*—Variations in lengths of two opposite sides of flat slab tops shall be not more than 6 mm.

13.6.4 *Length*—The underrun in length of a flat slab top shall be not more than 20 mm/m of length.

13.6.5 *Position of Reinforcement*—For flat slab tops with less than a 150-mm thickness, the maximum variation in the position of reinforcement from that prescribed in 13.5 shall be ±10 % of the thickness or ±6 mm, whichever is greater. For flat slab tops with a thickness greater than 150-mm, the maximum variation shall be ±10 % of the thickness or ±16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm.

13.6.6 *Area of Reinforcement*—Steel reinforcement areas that are 10 mm^2/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

13.7 *Rejection:*

13.7.1 Flat slab tops shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual flat slab top shall be subject to rejection because of any of the following:

13.7.1.1 Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

13.7.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honeycombed or open texture that would adversely affect the function of the flat slab top.

13.7.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the flat slab top, within the limits of permissible variations prescribed in 13.6.

13.7.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

13.7.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the slab.

14. Risers and Conical Tops

14.1 *Scope*—This section covers precast reinforced concrete risers and conical tops used in construction of manholes for use in sewer, drainage, and water works.

14.2 *Acceptance*—Acceptability of risers and conical tops covered by this specification shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by either 14.4 or 14.5 and meeting permissible variations as prescribed by 14.7, to determine its conformance with the design prescribed under this specification and its freedom from defects.

14.3 *Design*—The minimum wall thickness shall be one twelfth of the largest internal diameter of the riser or conical top.

14.4 *Welded Steel Cage Reinforcement:*

14.4.1 *Circumferential Reinforcement for Risers and Conical Tops:*

14.4.1.1 Circumferential reinforcement may consist of either one or two lines of steel. The total area of reinforcement per vertical metre shall be not less than 0.21 times the internal diameter in millimetres.

14.4.1.2 A line of circumferential reinforcement for any given total area may be composed of two layers if the layers are not separated by more than the thickness of one cross member plus 6 mm. The two layers shall be tied together to form a single cage. All other specification requirements such as laps, welds, and tolerances of placement in the wall of the riser or conical top shall apply to this method of fabricating a line of reinforcement.

14.4.1.3 Where one line of circumferential reinforcement is used, it shall be placed in the center third of the wall. The protective cover over the circumferential reinforcement in the wall shall be no less than 19 mm in accordance with 14.7.

14.4.1.4 Where two lines of circumferential reinforcement are used, each line shall be so placed that the protective covering over the circumferential reinforcement in the wall shall be 25 mm.

14.4.1.5 The location of the reinforcement shall be subject to the permissible variations in dimensions prescribed in 14.7.

14.4.1.6 The spacing center to center of circumferential reinforcement in a cage shall not exceed 150 mm.

14.4.2 *Longitudinal Members*—Each line of circumferential reinforcement shall be assembled into a cage that shall contain sufficient longitudinal bars or members to maintain the reinforcement in shape and position within the form to comply with permissible variations in 14.7.

14.4.3 *Joint Reinforcement*—The tongue or groove of the joint is not required to contain circumferential reinforcement.

14.5 *Steel Hoop Reinforcement:*

14.5.1 *Continuous Steel Hoop Reinforcement for Risers and Conical Tops up to and Including 1200 mm Diameter:*

NOTE 3—Care shall be taken to ensure that none of the steel hoop reinforcement is cut prior to installation of the riser or conical top.

14.5.1.1 Circumferential reinforcement for manhole risers and conical tops up to and including 600 mm in height shall consist of no less than two hoops of steel wire or reinforcing bars. The steel hoop shall have a minimum cross-sectional diameter of 6 mm and shall be located in each end quarter of the riser or conical top, with a minimum distance of 25 mm from the shoulder of the riser or conical top.

14.5.1.2 Circumferential reinforcement for manhole risers and conical tops greater in height than 600 mm and up to and including 1200 mm in height shall consist of no less than three hoops of steel wire or reinforcing bars. The steel hoops shall have a minimum cross-sectional diameter of 6 mm, and shall have a hoop located in each end quarter of the riser or conical top with a minimum distance of 25 mm from the shoulder of the riser or conical top. The third, or middle, hoop shall be located from the shoulder of the riser or conical top a distance equal to one-half the section height ±150 mm.

14.5.1.3 Circumferential reinforcement for manhole risers and conical tops greater in height than 1200 mm. and up to and including 1800 mm in height shall consist of no less than four hoops of steel wire or reinforcing bars spaced equally ±75 mm. throughout the height of the riser or conical top. The steel hoops shall have a minimum cross-sectional diameter of 6 mm and shall have a hoop located in each end quarter of the riser or conical top with a minimum distance of 25 mm from the shoulder of the riser or conical top.

14.5.1.4 The hoop reinforcement shall be placed in the center third of the riser wall or conical top. The concrete cover over the hoop reinforcement in the wall of the section shall be no less than 19 mm in accordance with 14.7.

14.5.1.5 For riser sections with openings, this section 14.5 is not permitted.

14.5.2 *Joint Reinforcement*—The tongue or groove of the joint need not contain circumferential reinforcement.

14.6 *Joints*—Precast reinforced concrete risers and conical tops shall be designed and manufactured with male and female ends, so that the assembled manhole base, riser and conical top

shall make a continuous and uniform manhole, compatible with the tolerances given in 14.7.

14.6.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

14.7 *Permissible Variations:*

14.7.1 *Internal Diameter*—The internal diameter of risers and conical tops shall not vary more than 1 %.

14.7.2 *Wall Thickness*—The wall thickness of risers and conical tops shall be not less than that prescribed in the design by more than 5 % or ±5 mm, whichever is greater. A wall thickness greater than that prescribed in the design shall not be cause for rejection.

14.7.3 *Height of Two Opposite Sides*—Variations in laying heights of two opposite sides of risers or conical tops shall be not more than 16 mm.

14.7.4 *Height of Section*—The underrun in height of a riser or conical top shall be not more than 20 mm/m of height with a maximum of 13 mm in any one section.

14.7.5 *Position of Reinforcement*—For risers or conical tops with a 100-mm wall thickness or less, the maximum variation in the position of reinforcement from that prescribed in 14.5 and 14.6 shall be ±10 % of the wall thickness or ±6 mm, whichever is greater. For sections with a wall thickness greater than 100 mm, the maximum variation in shall be ±10 % of the wall thickness or ±16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of the joint.

14.7.6 *Area of Reinforcement*—Steel reinforcement areas that are 0.1 mm^2/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

14.8 *Rejection:*

14.8.1 Risers and conical tops shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual riser or conical top shall be subject to rejection because of any of the following:

14.8.1.1 Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

14.8.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honeycombed or open texture that would adversely affect the function of the riser or conical top.

14.8.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the riser or conical top, within the limits of permissible variations prescribed in 14.7.

14.8.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

14.8.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the wall.

15. Base Sections

15.1 *Scope*—This section covers three types of precast concrete base sections manufactured for use in the construction of manholes used in sewer, drainage, and water works. The three types of base sections are (*1*) a base with riser wall and base slab cast monolithically as a single unit with or without benching, (*2*) a base consisting of a riser section with a secondary poured integral base slab, with or without benching, and (*3*) a two-piece base consisting of a separate precast base slab and a riser section with a sealed joint between the two. The riser portions of the base section shall meet all the requirements of Section 14.

15.2 *Acceptance:*

15.2.1 Acceptability of base sections covered by this specification shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by 15.4 and 15.7, to determine conformance with the design prescribed under this specification and its freedom from defects.

15.2.2 Unless otherwise designated by the owner at the time of, or before, placing an order, two separate and alternate methods of acceptance are permitted for the three types of base sections manufacturer designs prescribed in 15.1, in addition to test of materials and inspection required in 15.2.1.

15.2.2.1 *Acceptance on the Basis of Proof-of-Design Test*—Acceptance of base section or base slab prescribed in 15.1 on the basis of the results of a proof-of-design test performed in accordance with 15.5.1 in place of submission of design calculations and detail drawings.

15.2.2.2 *Acceptance on the Basis of Rational Design*—Acceptance of base sections prescribed in 15.1 on the basis of design calculations by rational method and detail drawings.

15.3 *Design:*

15.3.1 When acceptance is in accordance with 15.2.2.2, the basis of the rational design shall be the appropriate sections of the latest edition of ACI 318.

15.3.2 Base slabs or integral floors shall have a minimum thickness of 150 mm for risers up to and including 1200 mm in diameter and 200 mm for larger diameters.

15.3.2.1 When a base section is precast monolithically with a benched invert, the minimum concrete thickness from the invert to the bottom of the integral base section shall be 100 mm.

15.3.3 Benched inverts cast either monolithically with the base section or as a secondary casting in a cured base section shall have the following minimum dimensions:

15.3.3.1 Minimum slope of 40 mm/m from the channel to the inside diameter (ID) of manhole wall for the benching.

15.3.3.2 Minimum channel invert depth of one-half the pipe ID.

15.3.3.3 When a channel is cast in a cured base section, the minimum concrete thickness under the invert shall be 50 mm.

15.3.3.4 Width of channel at top of benching shall be a minimum of the pipe ID.

15.3.3.5 Invert shall provide a positive flow between inlet to outlet pipes.

15.3.3.6 The minimum channel centerline radius shall be the pipe ID.

15.4 *Reinforcement:*

15.4.1 *Base Section Circumferential Reinforcement*—Circumferential reinforcement shall meet all the requirements of Section 14, except that Paragraph 14.5 is not permitted.

15.4.2 *Base Slab Reinforcement:*

15.4.2.1 A layer of reinforcement shall be placed above the midpoint, and shall have a minimum area of 250 mm^2/linear m in both directions.

15.4.2.2 The minimum protective cover over the reinforcement shall be 25 mm.

15.4.3 *Longitudinal Members*—Longitudinal bars or members used to maintain a cage of circumferential reinforcement in shape and position within the form shall meet all the requirements of Section 14.

15.4.4 *Joint Reinforcement*—The mating surface of the base section joint is not required to contain circumferential reinforcement.

NOTE 4—(Advisory) Base sections with multiple openings, large openings, or both may require special consideration of their handling reinforcement.

15.5 *Physical Requirements*—Physical requirements for test shall conform to the requirements of Section 8.

15.5.1 *Proof-of-Design Test:*

15.5.1.1 If 15.2.2.1 has been designated as the basis of acceptance, one base section or base slab for each design shall be tested unless the owner has indicated otherwise.

15.5.1.2 The base section or base slab proof-of-design test procedures shall be in accordance with Test Methods C497.

15.5.1.3 The ultimate test load shall be the sum of at least 130 % of the dead load on the base section or base slab plus at least 217 % of the live load on the slab. Dead load is the weight of the column of earth cover plus the weight of the riser section(s) plus surcharge transmitted through the riser section(s) to the base section or base slab. Live load is the maximum anticipated wheel load that may be transmitted through the riser to the base section or base slab. The ultimate test load shall be applied to the base section or base slab as a uniformly distributed load.

15.5.1.4 The base section or base slab shall be acceptable if it supports the required ultimate test load without failure. Ultimate strength failure is defined as the inability of the slab to resist an increase in the applied load.

15.5.1.5 When agreed upon by the owner and manufacturer, the base section or base slab shall be acceptable based on certified copies of the results of tests performed on identical base sections or base slabs instead of requiring new proof-of-design acceptance test.

15.6 *Joints*—Precast reinforced base sections shall be designed and manufactured with a male or female ends, so that the assembled manhole base, riser and top will make a continuous and uniform manhole, compatible with the tolerances given in 15.7.

15.6.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

15.7 *Permissible Variations:*

15.7.1 *Internal Diameter*—The internal diameter of base sections shall not vary more than 1 %.

15.7.2 *Thickness*—The thickness of a base slabs with or without benching shall be not less than that prescribed in the design by more than 5 %. A thickness greater than that prescribed in the design shall not be cause for rejection.

15.7.3 *Height of Two Opposite Sides*—Variations in laying heights of two opposite sides of base sections shall be not more than 16 mm.

15.7.4 *Height of Sections*—The underrun in height of a base section shall be not more than 20 mm/m of height with a maximum of 13 mm in any one base section.

15.7.5 *Position of Reinforcement*—For base slabs with monolithic benched inverts with a 100 mm thickness, the maximum variation in the position of reinforcement from that prescribed in 15.4 shall be ±10 % of the thickness or ±6 mm, whichever is greater. For base slabs with a thickness greater than 100-mm, the maximum variation shall be ±10 % of the thickness or ±16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of base section joints.

15.7.6 *Area of Reinforcement*—Steel reinforcement areas that are 10 mm^2/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

15.8 *Rejection:*

15.8.1 Base sections shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual base section shall be subject to rejection because of any of the following:

15.8.1.1 Fractures or cracks passing through the riser wall, except or a single end crack that does not exceed the depth of the joint.

15.8.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honeycombed or open texture that would adversely affect the function of the base section.

15.8.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the base section, within the limits of permissible variations prescribed in 15.7.

15.8.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

15.8.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the base section.

16. Steps and Ladders

16.1 *Scope:*

16.1.1 This section covers manhole steps and ladders used for providing access through manholes for use in sewer and water works.

16.1.2 The user of this specification is advised that access through manholes may be by steps that are cast, mortared, or attached by mechanical means into the walls of base, riser, or conical top sections or by ladder.

16.2 *Acceptance*—Unless otherwise designated by the owner at the time of, or before, placing an order, acceptance of steps and ladders installed in manholes will be on the basis of tests and inspection of the completed product.

16.3 *Materials:*

16.3.1 Except as required by Section 16, manhole steps and ladders shall conform to the requirements of the Occupational Safety and Health Standards, U.S. Department of Labor.

16.3.2 Manhole steps that are cast, mortared, or attached by mechanical means into the walls of base, riser or conical top sections shall meet the requirements of 16.4 and 16.5 in addition to the following:

16.3.2.1 When dissimilar types of materials are used in the steps, appurtenances and fastenings, the materials shall be treated to prevent deleterious effects.

16.3.2.2 That portion of the step projecting into the base section, riser or conical top opening shall be free of splinters, sharp edges, burrs, or projections which may be a hazard.

16.4 *Design:*

16.4.1 Steps in base section, riser and conical top sections shall be aligned in each section so as to form a continuous ladder with rungs equally spaced vertically in the assembled manhole at a maximum design distance of 400 mm apart.

16.4.2 Steps shall be embedded in the base section, riser or conical top section wall a minimum distance of 75 mm.

16.5 *Dimensions:*

16.5.1 Ferrous metal steps not painted or treated to resist corrosion shall have a minimum cross sectional dimension of 25 mm.

16.5.2 The minimum width of rungs or cleats shall be 250 mm.

16.5.3 The rung or cleat shall project a uniform clear distance of 100 mm (minimum) to 150 mm (maximum) ± 6 mm from the wall of the base, riser, or conical top section measured from the point of embedment to the embedment side of the rung.

NOTE 5—Embedment point is considered the junction of the centerline of the step leg and the wall of the base, riser or conical top section.

16.5.4 The minimum clear distance between the rung or cleat and the opposite wall of the base, riser, or conical top shall be 450 mm measured at the center face of the rung or cleat.

16.5.5 The vertical spacing and vertical alignment between adjacent manhole steps and horizontal distance from the inside wall to the centerline of a manhole step may vary 25 mm from the design dimension.

16.6 *Physical Requirements:*

16.6.1 *Testing:*

16.6.1.1 The manufacturer furnishing manhole sections with steps under this specification shall furnish all facilities and personnel necessary to carry out the tests required in the Manhole Step Test section of Test Methods C497.

16.6.1.2 One installed manhole step of the type to be used on a project shall be tested unless certified test results are available.

16.6.1.3 Vertical and horizontal load test procedures for manhole steps shall be in accordance with Test Methods C497.

16.6.1.4 The horizontal pull out load shall be 1800 *N*.

16.6.1.5 The vertical load shall be 3600 *N*.

16.6.2 *Acceptance*—The step shall be acceptable if the following requirements are met:

16.6.2.1 The step remains solidly embedded after application of the horizontal load test.

16.6.2.2 The step sustains a permanent set of 13 mm or less after application of the vertical load test.

16.6.2.3 No cracking or fracture of the step nor spalling of the concrete is evident.

16.6.2.4 If certified test results are not available and the step selected fails to conform to the test requirements, the manufacturer may select two other steps for retests. If either of these steps fail the retest, the steps shall be rejected.

17. Keywords

17.1 absorption; acceptance criteria; base sections; compressive strength; concrete; cone tops; design; flat slab tops; grade rings; ladders; manhole; manufacture; reinforced; riser sections; sewer; steps; tests; water

Designation: C913 – 08

Standard Specification for Precast Concrete Water and Wastewater Structures[1]

This standard is issued under the fixed designation C913; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers the recommended design requirements and manufacturing practices for monolithic or sectional precast concrete water and wastewater structures with the exception of concrete pipe, box culverts, utility structures, septic tanks, grease interceptor tanks, and items included under the scope of Specification C478.

NOTE 1—Water and wastewater structures are defined as solar heating reservoirs, cisterns, holding tanks, leaching tanks, extended aeration tanks, wet wells, pumping stations, distribution boxes, oil-water separators, treatment plants, manure pits, catch basins, drop inlets, and similar structures.

NOTE 2—Insulation and sealant requirements should receive special consideration due to special features of the application.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement (Withdrawn 2013)[3]

A184/A184M Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement

A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete (Withdrawn 2013)[3]

A416/A416M Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

A421/A421M Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete

A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement (Withdrawn 2013)[3]

A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete (Withdrawn 2013)[3]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A616/A616M Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement (Withdrawn 1999)[3]

A617/A617M Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement (Withdrawn 1999)[3]

A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

C33 Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C94/C94M Specification for Ready-Mixed Concrete

C150 Specification for Portland Cement

C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C260 Specification for Air-Entraining Admixtures for Concrete

C330 Specification for Lightweight Aggregates for Structural Concrete

C478 Specification for Circular Precast Reinforced Concrete Manhole Sections

C494/C494M Specification for Chemical Admixtures for Concrete

C595 Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C685/C685M Specification for Concrete Made by Volumetric Batching and Continuous Mixing

C890 Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures

C990 Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

[1] This specification is under the jurisdiction of ASTM Committee C27 on Precast Concrete Products and is the direct responsibility of Subcommittee C27.30 on Water and Wastewater Containers.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

2.2 *American Concrete Institute Standard:*
ACI 318 Building Code Requirements for Reinforced Concrete[4]
2.3 *Federal Specification*:
SS-S-210A Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints[5]

3. Ordering Information

3.1 Unless otherwise designated by the purchaser before placing an order, a structure designed in accordance with Section 5 of this specification and found to satisfactorily meet the requirements imposed when tested and inspected as described herein shall be acceptable. The test of materials as required shall be done in accordance with applicable ASTM International standards. Inspection, when required, shall include checks on fabrication and placing of reinforcement and concrete in accordance with approved design drawings.

4. Materials

4.1 *Cementitious Materials:*

4.1.1 *Cement*—Cement shall conform to the requirements for Portland cement of Specification C150 or shall be Portland blast-furnace slag cement or Portland-pozzolan cement conforming to the requirements of Specification C595, except that the pozzolan constituent in the Type IP Portland-pozzolan cement shall be fly ash.

4.1.2 *Fly Ash*—Fly ash shall conform to the requirements of Specification C618, Class F or Class C.

4.1.3 *Ground Granulated Blast*—Furnace slag (GGBFS0-GGBFS) shall conform to the requirements of Grade 100 or 120 of Specification C890.

4.1.4 *Allowable Combinations of Cementitious Material*—The combination of cementitious materials used in concrete shall be one of the following:

4.1.4.1 Portland cement only;
4.1.4.2 Portland blast furnace slag cement only;
4.1.4.3 Slag-modified Portland cement only;
4.1.4.4 Portland-pozzolan cement only;
4.1.4.5 A combination of Portland cement and fly ash;
4.1.4.6 A combination of Portland cement and ground granulated blast-furnace slag; and
4.1.4.7 A combination of Portland cement, ground granulated blast-furnace slag (not to exceed 25 % of the total cementitious weight), and fly ash (not to exceed 25 % of the total cemenetitious weight.

4.2 *Aggregates*—Aggregates shall conform to Specification C33 and lightweight aggregates shall conform to Specification C330, except that the requirements for grading shall not apply.

4.3 *Water*—Water used in mixing concrete shall be clean and free of injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances incompatible with concrete or steel.

4.4 *Admixtures*—Admixtures shall conform to Specification C494/C494M or C618 and shall not be injurious to other products used in the concrete.

4.4.1 *Air-Entraining Admixtures*—Air-entraining admixtures conforming to Specification C260 shall be used when there is a risk that the concrete may be exposed to freeze-thaw cycles. The concrete mixture shall contain 5.5 ± 1.5 % air by volume as determined by Test Method C231.

4.5 *Steel Reinforcement*—Steel reinforcement shall conform to Specification A82/A82M or A496/A496M for wire; Specification A185/A185M or A497/A497M for wire fabric; Specifications A416/A416M and A421/A421M for prestressed wire and strand; or Specification A184/A184M, A615/A615M, A616/A616M, A617/A617M, or A706/A706M for bars.

5. Design Requirements

5.1 *Design Method*—The method of structural design of reinforced concrete as outlined in the ACI 318 Building Code shall be used to design the concrete sections, including the reinforcement required, when the structure is subjected to the loading conditions covered in Practice C890. Design requirements in excess of these specifications shall be identified by the purchaser.

5.1.1 *Alternative Method to Design*—An alternative method to the design of a structure is acceptable, with the permission of the purchaser, by performing required performance tests on the completed structure to confirm adequate strength.

5.2 *Access Openings*—The structural design shall take into consideration the number, placement, and size of access openings.

5.3 *Floors*—The minimum floor thickness resulting from slope shall be considered as nominal floor thickness in the structure.

5.4 *Knockouts and Sumps*—Knockouts and sumps shall be designed to carry the loads imposed upon them. The basic structure shall be designed to carry all imposed loads with knockouts removed.

5.5 *Placement of Reinforcement*—The minimum concrete cover for reinforcing bars, mats, or fabric shall not be less than 1 in. (25 mm) for water retaining structures and ¾ in. (19 mm) for other structures subject to the provisions of Section 7.

5.6 *Concrete Strength*—The minimum compressive strength (f'_c) for design shall be 4000 psi (28 MPa) at 28 days of age.

5.7 *Joints*—Where required, sealed joints in sectional precast concrete structures shall be of such a design to prevent unacceptable leakage when used with a sealant (Note 3) approved by the purchaser and acceptable to the manufacturer. The criteria for unacceptable leakage will be determined by the purchaser's specifications. Where potable water is involved, caution advises selecting a sealant that will not contaminate the water for its intended purposes.

NOTE 3—Refer to Specification C990 or Federal Specification SS-S-210A for guidance.

5.8 *Lifting Devices*—Design of embedded lifting devices shall conform to requirements as specified in 8.4 under Special Loading Considerations of Practice C890.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.
[5] Available from Standardization Documents, Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094. Attn: NPODS.

6. Manufacture

6.1 *Mixture*—The aggregates, cement, and water shall be proportioned and mixed to produce a homogeneous concrete meeting the requirements of this specification, and in accordance with Specification C94/C94M or C685/C685M.

6.2 *Forms*—The forms used in manufacture shall be sufficiently rigid and accurate to maintain the dimensions of the structure within the tolerances given in Section 7. All casting surfaces shall be of smooth nonporous material. Form releasing agents used shall not be injurious to the concrete.

6.3 *Reinforcement*—Reinforcement must be securely tied or welded (as allowed by the design) in place to maintain position during concrete placing operations. Where specified all chairs, bolsters, braces, and spacers in contact with forms shall have a corrosion-resistant surface.

6.3.1 Flexural reinforcing steel shall not exceed spacing of 12 in. (30.5 cm) center to center.

6.4 *Concrete Placement*—Concrete shall be placed in the forms at a rate such that the concrete is plastic at all times and consolidates in all parts of the form and around all reinforcement steel and embedded fixtures without segregation of materials.

6.5 *Curing*—The precast concrete sections shall be cured by any method or combination of methods that will develop the specified compressive strength at 28 days or less.

6.6 *Concrete Quality*—The quality of the concrete shall be in accordance with the chapter on concrete quality of ACI 318, current edition, except for frequency of tests, which shall be specified by the purchaser. Concrete tests shall be conducted in accordance with Test Method C39/C39M.

6.6.1 *Water-Cementitious Ratio*—Concrete that will be exposed to freezing and thawing shall contain entrained air and shall have water-cementitious ratios of 0.45 or less. Concrete that will not be exposed to freezing but that is required to be watertight shall have a water-cementitious ratio of 0.48 or less if the concrete is exposed to fresh water. For corrosion protection, reinforced concrete exposed to deicer salts, brackish water, or seawater shall have water-cementitious ratio of 0.40 or less.

7. Tolerances

7.1 *Dimensional Tolerances*—The length, width, height, or diameter measurements of the structure when measured on the inside surface shall not deviate from the design dimensions more than the following:

Dimension	Tolerance
0 to 5 ft (0 to 1.5 m)	±¼ in. (±6 mm)
5 to 10 ft (1.5 to 3.0 m)	±⅜ in. (±10 mm)
10 to 20 ft (3.0 to 6.1 m)	±½ in. (±13 mm)
20 ft (6.1 m) and over	as agreed upon between manufacturer and purchaser

7.2 *Squareness Tolerance*—The inside of the rectangular precast concrete component shall be square as determined by diagonal measurements. The difference between such measurements shall not exceed:

Measured Length	Allowable Difference
0 to 10 ft (0 to 3.0 m)	½ in. (13 mm)
10 to 20 ft (3.0 to 6.1 m)	¾ in. (19 mm)
20 ft (6.1 m) and over	as agreed upon between manufacturer and purchaser

7.3 *Joint Surfaces*—The following joint tolerances for water retaining structures shall apply:

7.3.1 *Flexible Joint*—The inside joint seam gap between two sections placed together before a joint sealant is applied shall not exceed ⅜ in. (10 mm).

7.3.2 *Grout Joint*—The opening to be grouted in a group joint shall not exceed 1 in. (25 mm).

7.4 *Reinforcement Location*—With reference to thickness of wall or slab, reinforcement shall be within ±¼ in. (6 mm) of the design location, but in no case shall the cover be less than 1 in. (25 mm) for water-retaining structures and ¾ in. (19 mm) for nonwater-retaining structures. The varations in reinforcement spacing shall not be more than one tenth of the designed bar spacing nor exceed 1½ in. (38 mm). The total number of bars shall not be less than that computed using the design spacing.

7.5 *Slab and Wall Thickness*—The slab and wall thickness shall be uniform and shall not be less than that shown in the design by more than 5 % or ⅜ in. (10 mm), whichever is greater. A thickness greater than that required in the design shall not be a cause for rejection.

8. Repairs

8.1 Repairs shall be performed by the manufacturer in a manner to ensure that the repaired structure will conform to the requirements of this specification.

9. Rejection

9.1 Precast concrete structures or sections of structures shall be subject to rejection because of failure to conform to any of the requirements contained herein.

10. Marking

10.1 The following information shall be clearly marked on each structure or section of structure, by indentation, waterproof paint, or other approved means:

10.1.1 Date of manufacture,

10.1.2 Name or trademark of the manufacturer, and

10.1.3 Initials or symbols to indicate the intended use of the structure.

11. Keywords

11.1 concrete; precast; structures; wastewater; water

APPENDIXES

(Nonmandatory Information)

X1. DESIGNS FOR RECTANGULAR BOXES

X1.1 Description of Designs

X1.1.1 The designs in Table X1.1 are provided as a convenience for specifying, purchasing, and manufacturing. Riser and base sections are shown in Fig. X1.1.

X1.1.2 The successful performance of the product depends upon the proper selection (based on field conditions), good manufacturing practices, and proper installation.

X1.1.3 Refer to Appendix X2 for instructions on the use of the designs.

X1.2 Structural Analysis

X1.2.1 The analysis is based on the slope-deflection solution of a frame with nonprismatic members.

X1.2.2 Loads are based on Practice C890.

X1.3 Design Calculations

X1.3.1 The concrete shall be designed to be proportioned for f_c' = 4000 psi (28 MPa).

X1.3.2 Reinforcing steel shall be Grade 60 (minimum yield strength of 60 000 psi) (3.84 MPa).

X1.3.3 The strength design method described in ACI-318 is used with U.L.F. = 1.7.

TABLE X1.1 Designs for Rectangular Boxes[A]

Size L by W	t (in)	d (in)	Class w (psf)			Reinforcing A_{sh} (in.^{2}/ft)	Reinforcing A_{sv} (in.^{2}/ft)
2 ft by 2 ft	6	3	300	500	700	0.14	0.14
2 ft 6 in. by 2 ft	6	3	300	500	700	0.14	0.14
2 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft by 2 ft	6	3	300	500	700	0.14	0.14
3 ft by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft by 3 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 2 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 3 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 2 ft	6	3	300	500	700	0.14	0.14
4 ft by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 3 ft	6	3	300	500	700	0.14	0.14
4 ft by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 4 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 3 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 4 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 4 ft 6 in.	6	3	300	500	700	0.14	0.14
6 ft by 5 ft 6 in.	6	3	300			0.14	0.14
6 ft by 5 ft 6 in.	6	3		500		0.17	0.14
6 ft by 5 ft 6 in.	6	3			700	0.24	0.14
6 ft by 6 ft	6	3	300			0.14	0.14
6 ft by 6 ft	6	3		500		0.18	0.14
6 ft by 6 ft	6	3			700	0.27	0.14

[A] One in. = 25.0 mm.

X1.3.4 Minimum reinforcement is 0.002 times the gross concrete area of the cross section.

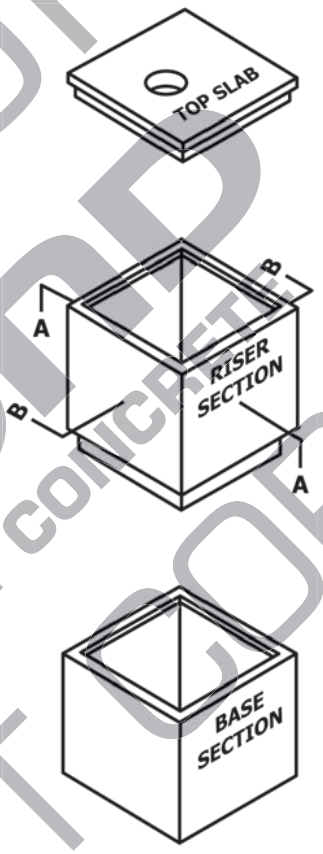

FIG. X1.1 Typical Assembly

X1.3.5 Calculations for units with integral slab (top or bottom) do not take into consideration rigidity or support from slab.

X1.4 Definitions

X1.4.1 *t*—Total thickness of wall (Fig. X1.2).

X1.4.2 *d*—Distance from centerline of horizontal steel to inside face of wall (Fig. X1.2).

X1.4.3 A_{sh}—Area of horizontal steel per vertical foot (Fig. X1.2).

X1.4.4 A_{sv}—Area of vertical steel per horizontal foot (Fig. X1.3).

X1.4.5 *Class*—a term that can be used to describe the product, for example, 300, 500, 700. The number also refers to the capacity of the unit in terms of lb/ft^2 (Pa).

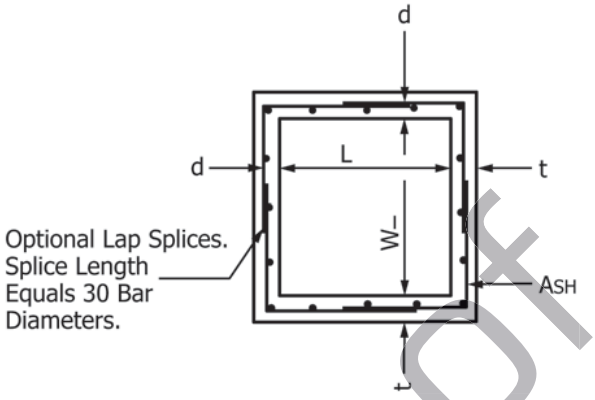

FIG. X1.2 Section AA

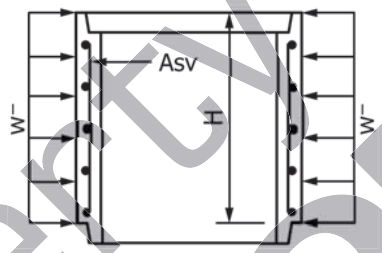

FIG. X1.3 Section BB

X2. INSTRUCTIONS FOR USE OF DESIGNS IN TABLE X1.1

X2.1 Each section can be designed individually but in an effort to save time select the section that carries the heaviest loads and use it for the whole box.

X2.1.1 Assume the height of each section based upon the size and location of pipes entering or leaving the box. The designs in the tables assume continuity of steel around the box. If a hole is made in a section, there should be concrete above and below and sufficient additional reinforcing to transfer forces across the opening.

X2.1.2 Determine depth of section to be designed (h_1 and h_{11} in Fig. X2.1).

X2.1.3 Determine depth of water table (d in Fig. X2.1).

X2.1.4 Assume a lateral soil pressure of 40 psf/ft of height and water weighing 62.4 lb/ft^3.

X2.1.5 From Fig. X2.1:

$$P(1) = 40\,h_1 + 62.4\,h_2 \qquad (X2.1)$$

$$P(2) = 40\,h_{11} + 62.4\,h_{22}$$

$$P = \frac{P(1) + P(2)}{2}$$

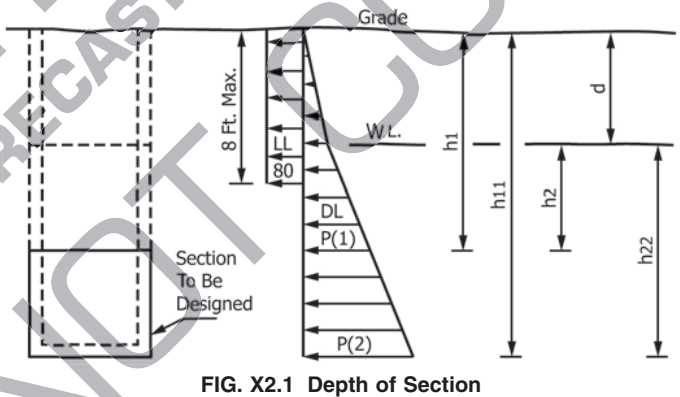

FIG. X2.1 Depth of Section

X2.1.6 Choose a Class (300, 500, 700) with capacity greater than P. Enter the table with desired size to obtain wall thickness, amount of reinforcing steel, and location of steel in the wall.

X2.2 Example Problem

X2.2.1 Select a Class for a concrete rectangular box to be used as a catch basin when the invert of the base is 11 ft (3.4 m) below grade and water level is 5 ft (1.5 m) below grade. Catch basin is in a highway.

X2.2.2 Since the catch basin is in a highway, a live load (*LL*) from truck traffic must be considered. Refer to Fig. X2.2 for load diagram.

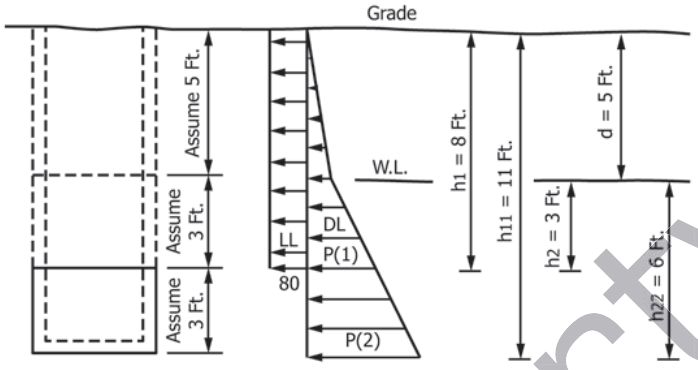

FIG. X2.2 Load Diagram

X2.2.3 From Fig. X2.2:

$$h_1 = 8 \text{ ft } (2.4 \text{ m}) \quad \text{(X2.2)}$$

$$h_{11} = 11 \text{ ft } (3.4 \text{ m})$$

$$h_2 = 3 \text{ ft } (0.91 \text{ m})$$

$$h_{22} = 6 \text{ ft } (1.8 \text{ mm})$$

$$P(1) = 40 \times 8 + 62.4 \times 3 = 507 \text{ lbf/ft}^2 (24.3 \text{ kPa})$$

$$P(2) = 40 \times 11 + 62.4 \times 6 = 814 \text{ lbf/ft}^2 (38.9 \text{ kPa})$$

$$P = \frac{507 + 814}{2} = 660 \text{ lbf/ft}^2 (31.6 \text{ kPa})$$

X2.2.4 Choose Class 700 since 700 is greater than 660. Go to the tables with desired size to obtain information necessary to produce the box.

X2.2.5 If P is greater than 700, the tables do not apply. An engineer should be engaged to provide design.

Quality Control Manual

- **For the Manufacturing of:**
  - **PRECAST CONCRETE PRODUCTS**
  - **PRECAST CONCRETE MANHOLES WITH LINERS, PRE-BENCHES**

In accordance with an ASTM C478 for Round Structure and ASTM C913 for Rectangle / Square Structures and CSA Standard A23.4 (A257.4-03)

BY DIAMOND PRECAST CONCRETE LTD,
7520 CONRAD STREET, BURNBAY, B.C. V5A 2H7
CANADA

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LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
ACI Certification	American Concrete Institute Lab and Testing Certification
AI	Authorized Inspector (Appointed by client)
AIA	Accredited Authorized Inspection Agency
AIS	Authorized Inspector Supervisor (Client)
ASTM	American Standard Testing of Material
BOM	Bill of Material
Standard	CSA A23.4 (az257.3-03) Class 8083-03
CSA	Canadian Standard Association
DE	Design Engineer
IS	Inspector Third Party
MMCD	Master Municipal Construction Document
MTR	Material Testing Report
NCR	Non Confirmative Report
NDE	Non-Destructive Examination
P.Eng	Professional Engineer
PM	Production Manager
PO	Purchase Order
PS	Production Supervisor
PT	Production Team
Pur.M	Purchasing Manager
SI	International System of Units
QC	QC
QCM	QC Manager
WO	Work Order

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DIAMOND PRECAST CONCRETE MUNICIPAL CASTINGS

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QA / QC Manager Approval — March 24, 2015 — Date

General Manager Approval — March 24, 2015 — Date

DIAMOND Precast Concrete Ltd.| 7520 Conrad St | Burnaby, BC V5A 2H7
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Section 1: Statement of Authority

The Management's objectives in producing this Production and QC Manual is to ensure that products manufactured at Diamond Precast Concrete fulfill the requirements and standards in accordance with CSA Standard A23.4

Management is committed to provide the necessary equipment, machinery, tools and space to achieve these objectives. Management is also committed to provide a safe working environment, as well as to ensure all employees receive the necessary training, and follow outlined regulations, in accordance with Work Safe BC policy.

Management is committed to review Quality System at regular intervals in order to ensure continuing suitability and effectiveness (Max. interval duration should not be more than one year).

Management will appoint and make contracts with Design Engineers having a BC P.Eng. License as well as the necessary experience in precast concrete product design. Design Engineers are made responsible for strategy, drawing and calculation of all product range at Diamond.

The QCM shall be responsible for the continuous update and implementation of the Production and QC System throughout the entire organization and acquire necessary training to perform CSA standard job.

He has the authority and the organizational freedom to identify Production and QC problems and to initiate, recommend and provide necessary solutions. Any complications which cannot be resolved to the satisfaction of the Production and QC Manager shall be brought to the General Manager for final resolution, in compliance with the CSA Standard A23.4 requirements and this Manual.

Any changes made in the Production and QC Manual shall be approved by the Production and QC Manager. Changes are subject to acceptance by the General Manager prior to implementation. The Production and QC Manager's approval and the General Manager acceptance shall be indicated on the Table of Contents.

The Production and QC Manager has a power to appoint, in writing, an assistant. The assistant will have the authority of the Production and QC Manger (separately) to perform production and QC activities as defined by QC Manual; however the Production and QC Manger shall retain the overall responsibility.

In carrying out these responsibilities, the Production and QC Manager has my full support.

Signed by: Jed Friesen Jed Friesen Date: March 24, 2015

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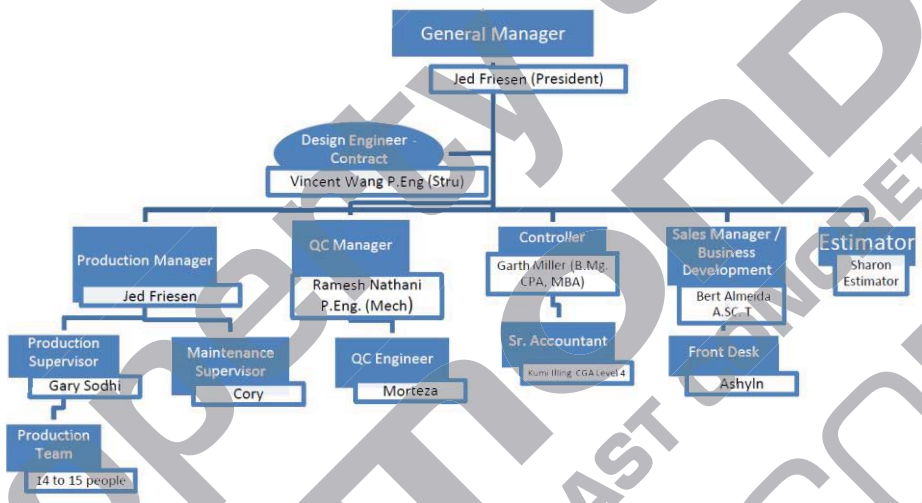
Section 2: Organizational Chart



1. Jed Friesen – Full time General and Production Manager. Owner/President since past 8 years.
2. Ramesh Nathani, P.Eng. (Mech.) & PMP. Operation & Quality Manager – 8 years working in QC.
3. Vincent Wang M.Sc. P.Eng (Structural) – 10 years of experience in Structural engineering projects, solid working knowledge of concrete and steel design, familiar with CAN/CSA codes and standards and has ACI certification.
4. Gary Sodhi- Production Supervisor. Working with Diamond past 25 years
5. Cory – Maintenance Supervisor. Working with Diamond past 25 years
6. Morteza Golkari- MSc. Civil Engineering – QC Engineer (ACI Certified) New recruit with Diamond and will acquire ACI certification
7. Sharon Smith– Working since Feb 2007, School of Construction and the environment –BCIT 2009, Municipal Planning Reading PUPW-1141, Estimating 1 BLDC-1300
8. Bert Almedia, ASc.T (Civil) - Business Development) – 25 years of working experience
9. Garth Miller, B. Mg. CPA, MBA - Controller – 25 years of working experience
10. Kumi Illing, CGA Level 4 – Sr. Accountant. Working with Diamond since 2008

Duties and Responsibility of each key personnel's is well described in Section 4

Signed: _____ Date: March 24, 2015

(General Manager)

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Section 3: Manufacturing Process

A. We manufacture a range of Precast Products: (List attached – Exhibit 10**)**

B. We use mixing ratio of raw materials to achieve required strength of the material as per ASTM and CSA A23.4 standard; approved by a Licensed P.Eng. The Mix design is documented in QC file with the date of formulation. Currently we have mix design dated 12th June 2014.

C. We have a skilled and dedicated production team (Exhibit # 8) as described in Section 4 and provide necessary training as and when required from time to time and recorded.

D. We have list of Assets (Exhibit # 9) used at our manufacturing plant described in Section 5.

E. We have a maintenance department managed by Maintenance Foreman and maintenance program for all our equipment's in place to operate safely at high efficiency as described in Section 5.

F. We have QC Program in place as described in Section 6 of QC.

G. We have Design Control plan and procedure as described in Section 7 of Design Control.

H. Material control system is described in Section 8 and procurement of CSA 23.4-09 raw materials is made by Standard of PO as described in Exhibit # 6.

I. We have Non Destructive Examination and Testing Program as described in Section 9.

J. We have list of Tools & Equipment's used in QC (Exhibit # 18) for measuring and testing described in Section 10

K. We have rejection and correction program of non-conformance for our products as described in Section 11

L. We have storage and transportation system program as described in Section 12

M. We have after Sales Service program for clients as described in Section 13

N. We have record retention system described in Section 14

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Actual Manufacturing Process:

Diamond Plant is in enclosed building where Sand and Gravel are stored in controlled environment. Cement is stored Silo and located at 50 meter distance.

A. Concrete mixer is set once in a week in morning as described in QC Section 6.

B. After Calibration and before production commences, slump tests done are as per ASTM / CSA standard. Tests are measured and recorded.

C. Air content test is conducted as per ASTM / CSA standard. Tests results are measured, recorded, and density is calculated. Temperature of concrete is measured and recorded.

D. Concrete cylinder samples are made as per ASTM / CSA standard procedure from same concrete mix used for our products and cured in same procedure as followed for our product range and then kept in QC room for testing by own developed testing facility as described in Section 9.

E. Test results for 1 & 28 days and occasionally 3 & 7 days too are reviewed, monitored and recorded to ensure that our product range achieves desired compressive strength of 32 -35 Mpa as per CSA standard.

F. Production planning for the day is given to the Production Supervisor as described in Exhibit # 17

G. Metal forms are cleaned, inspected - dimensional, roundness, locking arrangements, joints, seams and any other damages or repairs and then assembled and taken to the wet Mixer section at the concrete pouring station.

H. Necessary hardware's like step pins, lifting pins are placed at proper location as described in stamped drawings. Certificate of compliance for these hardware's are checked and documented.

I. At Mixer, Bio gradable release agent is applied on the surface of forms. Steel supplied as per specs specified in stamped drawings is inspected and approved is only used. Reinforced steel is placed in form with spacers as described in stamped product drawing (Exhibit # 3). There are three different kinds of steel being used as reinforcement material. Deformed steel hoop ring for catch basin for size below 42", Cage steel made from deformed steel is used for manholes sizes above 36" and rebar steel is used for bases and lids and covers. Most of the rebar steel is prefabricated as per drawing for bases and lids. The spacers are well defined in stamped drawings. No tacking or welding is done as our plant. Cage steel is received in rolls of 8' x 300' and is fabricated to the required dimension as per drawing and are tied by steel wire. Fabricated steel either cage steel or rebar steel for bases are placed manually in the form free from mud, oil, dirt & scale.

J. The QC in charge continuously monitors and inspects the production progress sheet (Exhibit 12) as described in Section 6

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K. Calibrated Volumetric Mixer produces the concrete (Preapproved mixture ratio of Cement, Sand, Birdseye, water & NCA admixture) is poured in form. Forms up to 48" are brought to the mixer and poured while concrete is taken in cart or bucket to the location where big forms, lids, trenches, meter boxes, drain box and curbs are kept. Vibrator is used for duration of 30 seconds at every foot of the pouring length as per ASTM / CSA standard to achieve required density.

L. Concrete is levelled in form, excess concrete is removed and area is cleaned and ready for initial curing in steam room. (Initial curing is just achieving sufficient strength to strip form and have quick turnaround). We do used Non Chloride accelerator from Sikka which approved as per CSA which helps them to achieve initial strength.

M. Steam rooms are maintained, monitored and recorded in Exhibit # 12 at 60 to 70 deg. C. Manholes of 48" diameter and less are subjected to initial curing. All big products above 48" and other poured at site are cured naturally in forms for @ 24 hours before stripping product from the form.

N. Steam rooms are fully loaded with concrete products and then closed with insulated tarpaulin. Products are cured for 11/2 hour to 2 hours. Steam room has pipe distributed evenly in room and steam is not directed on concrete products. Steam vapor after becoming water help to maintain high relative humidity in the concrete form.

O. Concrete products are then removed from steam room and brought to stripping station to remove pallet rings, tongue top ring, outer Jacket and inner core and finished product is ready for inspection. All products below 42" manholes have two pin holes for lifting while bigger products have dog bone EZ lift pins to lift the product. The lifting system and direction is reflected on to the drawings.

P. Water is sprayed immediately on concrete products after stripping to maintain humidity in concrete mostly required in summer time.

Q. ACI certified Level II QC Inspectors performs inspection of finished product. He updates the daily Progress Sheet of the inspection as described in Section 7.

R. If finished product is found defective then procedure described in Section 11 is followed and Non-Conformance report (Exhibit # 19) is made and hold tags are placed (Exhibit # 20)

S. Finished Products are labelled as described in Exhibit # 21 and sent for storage as described in Section 13.

T. At the end of the day, Production Planning Sheet (Exhibit 17) filled by Production Supervisor and Check list of Daily Production Batch (Exhibit # 12) filled by QC inspector in charge is given to Production Manager to review and recorded and sign off.

U. All the required documentation related production and QC are retained and stored in PM's office.

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Section 4: Manufacturing Team

Production Manager: The Production Manager is the in charge of the concrete manufacturing plant. He has been given the authority to hire, train and fire the necessary manpower. He may consult the Production Supervisor in hiring and firing as needed. The Production Manager may appoint the production supervisor to manage the production floor. He is responsible for smooth and safe operations of production and ensures necessary machinery, equipment's, training and tools are provided from time to time.

The Production Team:
Every newly acquired member to the Production Team is given orientation with specific education, training, and instruction. They are given knowledge on how production and the production team function at Diamond. This includes 2 hours of safety training in accordance with Work Safe BC guidelines. Requirements and expectations from employees and employers are outlined and described in detail. New employees are also explained the lock out procedure in case of emergency.

Quality Assurance and Control Manger: Duties include managing operations and QC department. He is responsible create QC Manual, implement & monitor QC program at Diamond. He is key personal implement and monitor CSA certification and implementation of the CSA program at Diamond. He manages QC inspector and is responsible for all QC / QA and CSA documentation and coordinate with Design Engineer for issuance of Certificate of Compliance. He is the key responsible for coordination and audit of CSA from time to time.

Design and Structural Engineer: Duties & Responsibility at Diamond – Working on Contract basis to design and generate stamped shop drawing of the Diamond precast products. Ensure the Diamond produces the products as per stamped drawings and follow all quality steps to improve precast products and issue certificate of compliance of manufacturing products as per CSA standards.

Production Supervisor: He is responsible for ensuring the quality products are made as per drawings and each step of quality checks are performed by the team of production. Manage the production team works efficiently and with high safety.

Maintenance Supervisor: is responsible for maintaining the plant and machinery to produce high quality products with minimum downtime.

QC Inspector: is responsible to carry out all necessary steps to perform all quality steps as described in progressive inspection sheet Exhibit 12, perform daily slump and air content test, complete the

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inspection and documentation as per Exhibit 7 for incoming material. Carryout calibration of Mixer and prepare cylinders for lab testing. Ensuring labelling of each product and do repairs as per non-conformance and maintain all documentations.

Training is provided if necessary to upgrade the skills and the training records are maintained.

Uniform and Tools & Equipment:
Diamond Management provides all production employees with the appropriate uniform and necessary safety tools & equipment's. These include, but are not confined to, coveralls, ear plugs, respiratory protection, appropriate gloves, safety glasses and safety shoes to use during their working hours at Diamond's production plant.

The production team checklist is provided to the production supervisor on daily basis as enclosed in Exhibit 8

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Section 5: Assets at Diamond Plant

A. All assets used in and for the production process of our concrete and cast iron materials are listed in Exhibit: 9

B. The Equipment is regularly inspected, serviced, and upheld by our in-house Maintenance Department. We have a daily, weekly, and monthly Maintenance Schedule plan for all Diamond equipment. This contains a detailed account of the maintenance procedures and relevant systems in place. Records are maintained.

C. The Maintenance Team in charge is responsible for keeping the performance of Diamond machines, tools and equipment up to date and able to perform their appropriate functions.

D. If a piece of Diamond equipment requires service or repair, a work order is promptly issued by the Production Supervisor. It is given to the Maintenance Department, and the Diamond individual who is best suited to conduct the repairs will do so to the best of his abilities. The work order is then signed off by the individual when the requested task is completed. The work order is then filed.

E. Major repairs of equipment are carried out by reputed and authorized companies which are approved by Production Manager.

F. We make sure all of our equipment has safety features. We also make sure that each piece of equipment is operated by qualified personnel; forklift and crane operators are trained and certified at Diamond.

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Section 6: Quality Control

Responsibilities

A. The QCM is responsible for the preparation, approval, distribution and implementation of the QC Manual.

B. Proposed revisions of this manual shall be submitted to the CSA authority during prior to audit for information..

C. The QCM is responsible for controlling the revisions, and shall do so as follows:

1. Each revision will have its own section. Each revision will be identified by bold italics. Only the latest revision will be indicated.
2. The revision number and the date of the revision will be marked next to the section title. Exhibits shall be revised individually. All revisions will be given in the Table of Contents, as well as on the top of the page, or pages, of the revised section.
3. For major QC manual revisions, a new Edition will be issued, with all revision levels reverting to "0".
4. Copies of the section(s) bearing revision number and corresponding date shall be distributed to each controlled copy holder with the revised table of contents. At that time, a copy of obsolete page or pages shall be kept on Obsolete QC files.

D. Each revision will be issued under a formal Transmittal Letter, which will be signed by the recipient and returned to the QCM.

E. When controlled copies of the QC Manual are issued to individuals or companies, a serial number will be entered on the Manual cover page. Manuals issued to companies or individuals that are for information only will be marked as an uncontrolled copy.

F. When an officer listed in the organizational chart in Section 2 is not available to perform his or her duties, including signing of documents, a qualified delegate may be appointed in writing. This delegate shall report directly to the officer, and the ultimate responsibility shall remain with the officer listed in the organization chart.

G. Upon receipt of an amendment / revision, the recipient shall:

1. Enter the revision in the QC Manual.
2. Sign the bottom half of the Transmittal Letter and return it with the obsolete pages to the QCM.
3. To ensure that up to date records are maintained, it is essential that the recipient, upon receipt, enter their copy of any revision immediately in their QC Manual.

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H. The QCM shall review the ASTM / CSA Standard Editions within 6 months of issue. This is to determine whether any Standard changes affect the QC Manual, as well as QC system or procedures. This review shall be documented by the QCM on the Summary of Changes Sheet of the particular section of the Standard. If the QCM elects to choose an electronic version, this review must be documented by a memo to the file**.**

I. Any required changes to the QC system shall be implemented after reviewing and arriving to consensus with GM, Production Manager and Design Engineer and Diamond QC system changes shall occur within six months of the ASTM / CSA Standard Editions issue date.

J. On receipt customized orders, the QCM shall review the order. After obtaining approved drawings from the DM, a WO **(**Exhibit #1**)** will be issued which will indicate the contracts' general requirements.

K. The QCM will select a qualified individual to be in charge of daily inspections at the Diamond plant during the time of production according as per procedure described in actual manufacturing process Section 3.

L. The individual in charge will have ACI Certification Level II, with a backup individual with the same qualification.

M. The daily Production QC Check list sheet for Inspection, as described in Exhibit # 12**,** is maintained and signed by the QC in charge, as well as the PM and QCM.

N. QC individual in charge is responsible for Mixer Calibration (Exhibit # 13), Daily Slump & Air Content in Concrete (Exhibit # 14), the Form / Mold Inventory Check-list (Exhibit # 15) and the Product Check-list (Exhibit # 16)

O. QC individual in charge is responsible Testing lab for compression testing of cylinders, compression rate of loading and checking of compression machine platen planeness.

P. Management Review: QC Manager is responsible for arranging yearly meeting with management to review QC Manual and other systems to improve the Quality of the product.

The main focus will be on the

a. Continuous improvement on the quality of the product,
b. Process improvement
c. Efficiency of the production and of the plant.
d. Rejections, failures and complaints of the products during production, storing and installation.
e. Necessary training to be provided to the right personnel to perform required job.

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Section 7: Design Control

A. The DE designated P.Eng is responsible to ensure that all design calculations, specification and drawings (either developed by DIAMOND PRECAST CONCRETE LTD. or by others) are in accordance with the client's specifications, as well as the CSA 23.4 (A257.4-03) Standard Editions, at the time of work order entry. In general, it is expected that a single system of units shall be used for all aspects of design, except where unfeasible or impractical. US customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this edition; e.g. materials, design, production, examination, inspection and testing.

B. Prior to becoming effective, all design calculations, specifications and drawings shall be approved and stamped by DE and copy to be submitted to the CSA jurisdiction for information.

C. The P.Eng is responsible to ensure that all revisions to existing registered designs are also submitted to the CSA jurisdiction for information only.

D. The P.Eng is also responsible to Design and approve concrete mix to ensure to achieve desired compressive strength as per CSA Standard A23.4

E. Distribution of revised drawings and specifications shall be done by the QCM, who will ensure that all superseded copies are removed. The removed copies are to be marked void, or destroyed.

F. The P.Eng is responsible for establishing that all customer specifications and details meet CSA 23.4 (A257.4-03) Standard requirements as a minimum.

G. The P.Eng shall review and approve all drawings, design calculations, and specifications of the standard precast concrete products for compliance with the current edition of the Standard. This review shall be documented by a memo to the file. If the customer submits calculations and /or drawings, the P.Eng shall review, and where necessary, prepare drawings to meet Standard requirements.

H. All calculations and drawings shall be submitted to the CSA Authorized Inspector for review during their visit for audit.

1. If drawings are amended during the manufacturing cycle, the QCM will ensure that the obsolete or revised drawings are removed from the shop floor. One copy of the obsolete drawings - marked obsolete - shall be kept in the Obsolete Drawing File; the rest shall be discarded.

2. On completion of Special Jobs, the drawings will be withdrawn from shop floor, marked "Reference only" and filed in the P.O / W.O file.

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I. The P.Eng will select all materials from the applicable CSA 23.4 (A257.4-03) Standard. The P.Eng will list the selected constituents on the Bill of Material (Exhibit #5) with the applicable Standard specification number, type and/or grade. The P.Eng and QCM shall review and approve the BOM.

J. When drawings have been approved and stamped they shall be distributed by the Q.C.M. as follows:

1. Copy to Production Manager
2. Copy to Customer (or as requested)
3. Copy to Work Order File

K. Drawings will show all Revisions level, applicable Standard Edition, Drawing Number, Tolerances, Concrete Strength at 28 days, Approval, Signature and Date, as well as any other requirements deemed necessary. Any drawing without a revision level indicated is considered revision zero.

L. Shop Drawing is made by design engineer and shall be marked with "released for production". (steel and product separately) It should be signed by Design Engineer and approved by Production Manager.

M. Placement of steel reinforcement, other hardware's like lift pins and stairs in the form are well described in section 3 following approved drawings.

N. Production manager is responsible for the ensuring the correct steel drawings are submitted to the steel suppliers along with PO and product drawing on shop floor.

O. QC Inspector will inspect the reinforcement steel placement before pouring of concrete and finished product dimensions from the shop drawings. (Exhibit 12)

P. Lifting pins and step pins are reflected in drawings and forms are to be made having embedded hardware's. QC will is responsible to ensure they ae correctly placed before concrete pouring (Exhibit 12)

Q. Drawings and documents shall be transmitted using the Drawing and Document Transmittal form (Exhibit #4.)

R. Design Engineer is also responsible to review and audit the production of Precast Products every two months' time but under no circumstances will exceed three month of time to issue the Certificate of Compliance of Diamond Precast manufacturing process and products to CSA standard A23.4 as per Exhibit # 22

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Section 8: Material Control

The PM and QCM are responsible for Material Control. Only materials of CSA 23.4-09 Standard will be ordered from the Standard of Bill of Material (Exhibit # 5) by the PM. The PO will state that the material is of CSA 23.4-09 Standard.

Purchase Orders of CSA 23.4-09 Standard (Exhibit #5) will be reviewed by the QCM prior to issuing. Material substitution may be made only after approval by the DM. When material substitution results in revision of drawing and/or calculations being revised, the drawing and calculation in question will be submitted to CSA for acceptance by the authority having jurisdiction. All revised drawings and calculations shall be submitted to the CSA for review.

The CSA 23.4-09 Standard PO for Material, including Steel, will state that MTR's or Certificates of Compliance as applicable are required with supply of material.

The P.O. will be distributed as follows:

1. Original to supplier
2. Copy to QCM

On the Receipt of Material, the material will be checked by the QC In charge as per CSA 23.4-09 Standard Material Receiving Report (Exhibit # 7) using the appropriate measuring device, for dimension, thickness and compliance with the P.O. and MTR. The Incoming material is also checked for any defects or damage conditions. It is responsibility of the QCM to inspect not only the steel received but also all necessary hardware used in manufacturing the products like lift pins, steps and necessary chains and hooks used on the shop floor needs to have testing certificates / tags and are safe to use.

The QCM will establish a material tagging system based on material specification. The QMC will ensure that materials are identified by appropriate tags. Accepted material is stored properly in covered place. The QMC will also ensure that MTR's have been supplied and that the materials conform, and are traceable, to the MTR.

The Purchasing Manager will notify the supplier when the material is unacceptable and make arrangements to obtain acceptable replacements.

Incorrect material will be returned to the Supplier, marked 'Rejected' with Tag. Such material is Segregated and kept separately from all other production materials. The rejected material never goes to stores or to the production floor.

The QCM will review, initial, and date each MTR for compliance with the material specification. The MTCs are filed in the QCM office.

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All accepted material will be stored in the area allocated for Approved Material and marked 'CSA 23.4-09 material.'

List of Material Procured at Diamond:

A. **Bulk Purchase:**

1. CEMENT – CSA A 3001, Type GU Low Alkali Cement
   - MTR once in a month
2. SAND - ASTM C33 / CSA A23.2-2A & 5A
   - Gradation Report once a month - after 1500 tons
   - Lab Repot received every day
3. GRAVEL / AGGREGATE - ASTM C33 / CSA A23.2-2A & 5A
   - Gradation Report once a month – after 2000 tons
   - Lab Report Received once in a month.

B. **Major Items used**:

1. FORM RELEASE AGENT
2. NON CHLORIDE ADMIXTURE
3. STEEL REEBAR : CAN/CSA G30.18 with Fy-400 Mpa5 -MTR to be received for each supply
4. WELDED STEEL WIRE CAGE –Deformed Steel ASTM A497M CSA G30.14 with 485 MPa- MTR to be received for each supply
5. WELDED STEEL RING – ASTM S496 / CSA G30.18 400R- MTR to be received for each supply
6. City water**:** used for mixing concrete mixture as per ASTM C 1602

C. Forms

D. Shop Supplies

Procured Material Procedures:

A. Bulk Purchases

Reputed suppliers are approved for bulk material. An open PO is used as per CSA 23.4-09 standards. Batch test certificates are received, verified, and filed by the PM.

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B. Major Items

At the end of every Friday, the assigned person in-charge is given inventory sheets. The person-in-charge records low level items; the inventory sheets are given to the PM (in-charge of procurement).

We have separate suppliers for different grades of wire. They supply Diamond with steel material as per drawings submitted. An MTR of each supply is collected; these are well specified in orders. Every MTR is verified and signed by the PM. Each material test report is filed, and all such documents are under control of the PM.

POs are issued by the PM. Every PO is detailed with material specifications and MTR requirement of each supply.

On receipt of Material, QC inspects the material as per PO specification. MTR comes to PM. Certificate of compliance is received from the manufacturer; this is for most regular items, such as Lifting lugs and Ladders.

No welding is done to Reinforced Steel Material. No Aluminum material sleeves or pipes or conduits are used. Drawings are well defined for steel reinforcement. No cuts are allowed to accommodate any inserts or other hardware.

C. Metal Forms

All precast products are manufactured from Metal forms except lids. Lid forms are made from ABS Plastic material. Diamond has various suppliers to supply metal forms.

Diamond sends product drawings and features - required for our forms - to the Manufacturer. In return they send Diamond shop drawings. These are verified as per Diamond requirements and approved by the PM. All New forms have proper seam plate to prevent concrete flowing out.

Before issuing a Purchase order, the forms are reviewed on the basis of their functionality, sustainability, and overall maintenance. Safety and easiness to use in operation is also reviewed.

All forms are identified with ID # as per list in Exhibit # 11

D. Shop Supplies

Diamond has created a Shop Supplies procedure. Any person needing items gives his requirement to QC individual. The entire Material requisition document has to be signed and approved by PS. Then it is given to PM (in charge of Procurement) who organizes to buy from reputed reliable suppliers.

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Section 9: Non-Destructive Examination and Testing

A. All Precast Concrete Products produced at the Diamond plant require Non Destructive Examination. Inspection and Testing shall be performed in accordance with CSA 23.2-09 standard, as applicable, and in accordance with the referenced Section : Annex 1

B. We carry out only visual examinations and is done during the production progress by approved QC in charge a qualified ACI level 1

C. We have in house compression testing facility and machine is calibrated yearly. In case of emergency we will be sending samples to the Testing Laboratory (CCIL certified lab.)

D. Since testing technology is limited, a qualified and certified ACI Level I QC personnel shall be appointed by letter, as required, to act on behalf of DIAMOND PRECAST CONCRETE, by the QCM.

E. The QCM shall retain the approved Testing Laboratory on file. The qualification and certification records of each Lab/Test performer and Examiner will also be kept in the Testing Lab file.

F. All such documentation shall be made available to the Authorized Inspector (CSA). He shall have the option to order re-qualification of procedures. He shall also have the option to order re-qualification of personnel should he have reason to question their ability to perform properly

G. The results of all Testing Reports will be reviewed by an Examiner. If accepted, all Testing Reports will be reviewed by the QCM for approval. If approved, the Testing Reports are presented to the A.I. for review and acceptance.

H. The QCM shall make the necessary equipment available to the AI in order to enable the necessary Slump Test; Air Entrainment Test all using calibrated instruments.

I. Inspection is continuous ongoing during the production from raw material to the finished product stored in yard.

J. Once the manufacturing of Precast Concrete products has started, inspection, monitoring of concrete mix, as well as necessary testing, is carried out. Performed tests are documented recorded and recorded as described in Section 6.

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K. Inspection and monitoring is done of below mentioned material:

1. All Forms used at plant for precast concrete products
2. Application of release agent on Form
3. Selection of appropriate steel reinforcement
4. Placement of the steel reinforcement in the forms during concrete pouring
5. Checking of proper coverage with appropriate size of spacer used
6. Leveling of concrete
7. Cleaning, curing and stripping of precast concrete product
8. Finish precast product

L. Updating daily of production progress sheet of inspection - as mentioned in QC Section 6.

M. As per CSA and ASTM standards, all precast concrete products are repairable. At Diamond we have categorized into major (Not to be repaired) and minor (To be repaired) defect. For any defect is found, QC inspectors will inspect the defect immediately create NCR as per Exhibit #19 and defect is recorded and categorized as Major or Minor defect. Major defects are rejected written as NOT TOBE REPAIRED and products having Minor defects are put on hold as per Exhibit # 20 until repaired and again inspected.

N. Finished and inspected product are then labelled with Company Logo, Contact Information, Manufacturing Date, Weight of products and Product ID # as described in Label Exhibit # 2. Separate CSA label will be applied to each product. (painted by stencil)

O. Supplies are given from the oldest date manufactured.

P. Products are stored in yard to the specified identified position.

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Section 10: Calibration of Measuring and Testing Equipment

A. The QCM is responsible for the accuracy of all measuring and testing of equipment as described in Exhibit# 18

B. The QCM is responsible for scheduling test gauge renewal or calibration.

C. All calibration of test gauges and measuring of equipment will be done at the frequencies indicated below unless there is reason to doubt the accuracy of the equipment:

1. Water flow meter is calibrated every 180 days, but at our plant done every week during mixer calibration by actual measurement in measuring container.
2. Slump cone dimensional verification is performed every 90 days
3. Air meters are calibrated every 90 days. The date of calibration and I.D. number is marked on the back of each gauge
4. Field thermometers are calibrated yearly with reference thermometer and records are maintained and monitored as per CSA A23.2-09
5. Max. / Min thermometers are calibrated yearly with reference thermometer and records are maintained and monitored as per CSA A23.2-09
6. Reference thermometers is calibrated once
7. The calibration of the scale is to be done every 6 months by reference certified standard weights
8. Calibration of admixture flowmeter is being done manually. We measure every week the quantity flowing and set accordingly and we have not noticed any flow change thereafter.
9. Compression machine is calibrated yearly.
10. Compression machine rate of loading done weekly and monitored as per Clause 6.2 of test method 9C of CSA A23.2-009 (between 0.15 and 0.35MPa/S – 1.21KN/s and 2.82KN/s)
11. Records of Neoprene pad usage count are maintained. Log sheet is created for each time of the usage of pads. (100 times usage for 50 MPa strength pad and 50 times for 60 & 70 MPa strength pad
12. Initial curing temperatures (Max. / Min) of concrete cylinders are being monitored and recorded as per Clause 8.3.2.1 of test method 3C of CSA A23.2-09. Reading is recorded two times in a day during starting of the day and normal temperature is also recorded.
13. Concrete temperature during the curing cycle as per Clause 19.5.1 of CSA A23.4-09 standard. Reading is recorded two times in a day during starting of the day and normal temperature is also recorded.
14. Concrete cylinder dimensions are daily recorded (Minimum 3 cylinders per day
15. Planes of the compression machines platens are recorded and monitored by feeler gauge and straight gauge and is done monthly basis.

D. Non Chloride Admixture is added via the Mixer's automated flowmeter system; the appropriate dosing amount is set by the manufacturer. Technical Specification and MSDS documents are documented.

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E. Copies of calibration certificates shall be kept on file by the QCM and the PM.

F. Any measuring or test equipment found or suspected to be faulty will be re-calibrated before use. Deviations will be evaluated by the QCM; an NCR shall be issued against the device and all previously inspected items back to the last satisfactory calibration or successful periodic check, in accordance with Section 14.

G. The QCM shall verify calibration records submitted by sub-contractors.

H. The Quality Manager shall ensure that each item is marked to be readily identifiable and shall maintain a written record of each calibration, showing date and names of authorized calibration agent, item number and traceability to the national standard.

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Section 11: Correctness of Non-Conformities

A. In Material Control Inspection of raw material in progress, as well as inspection of material in finished products, is described in Material Control Section 8 and NDE and Testing Section 9.

B. Non-conformity is any condition of material, parts, documentation, or process, which does not meet CSA Standard, this Manual, or customer's requirements.

C. It is the duty of all DIAMOND PRECAST CONCRETE employees to report non-conformities to their supervisor, who will immediately notify the QCM

D. The QCM shall document all non-conformities on a NCR (Exhibit #19). This shall include signature and dates of QCM approval, as well as AI concurrence. The NCR number shall be recorded on the applicable Production Progress Q.C. Sheet.

E. Non-conformities found during fabrication shall be identified with a "Hold Tag" (Exhibit # 20) and resolved as follows:

1. Use As Is

When the disposition is *"Use as is,"* the QCM shall consult with, and obtain the approval of, the DM. The QMC shall also obtain acceptance by the AI. Any required revisions to the drawings, calculations or specifications are made as described in Section 7 of this manual, including submittal to the AI for review.

2. Repair / Rework

All dispositions requiring repair or reworking shall be carried out using a procedure approved by the QCM, subject to acceptance of the AI. The AI may also establish "Hold Points" for the inspection during the repair or reworking. Minor repairs like chip off, broken edges or holes are carried out at Diamond. These repairs are carried out by qualified ACI trained person or experience concrete person as below mentioned procedure.

3. Scrap / Return to Vendor

This disposition requires the QCM to verify that the item has been removed from the work area and marked "Reject" in order to prevent inadvertent use prior to disposal. Any finished products with through cracks, steel exposed or hardware exposed are considered major repair is rejected. The QMC shall document the removal of these items on the NCR; this action is also reported to the accounting department.

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F. The QCM shall inspect non-conformities after completion of dispositions described in Para E (1) and Para E(2). When the QCM is satisfied that the item meets all requirements, he shall sign and date the NCR, obtain AI acceptance, remove the "Hold Tag" and release the item to production.

G. **Minor repair procedure**: Clean the surface, remove hair line cracks / exposed and then watering is done. Necessary reinforcement is done if required with wire bars. Required concrete is taken from the mixer (same concrete used to for our precast products.) and repair is carried out. After proper setting the QC inspector inspects and approves the repair and releases for the storage at proper place.

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Section 12: Storage System and Transportation

A. All incoming raw material is stored with great care. Cement is stored in Silo fully protected from weather and there is separate bay for Sand and Gravel inside the plant in controlled atmosphere.

B. For Steel, we have a designated location. In this location we make sure the material does not deteriorate, or become contaminated.

C. Labelling: All finished products are labelled as described in Exhibit # 21. Labelling is done by spray paint on stencil. Once labelled, products are then taken to the yard. Finished products are handled with forklift by storing on pallets. The QC in charge is responsible to identify and label products and materials correctly. All products produced at Diamond will marked as CSA mark.

D. Inventory: The Yard is maintained by highly dedicated working with us past 6 years having forklift certification and is responsible for managing and controlling inventory of finished product. All finished products are properly labelled (Permanent marked by spray paint) from the production department and stored in groups of range of product. They are stacked & palletized in proper rows to height of capacity of Forklift. Yard person has high capacity forklift with 8000 lbs capacity and moves the products after placed on pallets by production team.

Concrete products stored in yard are watered in summer when the temperature rises above 27 deg. C

Products are maintained in yard on principle of "First-In, First-Out." We have created two rows of each product and achieve 28 days of natural cure. Oldest product is always to be shipped first.

There are four different types of material kept in Yard:

1) Finished Products - Good for Sale
2) Defective Products generated in Production - to be Repaired
3) Rejected material - NOT FOR SALE, TO BE DESTROYED
4) Returned material – may be rejected or defective to repair

E. Transportation:

Diamond follows all current DOT and Municipal policies in regards to the transportation of goods. We have 2 full time drivers and 1 driver as back up.

One driver is Class 1 certified and other two have Class 3 certified. They have Air Brakes and Folding Boom Crane certification we have 2006 – Sterling (Crane Truck), 2010 – Hino (Crane Truck), 2005 – Sprinter (Flatbed Truck) & 1966 Brand ford (Trailer)

All fleet vehicles are certified by Western Star Sterling as per the appropriate GVW rating for MVI, and the applicable cranes are certified yearly through Falcon Equipment as per the government requirements.

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All products are loaded as per packing slip of the client by our yard person by forklift. Products is either shipped with pallets or directly placed on deck depending upon the client's confirmation of having lifting system at site. Each product is properly secured to the deck through ratcheting straps. Trucks are loaded as per their load ratings. Each truck has his own set of steel certified chains / hooks and shackles for lifting from trucks and placing on the site.

F. Lifting Equipment: We have proper lifting equipment and certified chain to lift required loads. We maintain record of certification for all chains and hooks used at the Diamond Plant, as well as on our delivery trucks.

G. Installation: We do not install our products on any site. We only sell and deliver precast concrete products.

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Section 13: After Sales, Service and Warranty

A. The majority of products manufactured are sold to contractors / builders who carry out the installation as per city corporation guidelines; they follow MMCD specification.

B. Regarding Contract:

Diamond Sales Representatives review each contract. They are reviewed with the original tender and the quoted specifications. The difference in contract is be noted and rechecked regarding product compliance with CSA standard 23.4. They confirm the production capability and ability to match the products within the limits of CSA A23.4 -09 compliance, as well as other standards and specifications, if any. In case if contract does not comply CSA standard, it should immediately notify to customer about deficiency of not meeting the CSA standard and inability to label the products produced from CSA certified Plant.

C. Sales records maintained and reviewed periodically by the Sales Team.

D. The Production Date is recorded on each Packing Slip for all the material shipped or picked up at the Diamond site. Packing Slips are provided to each customer; as well, one copy is retained alongside the corresponding Invoice. Each Invoice and matching Packing Slip goes to customer and one copy are retained with Invoice.

E. Three major problems are addressed by the Sales Team.

1. Managing of Complaints
   - We typically try to address them timely and see what really happened.
   - We log all complaints related to quality and do analysis to make sure it is not repeated again and if we needed repair form to the correct size.
   - Steps taken to address complaints from sites are:
     A. Speak to our driver that delivered it, see if he/she recalls anything wrong with product
     B. Ask customer to supply picture/photo to us of the rejected item
   - Offer to send a free replacement with good quality product and bring back the old one
   - At the end of the day, Diamond ensures customer satisfaction as first priority.

2. Managing Customer Returns.
   - All material returns are to be approved by sales in charge; accounting is to be informed.
   - Reason of return is evaluated by Sales, Yard personnel, and/or the PM.
   - If Return is due to product defect, then a non-conformance procedure will take place as described in Section 11.

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- If the material returned has no defect condition, then the product is again inspected by QC in charge. The product is added to inventory and stored at the right place without any marking. QC person has to ensure proper labelling is restored.
- Sales Team is responsible for Refund, as per Diamond Warranty conditions.

3. Customer Acceptance.

We have developed below Customer Acceptance Stamp on every packing and delivery slip where client signs as below.

CUSTOMER ACCEPTANCE

- All items received in good condition – Quality Accepted.
- Quantity and Sizes matches Diamond Packing Slip
- Returned Items require signed Diamond Packing Slip
- Only Unused, Undamaged & Unmarked items accepted for return.
- Returns must be within 60 days of Receipt
- 25% Restocking Fee on all Approved Returns
- Returned items subject to inspection by DPCL QA / QC
- Refunds will be determined at the discretion of Diamond.

Signature: __ _____
Date: ____ _____

4. Warranty:

We manufacture and sell the products and do not install these products on any site.
We have very limited warranty on the products as mentioned on Customer Acceptance Signature.

In case of installation failure our liability is nil.
Failures of our product in service go through investing process made by clients and we offer free replacement if proven failure due to quality.

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Section 14: Retention of Records

The QCM is responsible for maintaining the following records for a minimum period of 5 (five) years, as per section CSA 23.4-09 Standard:

1. Production Planning Sheet of all CSA labelled products
2. Drawings of every Diamond Precast manufacture
3. Design Calculations including any applicable Proof Test Reports
4. MTRs and / or material certification
5. NDE records and Testing reports of compressive strength
6. NCRs and Disposition
7. Repair procedures; records of all products repaired
8. Progress sheet of inspection
9. Certificate of Compliances signed by P.Eng.

Distribution of the QC Manual shall be in accordance with the applicable Standard Sections (as mentioned in this manual):

1. Copy to CSA authorized Inspector.
2. Copy to Work Order File (Original)

The QCM shall prepare and maintain a CSA record to assure that they are assigned as required. There shall be no skips or gaps of unused numbers or duplications.

The record shall show:

1. Date
2. Production
3. Item Type
4. DIAMOND PRECAST CONCRETE.

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Section 15 : List of Exhibits

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Exhibit 1

Work Order

From Sales Dept.: _____ Date: _____

To: Production Manager Sr. #: _____

Item	Description of Material	Qty	Delivery Date	Remark

Signature: _____ Date: _____

Production Manager Remarks:

_____

_____

_____

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Section 11: Correctness of Non-Conformities

A. In Material Control Inspection of raw material in progress, as well as inspection of material in finished products, is described in Material Control Section 8 and NDE and Testing Section 9.

B. Non-conformity is any condition of material, parts, documentation, or process, which does not meet CSA Standard, this Manual, or customer's requirements.

C. It is the duty of all DIAMOND PRECAST CONCRETE employees to report non-conformities to their supervisor, who will immediately notify the QCM

D. The QCM shall document all non-conformities on a NCR (Exhibit #19). This shall include signature and dates of QCM approval, as well as AI concurrence. The NCR number shall be recorded on the applicable Production Progress Q.C. Sheet.

E. Non-conformities found during fabrication shall be identified with a "Hold Tag" (Exhibit # 20) and resolved as follows:

1. Use As Is

When the disposition is *"Use as is,"* the QCM shall consult with, and obtain the approval of, the DM. The QMC shall also obtain acceptance by the AI. Any required revisions to the drawings, calculations or specifications are made as described in Section 7 of this manual, including submittal to the AI for review.

2. Repair / Rework

All dispositions requiring repair or reworking shall be carried out using a procedure approved by the QCM, subject to acceptance of the AI. The AI may also establish "Hold Points" for the inspection during the repair or reworking. Minor repairs like chip off, broken edges or holes are carried out at Diamond. These repairs are carried out by qualified ACI trained person or experience concrete person as below mentioned procedure.

3. Scrap / Return to Vendor

This disposition requires the QCM to verify that the item has been removed from the work area and marked "Reject" in order to prevent inadvertent use prior to disposal. Any finished products with through cracks, steel exposed or hardware exposed are considered major repair is rejected. The QMC shall document the removal of these items on the NCR; this action is also reported to the accounting department.

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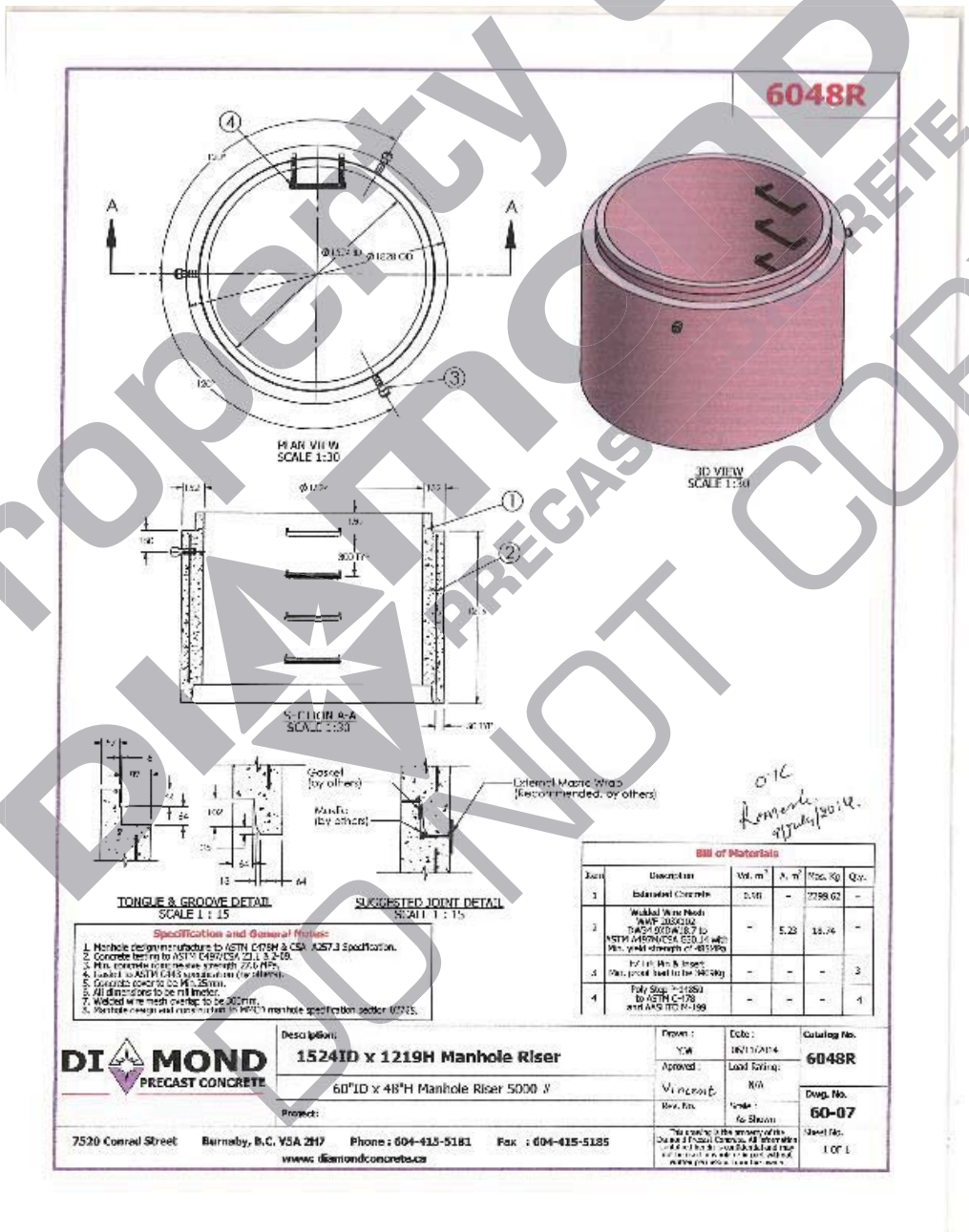
Exhibit 3

Drawing



F. The QCM shall inspect non-conformities after completion of dispositions described in Para E (1) and Para E(2). When the QCM is satisfied that the item meets all requirements, he shall sign and date the NCR, obtain AI acceptance, remove the "Hold Tag" and release the item to production.

G. **Minor repair procedure**: Clean the surface, remove hair line cracks / exposed and then watering is done. Necessary reinforcement is done if required with wire bars. Required concrete is taken from the mixer (same concrete used to for our precast products.) and repair is carried out. After proper setting the QC inspector inspects and approves the repair and releases for the storage at proper place.

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Exhibit 5

CSA 23.4-09 Standard Bill of Materials

Mechanical

Part / Dwg#	Qty.	unit	Description	Other information
				MTC Required
				MTC Required
				MTC Required

Comments:

Approved by:

DM: _____ Date: _____

QCM: _____ Date: _____

CC: Purchasing Manager
CC: Production Manager

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Exhibit 6

CSA 23.4-09 Standard of Purchase Order

Diamond Pre-Cast Concrete Ltd.
7520 Conrad Street
Burnaby, British Columbia V5A 2H7
P: 604-415-5181 F:604-415-5185

PURCHASE ORDER

Order No.: 3403
Date: 16/06/2014
Page: 1
Ship Date:

Purchased From:
True Blue Wire Products Inc.
3072 192nd Street
Surrey, British Columbia V3S 9V2
Canada
Attn: Chris

Ship To:
Diamond Pre-Cast Concrete Ltd.
7520 Conrad Street
Burnaby, British Columbia V5A 2H7
P: 604-415-5181 F:604-415-5185
Contact: Ramesh

Business No.: 104580998RT0001

Item No.	Ordered	Unit	Description	Tax	Unit Price	Amount
Ring30	1,000	Each	30" Ring (33.5" OD) Steel CSA G30.14 Deformed	G	1.24	1,240.00
Ring36	1,000	Each	36" Ring (39.25" OD) Steel CSA G30.14 Deformed Note: Submit MTR with each supply with HT# highlighted	G	3.35	3,350.00
			G - GST 5% GST			229.50

Approved By
Ramesh
PM & CM.
16/June/2014

Diamond Pre-Cast Concrete Ltd. GST: #104580998

Shipped By:

Total Amount 4,819.50

Exhibit 7

CSA 23.4-09 Standard of Material Receiving Report

Supplier: _____ P.O. #:_____

Material Received By:_____ Date: _____

Condition of Material:	ACCEPTED	NOT ACCEPTED – Defects / Damages
Material Complies with PO:	YES	NO

Verification

Dimensions & Qty.		
Specifications		
Device Used		Heat #:

Mill Test Certificates Received By_____ Date_____

Material Markings
Verified as to Mill Test details By_____ Date_____

Material Markings verified as being In Compliance with CSA 23.4-09 Standard By_____ Date_____

Mill Test Chemical Compositions checked By_____ Date_____

We certify that as far as can be determined from the documentation supplied, the above materials comply with the CSA 23.4-09 requirements and are suitable for use in Production.

QC In-Charge:_____ Signature:_____ Date _____

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Exhibit 8

Daily Production Team Checklist

Sr. #	Name	Work Location	Time In	Time Out	Remark
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

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Exhibit 9

List of Assets

Vehicles

YEAR	MAKE	MODEL	SR.#	MAINTENANCE	MAINTAINED BY

Forklifts

YEAR	MAKE	MODEL	SR.#	MAINTENANCE	MAINTAINED BY

Shop Equipment

YEAR	MAKE	MODEL	SR.#	MAINTENANCE	MAINTAINED BY

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Exhibit 10

Product Range Manufactured at Diamond

1. **Manholes and Risers** — Size range: 12” to 72” Inside Diameter
   Height range from 6” to 60”
2. **Manholes and Risers with Liners** — Size range: 12” to 72” Inside Diameter
   Height range: 12” to 60”
3. **Manholes with Extended Base**: — Size range: 12” & 72” Inside Diameter
   Base Heights: Only 12” to 60”
4. **Pre-benches of Manholes:** — Size range: 12” to 72” Inside Diameter
   Height range: 12” to 60” Bases: Only 12” to 60”
5. **Donut Lids, Rings and Cover For Manholes**: — Size range: 12” to 72” Inside Diameter
   Height range: 12” to 60”
6. **Catch basins Rings**: Size and Style Ranges:
   - CBR1: 1” Thick, 22# (25” ID Round Opening)
   - CBDR2: 2" Thick 52# (25” ID Round Opening)
   - Sloped: 2” to 1” Thick. 35# (25” ID Round Opening)
   - "C" Ring 2" Thick, 30# (C-shaped)
   - "D" Ring, 2" Thick 44# (D-Shaped)
7. **Trenches & Grates** Size and Style Ranges:
   - Driveway Trench 150 48”L x 7”H x 6”ID
   - Driveway Trench 200 48”L x 8”H x 8”ID
   - Driveway Trench End 25”L x 7”H x 6”ID
   - D624 Grate 24”L x ¾” H x 6”W
   - D824 Grate 24”L x 1”H x 8”W
8. **Concrete Shim** 19” x 15.5” for IC. 60#
9. **Driveway Drain Box** 13" x 13" Outside Diameter. 12" H.
10. **Ladder (Steel/Plastic)** *Outsourced*

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Exhibit 10

11. Oil Interceptors: Vaults and Lids, size and range:

▪ Lid	24” ID Round Openings (2) 106" x 47" x 8"H	#2350
▪ Lid	24” ID Round Opening (1) 36” ID Round Opening (1) 106" x 47" x 8"H	#2200
▪ Lid	24” ID Round Openings (2) 106" x 47" x 8"H	#1401
▪ Vault	106 "x 47" x 64"H	#9200
▪ Lid Only	58" x 26" x 6"H	#665
▪ Vault Only	70" x 46" x 64"	#6166

12. Meter Boxes Range and Sizes

- DMB 37 – 11.5” x 18” ID x 6”H
- DMB 37 – 11.5” x 18” ID x 12”H
- DMB 66 – 17” x 28” ID x 8”H
- DMB 66 – 17” x 28” ID x 13”H
- DMB 5686 – 22” x 34” ID x 7”H
- DMB 5686 – 22” x 34” ID x 15”H

13. Parking Curbs & Pins Ranges and Sizes

- Concrete - 8”W x 5.5”H x 84”L
- Pins - 5/8” OD x 12”L
- Polyethylene encased Parking Curbs
  - 6"W x 5"H x 72"L #125
  - Available in colors.

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DIAMOND PRECAST CONCRETE MUNICIPAL CASTINGS

Exhibit 11

Form List

Section: 15
Date: 12/03/2015
Edition 1, Revision: 0
Exhibit 11

Sr. #	Item No.	Description	Form List					
			Wall	Base	Form 1	Form 2	Form3	Form 4
			Thickness					
1	1206R	12"ID x 6"H Riser Tongue & Groove 46#	2"		1	1	1	1
2	1218CLS	12"ID x18"H Sump W/ Solid Concrete Lid #185						
3	1218D14	12"ID x18"H Sump With CI D14 Grate #190						
4	1218R	12"ID x 18"H Riser Tongue & Groove 137#			1	1	1	1
5	1218S	12"ID x 18"H Sump Catch Basin, Groove Top 170#		2"	1	1	1	1
6	12CLP	Concrete Perforated Lid Tapered for 12"ID 15#			1	1		
7	12CLS	Concrete Lid Solid; Tapered for 12"ID 15#			1	1	1	2
8	1806R	18"ID x 6"H Riser Tongue & Groove 65#	2"		Spacer	Spacer	Spacer	Spacer
9	1812R	18"ID x 12"H Riser Tongue & Groove 126#			1	1	1	1
10	1824R	18" ID x 24"H Riser Tongue & Groove 264#			1	1	1	
11	1824S	18" ID x 24"H Sump Groove Top 340#		2"	No Ring	No Ring	No Ring	
12	1824ST	18"ID x 24"H Sump Tongue Top 328#		2"	Ring Flipped	Ring Flipped	Ring Flipped	
13	18CLP	Concrete Lid Perforated Tapered for 18"ID 45#	2"	2"	1	1		
14	18CLS	Concrete Lid Solid Tapered for 18"ID 55#	2"	2"	1	1	1	3
15	2406R	24"ID x 6"H Riser Tongue & Groove 135#	3"		1	1	1	2
16	2412R	24"ID x 12"H Riser Tongue & Groove 270#			1	1	1	1
17	2424CBS	24"ID X 24"H Sump Groove Top 602#		3"	1	1		

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Exhibit 12

Progress Sheet for Inspection

Daily QC Production Checklist **DATE:_____**

Sr. #	PM. Review Initials: Date:	Quality Control Inspector			Production Supervisor		
	Manufactured Product Documents Attached	OK	Remark	Initials	OK	Remark	Initials
1	Mixer Check list						
2	QC Test of Concrete Batch						
3	Forms Inspection Checklist						
4	Steel Reinforcement Checklist						
5	Actual Production Checklist						
6	Finished Product Checklist						
7	" CSA" Certification Mark						

1. Mixer Checklist

MIXER POINTS	OK	NOT OK	REMARKS	QC INTIALS
LUBRICATION				
WEIGHT SETTING				

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Exhibit 12

2. CONCRETE BATCH TEST

Weight Mixer Setting is done once a Week Every Monday. Sample Testing is done at Metro Testing Lad- CSA registered. Sample tests are done once a week.
*NOTE: Current Mixer Setting: Approved by P.Eng and controlled by QA / QC Manager

TEST	Done	OK	Not Ok	Remarks
Slump Test				
% of entrained air				
Sample Test for Lab.				

3. FORM INSPECTION CHECKLIST

	OK	NOT OK	REMARKS / ACTION
ID of the form			
Dimensional			
Locking system			
Joint -Seam			

*NOTE: Dimensional Check Bi-weekly

4. STEEL REINFORCEMENT CHECKLIST

	OK	NOT OK	REMARKS / ACTION
Correct steel size selection of steel as per dwg. Free from dirt, oil or scale			
Placement of steel in form as per drawing with appropriate size of spacer			
Lifting and step pins placed in form as per drawings			

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Exhibit 12

5. ACTUAL PRODUCTION

	OK	NOT OK	REMARKS / ACTION
Concrete Mix –Inspected			
Steel Reinforcement Inspection			
Release Agent applied to Forms			
Vibration done			
Levelling			
Pre-Curing Cleaning			
Staking in curing room			
Curing Time (Steamer)			

7. FINAL PRODUCT INSPECTION

	YES	NO	REMARKS / ACTION
Leveling			
Stripping difficulties			
Dimensional Check, cracks exposed hardware's			
Date of Production Marked			
Labelling			
Yard Storing Location			

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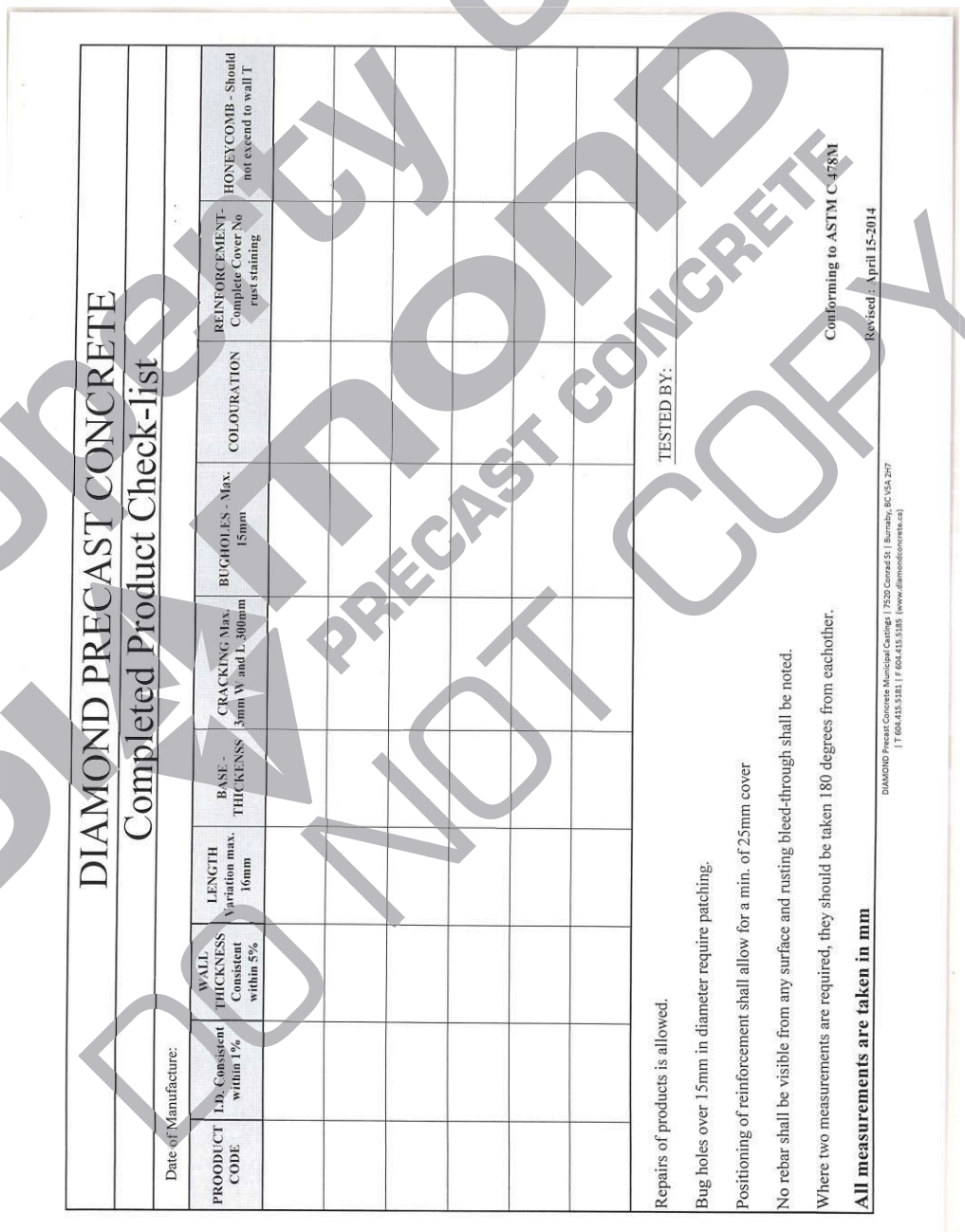
Exhibit 13

Mixer Calibration by Weight



DIAMOND PRECAST CONCRETE

Completed Product Check-list

Date of Manufacture:

PROODUCT CODE	I.D. Consistent within 1%	WALL THICKNESS Consistent within 5%	LENGTH Variation max. 16mm	BASE - THICKENSS	CRACKING Max. 3mm W and L 300mm	BUGHOLES - Max. 15mm	COLOURATION	REINFORCEMENT- Complete Cover No rust staining	HONEYCOMB - Should not exceed to wall T

TESTED BY:

Repairs of products is allowed.

Bug holes over 15mm in diameter require patching.

Positioning of reinforcement shall allow for a min. of 25mm cover

No rebar shall be visible from any surface and rusting bleed-through shall be noted.

Where two measurements are required, they should be taken 180 degrees from eachother.

All measurements are taken in mm

Conforming to ASTM C 478M

Revised : April 15-2014

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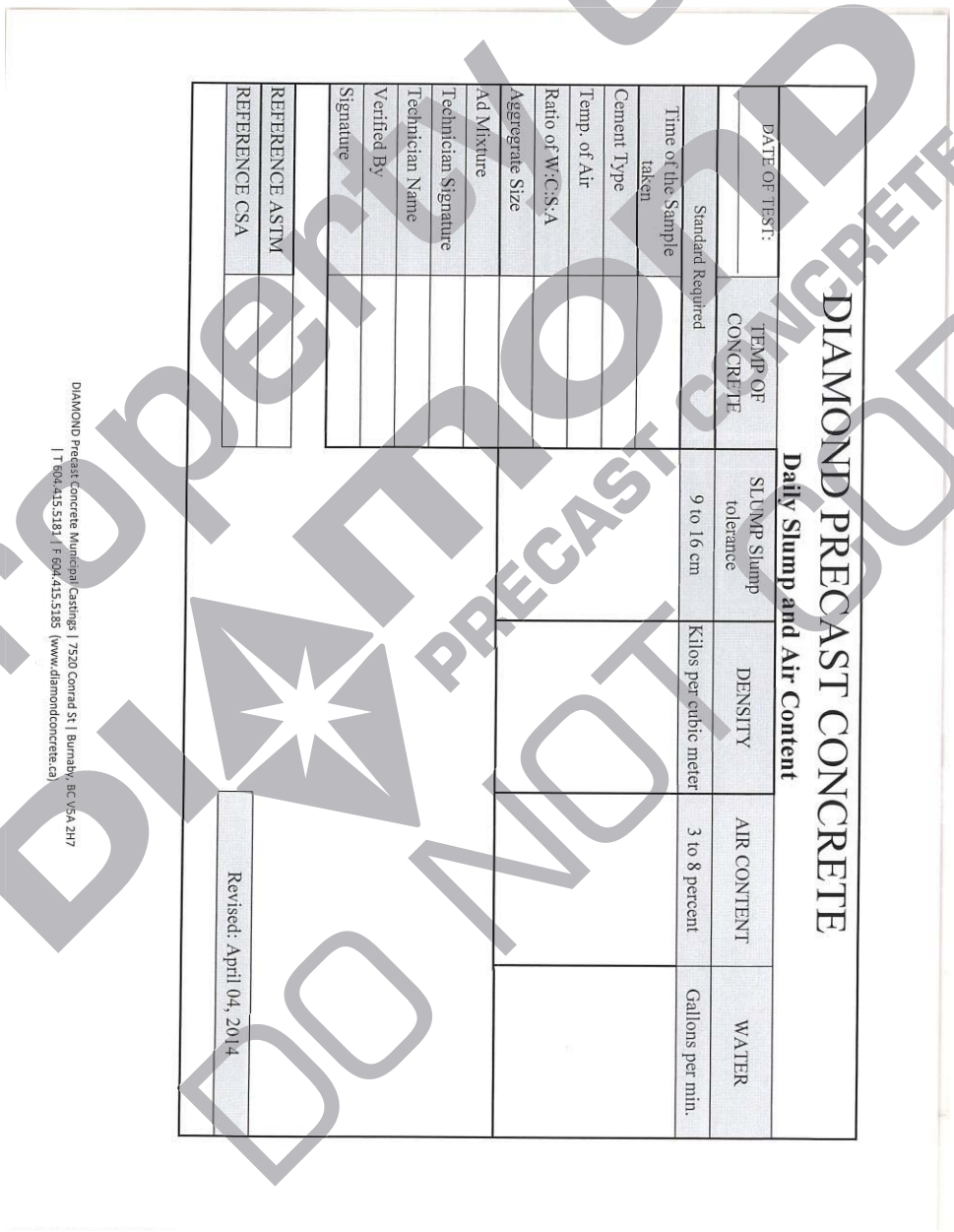
Exhibit 14

Daily Slump & Air Content



DIAMOND PRECAST CONCRETE

Daily Slump and Air Content

DATE OF TEST:	TEMP OF CONCRETE	SLUMP Slump tolerance	DENSITY	AIR CONTENT	WATER
	Standard Required	9 to 16 cm	Kilos per cubic meter	3 to 8 percent	Gallons per min.
Time of the Sample taken					
Cement Type					
Temp. of Air					
Ratio of W:C:S:A					
Aggregrate Size					
Ad Mixture					
Technician Signature					
Technician Name					
Verified By					
Signature					
REFERENCE ASTM					
REFERENCE CSA					

Revised: April 04, 2014

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Exhibit 15

Form / Mold Inventory Check-list

DIAMOND PRECAST CONCRETE

FORM / MOLD INVENTORY CHECK-LIST

DATE:

FORM / MOULD ID	OUTER JACKET: CLAMPS - Max. Gap 2mm	OUTER JACKET: SHELL	OUTER JACKET: TOP EDGE - Check Gross and deformation	INNER JACKET: CLAMPS - Max. Gap 2mm	INNER JACKET: SHELL	INNER JACKET: TOP EDGE - Check Gross and deformation	PALLET: FLAT	PALLET: ROUND	PALLET: CRACKS	TRUING RING: FLAT	TRUING RING: ROUND	TRUING RING: CRACKS	SENT FOR - Repair

CORRECTIVE ACTIONS:

Repair in Shop		Repair outside		After Repair Inspection - Repeat above check		
OK	NOT OK	OK	NOT OK	OK	NOT OK	CHECKED BY:

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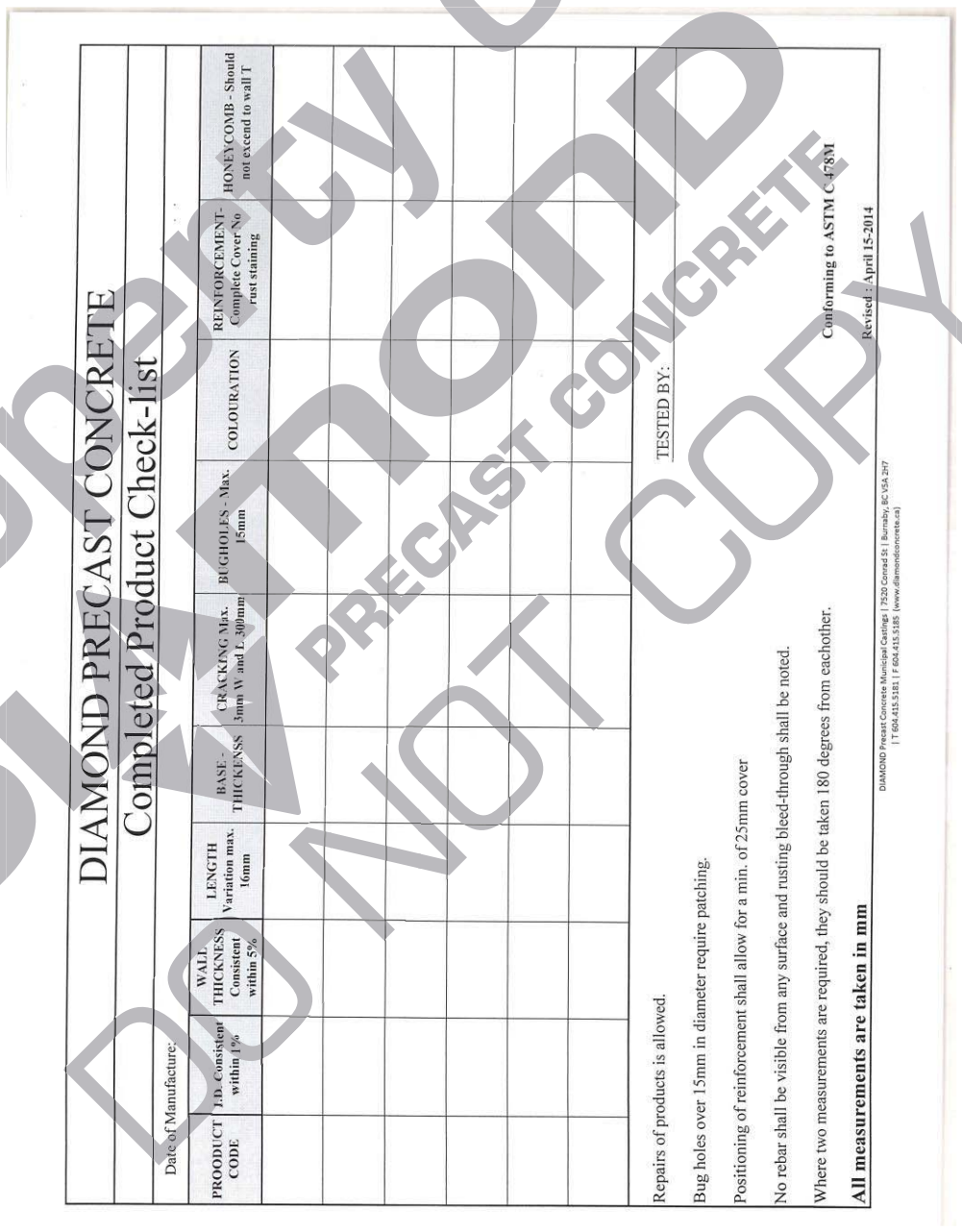
Exhibit 16

Completed Product Check-list



DIAMOND PRECAST CONCRETE

Completed Product Check-list

Date of Manufacture:

PRODUCT CODE	I.D. Consistent within 1%	WALL THICKNESS Consistent within 5%	LENGTH Variation max. 16mm	BASE - THICKENSS	CRACKING Max. .3mm W and L 300mm	BUGHOLES - Max. 15mm	COLOURATION	REINFORCEMENT- Complete Cover No rust staining	HONEYCOMB - Should not exceed to wall T

TESTED BY:

Repairs of products is allowed.

Bug holes over 15mm in diameter require patching.

Positioning of reinforcement shall allow for a min. of 25mm cover

No rebar shall be visible from any surface and rusting bleed-through shall be noted.

Where two measurements are required, they should be taken 180 degrees from eachother.

All measurements are taken in mm

Conforming to ASTM C478M

Revised : April 15-2014

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| T 604.415.5181 | F 604.415.5185 (www.diamondconcrete.ca)

Exhibit 17

Production Planning

Production Planning Week 20: 12th May -17th May By Ramesh 9th May 2014				Date
Item #	**Stock**	**Min**	**Need**	**18**
7212R	15	10	**5**	
7224R	10	8	**2**	
7236B	7	15	**-8**	
7236R	13	15	**-2**	
7248B	0	0	**0**	
7248R	9	5	**4**	
72Base	2	0	**2**	
72DL	17	10	**7**	
72DLH	7	5	**2**	
CBDB	272	50	**222**	
CBCR	288	50	**238**	
CBDR	68	200	**-132**	
CBR1	92	50	**42**	
CBR2	175	150	**25**	
CBRS21	58	20	**38**	
CNV-Shim	62	50	**-113**	
DMB3706	89	40	**49**	
DMB3712	99	220	**-121**	
DMB568607	57	28	**29**	
DMB568615	34	68	**-34**	
DMB6608	30	20	**10**	

MANPOWER – PRODUCTION (HOURS)				
	Name	**IN**	**OUT**	**OT**
1	Gary Sodhi (Sup.)			
2	Gurnam Bajwa			
3	Cory (Maint.)			
4	DarHei Lian-Ching			
5	Moe Golkari (QC)			
6	Jamsran Ganbold			
7	Luisito Cabello			
8	Colton			
9	Nicasio			
10	Morteza			
11	Leonard			
12	Scott			
13	Joshua			
14	James			
15	Jet			
16	Shawn			

Notes:

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Exhibit 18

List of Tools & Equipment's used in QC

Sr. #	Item Description	Serial #	Model #	Calibration Date	Valid Until

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Exhibit 19

Non Conformance Report

ITEM: _____

DESCRIPTION OF NON-CONFORMITY:

_____

_____

_____

_____

DATED:_____ SIGNATURE:_____
QCM

CORRECTIVE ACTION:

_____

_____

_____

_____

ACTION AGREED UPON:_____ _____
DM AND QCM AUTHORIZED INSPECTOR

	Name	Signature	Date
COMPLETED BY:	_____	_____	_____
HOLD REMOVED BY:	_____	_____	_____
QC MANAGER:	_____	_____	_____
PRODUCTION MANAGER:	_____	_____	_____
DESIGN ENGINEER:	_____	_____	_____

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Exhibit 20

Hold Tags

ITEM IDENTIFICATION

_____

HOLD - DO NOT USE

HOLD BY: _____ DATE ___/____/___

TO BE REMOVED ONLY BY AUTHORITY OF QUALITY CONTROL MANGER.

FRONT - BLACK ON WHITE

DIAMOND PRECAST CONCRETE

REASON FOR HOLD

USE AS IS:
REPAIR/ REWORK:
SCRAP/RETURN TO VENDOR:

_____
_____
_____

REPORT # : _____

QUALITY CONTROL MANAGER: _____SIGNATURE:_____

DATE: _____/_____/_____

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Exhibit 21

Labels

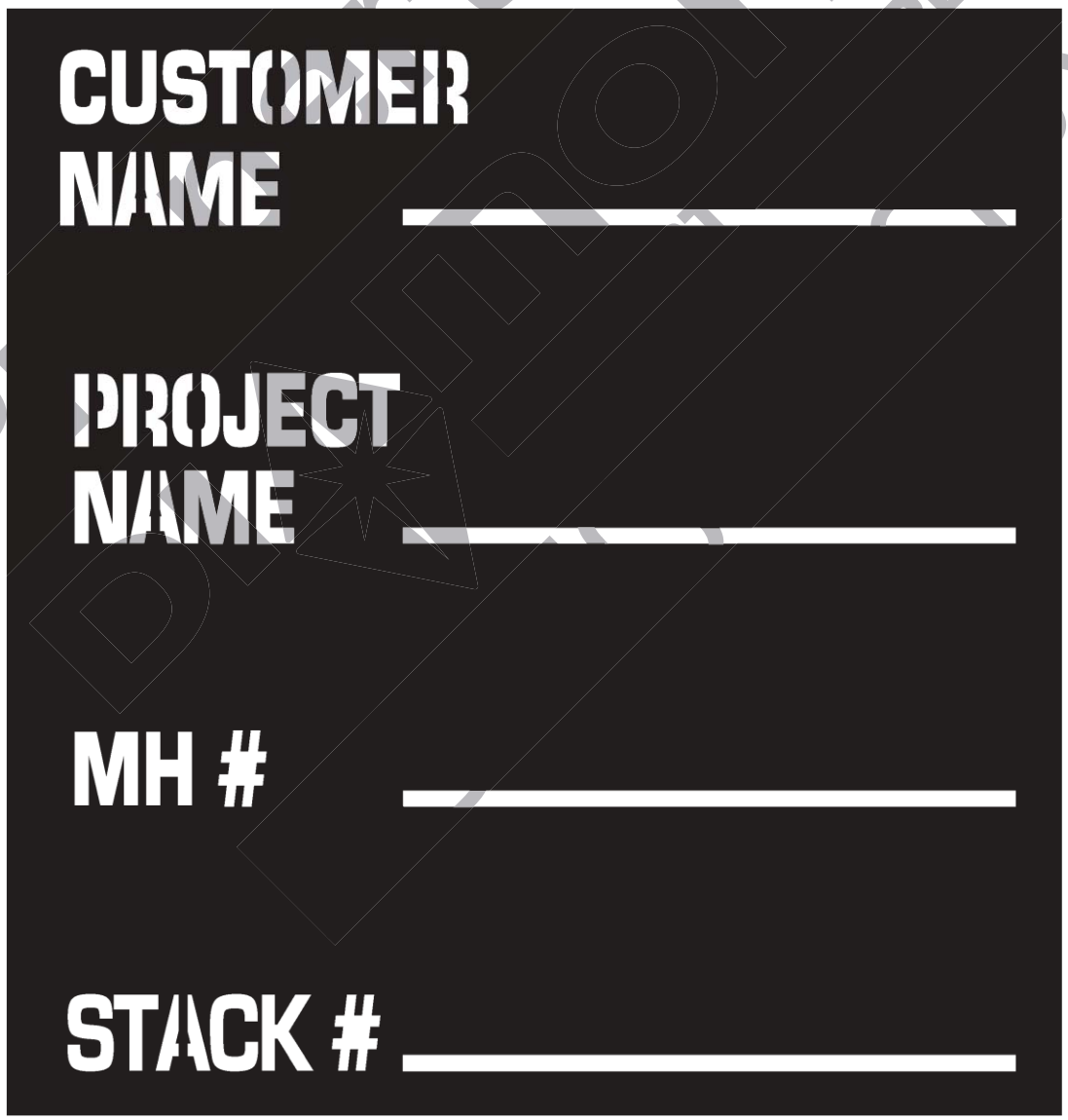

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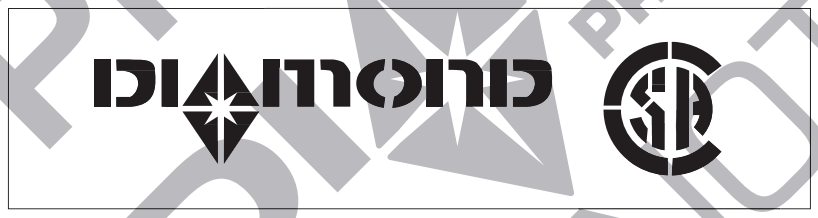
Exhibit 21

Labels

Large 20”x12” Option B



Single 3”x12”

DIAMOND Precast Concrete Ltd.| 7520 Conrad St | Burnaby, BC V5A 2H7
Tel: 604.415.5181 | Fax: 604.415.5185 | www.DiamondPrecast.com

Exhibit 22

Certificate of Compliance

Precast products produced from Date _____ till _____

Precast Project # _____

Precast Project Engineer Final Inspection

Shop Drawings	
Pre-pour Inspections	
Post-pour Inspections	
Concrete Tests	
Rebar Mill Certificates	
Wire Mesh Mill Certificates	
Hardware Mill Certificates	
Any other Misc. to review _____	

I have inspected all of the above mentioned documents and verified that all quality requirements have been met. Based on verification of records as listed above the products were produced in compliance with the CSA A23.4 standard.

_____ _____

Wang Xiao Song (Vincent), P.Eng.
Precast Project Engineer

Date

_____ _____

Ramesh Nathani P.Eng.
QC / QA Manager

Date

DIAMOND Precast Concrete Ltd.| 7520 Conrad St | Burnaby, BC V5A 2H7
Tel: 604.415.5181 | Fax: 604.415.5185 | www.DiamondPrecast.com

Standards Council of Canada
Conseil canadien des normes

Directory of Accredited Product, Process and Service Certification Bodies

A certification mark is proof of conformity that opens borders and increases recognition. Please select from amongst the following SCC-accredited certification bodies.

Air-Conditioning, Heating and Refrigeration Institute

2111 Wilson Boulevard, Suite 500
Arlington, VA 22201-3001
USA
http://www.ahrinet.org

Status: Accredited
As of: 2009-04-23
Scope of Accreditation (pdf)

Rupal Choksi
Quality System Manager
rchoksi@ahrinet.org
+1 703 524 8800
+1 703 524 9011

APA - The Engineered Wood Association

7011 South 19th Street
Tacoma, WA 98466
USA
http://www.apawood.org

Status: Accredited
As of: 1993-01-04
Scope of Accreditation (pdf)

Steve Zylkowski
Director, Quality Services Division
steve.zylkowski@apawood.org
+1 253 565 6600
+1 253 565 7265

Bureau de normalisation du Québec

Parc technologique du Québec métropolitain,
333, rue Franquet
Quebec, QC G1P 4C7
Canada
http://www.bnq.qc.ca/

Status: Accredited
As of: 1994-07-08
Scope of Accreditation (pdf)

Jean Rousseau
Directeur
jean.rousseau@bnq.qc.ca
+1 418 652 2219
+1 418 652 2292

Canadian General Standards Board

Place du Portage,
Phase 111, 6B1
11 Laurier Street
Gatineau, QC K1A 1G6
Canada
http://www.ongc-cgsb.gc.ca

Status: Accredited
As of: 1998-05-08

Donald Fulton
Team Leader, Certification Services
donald.fulton@pwgsc.gc.ca
+1 819 956 3825
+1 819 956 5740

Scope of Accreditation (pdf)

Canadian Seed Institute dba the Centre for Systems Integration

200-240 Catherine Street
Ottawa, Ontario K2P 2G8
Canada

Roy van Wyk
Executive Director
rvanwyk@csi-ics.com
+1 613 236 6451
+1 613 236 7000

Status: Accredited
As of: 2013-06-07
Scope of Accreditation (pdf)

Canadian Standards Association operating as CSA Group

178 Rexdale Boulevard
Toronto, ON M9W 1R3
Canada
http://www.csagroup.org/us/en/home

Ben Barker
Manager, Accreditations
Benjamin.Barker@csagroup.org
+1 416 747 4013

Status: Accredited
As of: 1983-06-28
Scope of Accreditation (pdf)

Canadian Welding Bureau (Division of CWB Group - Industry Services)

8260 Park Hill Drive
Milton, ON L9T 5V7
Canada
http://www.cwbgroup.org

Inderpal Jaswal
Registrar & Manager, Quality Assurance
Inderpal.Jaswal@cwbgroup.org
+1 800 844 6790 ext. 246
+1 905 542 1318

Status: Accredited
As of: 1991-06-05
Scope of Accreditation (pdf)

Curtis-Straus LLC

Littleton Distribution Center
One Distribution Center Circle, Suite #1

Littleton, MA 01460
USA
http://www.bureauveritas.com/wps/wcm/connect/bv_us/our-busi...

Tadas Stukas
Quality Manager
tadas.stukas@us.bureauveritas.com
+1 978 486 8880
+1 978 486 8828

Status: Accredited
As of: 2006-10-04
Scope of Accreditation (pdf)

Electrical Safety Authority Operating As ESA Field Evaluation (ESAFE)

155A Matheson Boulevard West
Mississauga, Ontario
L5R 3L5

Operating from

Jacques Martin
jacques.martin@electricalsafety.on.ca
+1 613 271 1489
+1 613 271 6441

4043 Carling Avenue, Suite 106
Ottawa, Ontario K2K 2A4
Canada
http://www.esafieldevaluation.ca/

Status: Accredited
As of: 2014-03-14
Scope of Accreditation (pdf)

FM Approvals LLC

1151 Boston-Providence Turnpike
P.O. Box 9102
Norwood, MA 02062
USA
http://www.fmglobal.com

Status: Accredited
As of: 2005-04-28
Scope of Accreditation (pdf)

John Hill
Manager, Accreditations, QA, and Quality System Registrations
john.hill@fmglobal.com
+1 781 255 4972
+1 781 762 9375

Global Organic Alliance, Inc.

3185 Township Road 179
P.O. Box 530
Bellefontaine, OH 43311-0530
USA
http://www.goa-online.org

Status: Accredited
As of: 2010-02-26
Scope of Accreditation (pdf)

Betty Kananen
President/CEO
goaorg@centurylink.net
+1 937 593 1232
+1 937 593 9507

IAPMO Research and Testing, Inc.

5001 E. Philadelphia Street
Ontario, CA 91761
USA
http://www.iapmo.org

Status: Accredited
As of: 2002-09-19
Scope of Accreditation (pdf)

Shirley Dewi
Director, Quality Assurance
shirley.dewi@iapmort.org
+1 909 230 5530
+1 909 472 4199

ICC Evaluation Service, LLC

3060 Saturn Street, Suite 100
Brea, CA 92821
USA
http://www.icc-es.org

Status: Accredited
As of: 2011-07-28
Scope of Accreditation (pdf)

David Pereg
Quality Systems Manager
dpereg@icc-es.org
+1 562 699 0543
+1 562 695 4694

Intertek Testing Services NA Inc.

545 East Algonquin Road, Suite F

Paul Moliski

Arlington Heights, IL 60005
USA

Status: Accredited
As of: 1993-06-07
Scope of Accreditation (pdf)

Vice President - Accreditation
paul.moliski@intertek.com
+1 607 753 6711
+1 607 756 6699

LabTest Certification Inc.

3133 - 20800 Westminster Highway
Richmond, BC V6V 2W3
Canada
http://www.labtestcert.com

Status: Accredited
As of: 2007-07-18
Scope of Accreditation (pdf)

Kavinder Dhillon
President
kdhillon@labtestcert.com
+1 604 247 0444
+1 604 247 0442

MET Laboratories, Inc.

914 West Patapsco Avenue
Baltimore, MD 21230-3432
USA
http://www.metlabs.com

Status: Accredited
As of: 1995-12-20
Scope of Accreditation (pdf)

Jonathan Fuhrman
Quality Manager
jfuhrman@metlabs.com
+1 410 949 1880
+1 410 354 3313

Nemko Canada Inc.

303 River Road R.R. #5
Ottawa, ON K1V 1H2
Canada
http://www.nemko.com

Status: Accredited
As of: 2003-11-24
Scope of Accreditation (pdf)

Stuart Beck
Director of Certification
stuart.beck@nemko.com
+1 613 737 9680
+1 613 737 9691

Nemko-CCL, Inc.

1940 West Alexander Street
Salt Lake City, Utah 84119-2039
USA

Status: Accredited
As of: 2013-07-02
Scope of Accreditation (pdf)

Thomas Jackson
General Manager
Tom.Jackson@Nemko.com
+1 801 972 6146
+1 801 972 8432

NSF International

789 Dixboro Road
Ann Arbor, MI 48105
USA

Craig S. Morr, CEI/CEM
Quality Assurance & Organizational Safety

http://www.nsf.org

Status: Accredited
As of: 1997-03-05
Scope of Accreditation (pdf)

Manager
cmorr@nsf.org
+1 734 769 5143
+1 734 827 7182

OMNI-Test Laboratories, Inc.

13327 NE Airport Way
P.O. Box 301367
Portland, OR 97294
USA
http://www.omni-test.com

Status: Accredited
As of: 1998-06-04
Scope of Accreditation (pdf)

Alex Tiegs
Accreditation and QA Manager
atiegs@omni-test.com
+1 503 643 3788
+1 503 643 3799

Organic Producers Association of Manitoba Co-operative Inc.

123 North Railway Avenue P.O. Box 279
Miniota, MB R0M 1M0
Canada
http://www.opam-mb.com

Status: Accredited
As of: 2002-12-04
Scope of Accreditation (pdf)

Tiffany Priestley
Business Manager
info@opam-mb.com
+1 204 567 3745
+1 204 567 3749

PFS Corporation

1507 Matt Pass
Cottage Grove, WI 53527
USA
http://www.pfscorporation.com

Status: Accredited
As of: 1998-11-30
Scope of Accreditation (pdf)

Mr. James J. Husom
President & CEO
jhusom@pfscorporation.com
+1 608 839 1372
+1 608 839 1014

PricewaterhouseCoopers LLP

250 Howe Street, Suite 700
Vancouver, BC V6C 3S7
Canada
http://www.pwc.com/ca

Status: Accredited
As of: 2007-05-29
Scope of Accreditation (pdf)

Mike Harris
mike.harris@ca.pwc.com
+1 604 806 7595
+1 604 806 7806

Pro-Cert Organic Systems Ltd.

Box 100A, R.R. #3
475 Valley Road
Saskatoon, SK S7K 3J6

Wallace Hamm
General Manager

Canada
http://www.pro-cert.org

Status: Accredited
As of: 2001-11-28
Scope of Accreditation (pdf)

wallace.hamm@pro-cert.org
+1 306 382 1299
+1 306 382 0683

QAI LABORATORIES LTD.

#16-211 Schoolhouse Street
Coquitlam, BC V3K 4X9
Canada
http://www.qai.org/

Status: Accredited
As of: 1997-05-26
Scope of Accreditation (pdf)

Lawrence Gibson
President
lgibson@qai.org
+1 604 527 8378
+1 604 527 8368

QPS Evaluation Services, Inc.

81 Kelfield Street, Unit 8
Toronto, ON M9W 5A3
Canada
http://www.qps.ca

Status: Accredited
As of: 2004-11-29
Scope of Accreditation (pdf)

Nick Maalouf
Vice President
nmaalouf@qps.ca
+1 416 241 8857
+1 416 241 0682

Safety Equipment Institute

1307 Dolley Madison Boulevard, Suite 3A
McLean, VA 22101
USA
http://www.seinet.org

Status: Accredited
As of: 2001-08-02
Scope of Accreditation (pdf)

Patricia Gleason
President
pgleason@SEInet.org
+1 703 442 5732
+1 703 442 5756

SGS North America, Inc.

620 Old Peachtree Road, Ste. 100
Suwanee, GA 30024
USA
http://www.sgs.com

Status: Accredited
As of: 2011-04-04
Scope of Accreditation (pdf)

Paul Krauss
North American Certification Manager
Paul.Krauss@sgs.com
+1 770 570 1818
+1 770 277 1240

T.R.Arnold & Associates, Inc.

700 E. Beardsley Avenue, Suite 2A
Elkhart, Indiana 46514
USA

Tedd Huff
Director of Certification
THuff@trarnold.com
+1 574 264 0745

+1 574 264 0740

Status: Accredited
As of: 2014-03-25
Scope of Accreditation (pdf)

Timberco, Inc. (dba TECO)

1507 Matt Pass, Suite #2
Cottage Grove, WI 53527
USA
http://www.tecotested.com

Steve Verhey
Quality Manager
steve.verhey@tecotested.com
+1 855 266 8326 ext. 103
+1 608 433 0063

Status: Accredited
As of: 2006-03-07
Scope of Accreditation (pdf)

TransCanada Organic Certification Services (formerly OCIA Canada)

P.O. Box 3429
Humboldt, Saskatchewan S0K 2A0
Canada

Art Hesje
President
ahesje@tcocert.ca
+1 306 682 3126
+1 306 682 3127

Status: Accredited
As of: 2014-07-07
Scope of Accreditation (pdf)

TÜV Rheinland of North America, Inc.

12 Commerce Road
Newtown, CT 06470
USA
Website

Kenneth Kamer
NRTL Program Manager
kkamer@us.tuv.com
+1 919 554 3668
+1 919 554 3542

Status: Accredited
As of: 2000-01-31
Scope of Accreditation (pdf)

TÜV SÜD America Inc. (Product Service Division)

10 Centennial Drive
Peabody, MA 01960
USA
http://www.tuv-sud-america.com/

Gary Minks
Vice President, Quality & Regulatory Affairs
gminks@tuvam.com
+1 978 573 2500
+1 978 977 0182

Status: Accredited
As of: 2003-06-04
Scope of Accreditation (pdf)

UL LLC

Northbrook Division
333 Pfingsten Road
Northbrook, IL 60062-2096
USA
http://www.ul.com

Rick Titus
Manager - Accreditation Services
Rick.A.Titus@us.ul.com
+1 847 272 8800
+1 847 509 6321

Status: Accredited
As of: 1992-11-20
Scope of Accreditation (pdf)

UL Verification Services Inc.

333 Pfingsten Road
Northbrook, Illinois 60062-2096
USA

Rick Titus
Manager-Accreditation Services
Rick.A.Titus@ul.com
+1 847 664 3281

Status: Accredited
As of: 2014-08-20
Scope of Accreditation (pdf)

Underwriters Laboratories of Canada

7 Underwriters Road
Toronto, ON M1R 3A9
Canada
http://www.ul.com

Gunsimar Paintal
Regional Quality Manager and ULC Mark Program Owner
Gunsimar.Paintal@ul.com
+1 416 757 5250
+1 416 757 1781

Status: Accredited
As of: 1980-10-07
Scope of Accreditation (pdf)

Water Quality Association

4151 Naperville Road
Lisle, IL 60532-1088
USA
http://www.wqa.org

Tambra Thomas
Quality Manager
tthomas@wqa.org
+1 630 929 2541
+1 630 505 0752

Status: Accredited
As of: 2004-09-02
Scope of Accreditation (pdf)

Standards Council of Canada
Conseil canadien des normes

CERTIFICATION BODY ACCREDITATION PROGRAM (CBAP)

Scope of Accreditation

Accredited Legal Entity: Canadian Standards Association o/a CSA Group

Contact Name: Ben Barker

Address: 178 Rexdale Boulevard, Toronto, ON M9W 1R3

Telephone: +1 416 747 4013

Website: http://www.csagroup.org/us/en/home

Email: Benjamin.Barker@csagroup.org

SCC File #:	10004
Initial Accreditation Date:	1983-06-28
Reaccreditation Date:	2014-09-11
Accreditation Expiry Date:	2017-06-28
Accreditation Standard:	ISO/IEC 17065 CAN-P-1500:2013

Additional Critical/Key Locations:

The certification activities conducted by the above-mentioned legal entity at the following locations are also included in this scope of accreditation:

Location	Country	Address	City
A	Canada	CSA Group 1707-94 Street North West Edmonton, AB T6N 1E6	Edmonton
B	Canada	CSA Group 865 Ellingham Avenue Pointe Claire, PQ H9R 5E8	Pointe Claire
C	Canada	CSA Group 13799 Commerce Parkway Richmond, BC V6V 2N9	Richmond
D	USA	CSA Group 6215 Shiloh Crossing, Building 100, Suite A Alpharetta, GA 30005	Alpharetta

Location	Country	Address	City
E	USA	CSA Group 8501 East Pleasant Valley Road Cleveland, OH 44131-5575	Cleveland
F	USA	CSA Group 5970 Fairview Road Suite 722 Charlotte, NC 28210	Charlotte
G	USA	CSA Group 2860 Guilder Drive, Plano Texas, 75074	Plano
H	USA	CSA Group 2805 Barranca Parkway Los Angeles, CA 92606-5114	Los Angeles
I	USA	CSA Group 100 Bluegrass Commons Blvd, Suite 210 Hendersonville, TN 37075	Nashville
J	United Kingdom	CSA Group Chester Rake Lane, Eccleston, Chester, England CH49JN	Chester
K	United Kingdom	CSA Group Derbyshire 11 Arden House Deepdale Business Park, Bakewell, Derbyshire DE45 1GT	Bakewell
L	Germany	CSA Group Strasskirchen Ohmstraße 1-4 94342 Strasskirchen Germany	Strasskirchen
M	Germany	CSA Group Europe GmbH Weismüllerstr. 45 60314 Frankfurt Germany	Frankfurt
N	Netherlands	CSA Group Arnhem Utrechtseweg 310, 6812 AR Arnhem P.O. Box 1142 Arnhem 6801 BC	Arnhem
O	Italia	CSA Group Italy Centro Direzionale Colleoni, Palazzo Orione, Viale Colleoni 17, Scala 3 20864 Agrate Brianza Italia	Agrate Brianza
P	China	CCIC/CSA International Certification Co. Ltd., Shanghai Branch No. 10 Ke Yan Road, Guangzhou Science Park, Luo Gang District 510663,	Guangzhou

Location	Country	Address	City
		Guangzhou, China 510663	
Q	China	Canadian Standards Association (Far East Operations) Limited Suite 811, Tsimshatsui Center East Wing 66 Mody Road, International Business Center (IBC) Tsimshatsui East, Kowloon, Hong Kong	Hong Kong
R	China	CCIC/CSA International Certification Co. Ltd., Shanghai Branch Floor 1, Building 4, Qilai Industrial City, 889 Yishan Road Shanghai, China 200233	Shanghai
S	India	CSA India Private Limited Beary's Global Research Triangle, A-3, Einstein Building, Bidarahalli Hobli, Whitefield Ashram Road (SH 35), Bangalore - 560 067	Bangalore
T	Korea	CSA International-Korea 52, Chungmin-ro, Songpa-gu Seoul, Korea (Garden 5 Works C #705) 138-961	Seoul
U	Taiwan	Canadian Standards Association (Far East Operations Limited, Taiwan 3F, No. 653-1, Zhongzheng Road, Xinzhuang District, Taipei Hsien	Taipei

Certification Mark:

Product Certification Scheme:

ISO/IEC 17067, Conformity assessment - Fundamentals of product certification and guidelines for product certification schemes, scheme type 3 most closely resembles the product certification scheme operated by this organization. The surveillance part of this scheme involves periodically taking samples of the product from the point of production and subjecting them to determination activities to check that items produced subsequent to the initial attestation fulfil the specified requirements. The surveillance includes periodic assessment of the production process. This scheme does not provide any indication of the impact the distribution channel plays on conformity. When serious nonconformities are found, the opportunity may exist to resolve them before widespread market distribution occurs.

Scope of Accreditation:

The scope of accreditation for the above-mentioned legal entity limits the use of the certification mark shown, to products that meet standards classified by the following international classification coding:

ICS No.	Title	Purpose
23.040.70	Hoses and hose assemblies	Performance
25.180.20	Fuel furnaces	Safety & Performance
27.060.20	Gas fuel burners	Safety & Performance
27.060.30	Boilers and heat exchangers	Safety & Performance
27.080	Heat pumps	Performance & Safety
75.200	Petroleum, petroleum products and natural gas handling equipment	Performance and Safety
97.040.20	Cooking ranges, working tables, ovens and similar appliances	Performance & Safety
97.100.20	Gas heaters	Performance & Safety
97.200.30	Camping equipment and camp-sites	Performance and Safety

Certification Mark:

Standards Council of Canada
Conseil canadien des normes

Product Certification Scheme:

ISO/IEC 17067, Conformity assessment - Fundamentals of product certification and guidelines for product certification schemes, scheme type 3 most closely resembles the product certification scheme operated by this organization. The surveillance part of this scheme involves periodically taking samples of the product from the point of production and subjecting them to determination activities to check that items produced subsequent to the initial attestation fulfil the specified requirements. The surveillance includes periodic assessment of the production process. This scheme does not provide any indication of the impact the distribution channel plays on conformity. When serious nonconformities are found, the opportunity may exist to resolve them before widespread market distribution occurs.

Scope of Accreditation:

The scope of accreditation for the above-mentioned legal entity limits the use of the certification mark shown, to products that meet standards classified by the following international classification coding:

ICS No.	Title	Purpose
11.040.10	Aneasthetic, respiratory and reanimation equipment	Electrical Safety
11.040.20	Transfusion, infusion and injection equipment	Electrical Safety
11.040.30	Surgical instruments and materials	Electrical Safety
11.040.50	Radiographic equipment	Electrical Safety
11.040.55	Diagnostic equipment	Electrical Safety
11.040.60	Therapy equipment	Electrical Safety
11.060.20	Dental equipment	Electrical Safety
11.120	Pharmaceutics (child restrictive packaging)	Safety
11.140	Hospital equipment	Electrical Safety
13.030.40	Installations and equipment for waste disposal and treatment	Performance

ICS No.	Title	Purpose
13.060.20	Drinking Water (drinking water treatment units)	Performance, Safety and Health
13.060.30	Sewage water (residential wastewater treatment, recycle and water conservation systems and components)	Performance and Health
13.100	Occupational safety. Industrial hygiene	Performance
13.110	Safety of machinery	Safety
13.240	Protection against excessive pressure	Safety
13.260	Protection against electric shock	Performance and Electrical Safety
13.310	Protection against crime	Performance and Electrical Safety
13.320	Alarm and warning systems	Performance and Electrical Safety
13.340.20	Head protective equipment (including helmets, eye protectors, hearing protectors, etc.)	Performance and Safety
13.340.50	Protective footwear	Performance and Safety
13.340.99	Other protective equipment (ladders, lifeline systems, fall protection equipment and components)	Performance and Safety
19.080	Electrical and electronic testing	Electrical Safety
21.180	Housings, enclosures, other machine parts	Performance
23.020.10	Stationary containers and tanks	Performance
23.020.20	Vessels and containers mounted on vehicles	Performance
23.040.10	Iron and steel pipes	Performance
23.040.15	Non-ferrous metal pipes	Performance
23.040.20	Plastics pipes	Performance and Health
23.040.40	Metal fittings	Performance and Health
23.040.45	Plastics fittings	Performance and Health
23.040.50	Pipes and fittings of other materials	Performance and Health
23.040.60	Flange, couplings and joints	Performance
23.040.80	Seals for pipe and hose assemblies	Performance
23.060.10	Globe valves	Performance, Safety and Health
23.060.20	Ball and plug valves	Performance, Safety and Health

ICS No.	Title	Purpose
23.060.30	Gate valves	Performance, Safety and Health
23.060.40	Pressure Regulators	Performance and Safety
23.060.50	Check valves	Performance, Safety and Health
23.080	Pumps	Electrical Safety & Performance
23.100.50	Control components	Performance, Safety and Health
23.100.60	Filters, seals and contamination of fluids	Performance
23.120	Ventilators. Fans. Air-conditioners	Performance & Electrical Safety
23.140	Compressors and pneumatic machines	Performance and Electrical Safety
25.040.40	Industrial process measurement and control	Electrical Safety
25.080.10	Lathes	Electrical Safety
25.080.20	Boring and milling machines	Electrical Safety
25.080.25	Planing machines	Electrical Safety
25.080.30	Broaching machines	Electrical Safety
25.080.40	Drilling machines	Electrical Safety
25.080.50	Grinding and polishing machines	Electrical Safety
25.080.60	Sawing machines	Electrical Safety
25.140.20	Electric tools	Electrical Safety
25.160.30	Welding equipment	Electrical Safety
25.180.10	Electric furnaces	Safety and Performance
27.060.10	Liquid and solid fuel burners	Safety and Performance
27.070	Fuel Cells	Safety
27.160	Solar Energy Engineering	Electrical Safety (Photovoltaic Panels)
29.020	Electrical engineering in general	Performance, Safety
29.035.20	Plastics and rubber insulating materials	Performance
29.060.10	Wires	Performance and Electrical Safety

ICS No.	Title	Purpose
29.060.20	Cables	Electrical Safety and Performance
29.080.30	Insulation systems	Performance
29.100.10	Magnetic components	Electrical Safety and Performance
29.100.20	Electrical and electromechanical components	Electrical Safety
29.120.10	Conduits for electrical purposes	Electrical Safety
29.120.20	Connecting devices	Electrical Safety
29.120.30	Plugs, socket-outlets, couplers	Electrical Safety
29.120.40	Switches	Electrical Safety
29.120.50	Fuses and other overcurrent protection devices	Electrical Safety
29.120.70	Relays	Electrical Safety
29.130.10	High voltage switchgear and controlgear	Electrical Safety
29.130.20	Low voltage switchgear and controlgear	Electrical Safety
29.140.10	Lampholders	Electrical Safety
29.140.20	Incandescent lamps	Electrical Safety
29.140.30	Fluorescent lamps. Discharge lamps	Electrical Safety
29.140.40	Luminaires	Electrical Safety
29.140.50	Lighting installation systems	Electrical Safety
29.160.20	Generators	Electrical Safety
29.160.30	Motors	Electrical Safety
29.160.40	Generating sets	Electrical Safety
29.180	Transformers. Reactors	Electrical Safety
29.200	Rectifiers. Convertors. Stabilized power supply	Electrical Safety
29.220.30	Alkaline secondary cells and batteries	Electrical Safety
29.260.10	Electrical installations for outdoor use	Electrical Safety
29.260.20	Electrical apparatus for explosive atmospheres	Electrical Safety
31.040.10	Fixed resistors	Electrical Safety
31.040.20	Potentiometers, variable resistors	Electrical Safety

ICS No.	Title	Purpose
31.040.30	Thermistors	Electrical Safety
31.060.10	Fixed capacitors	Electrical Safety
31.060.20	Ceramic and mica capacitors	Electrical Safety
31.060.30	Paper and plastics capacitors	Electrical Safety
31.060.40	Tantalum electrolytic capacitors	Electrical Safety
31.060.50	Aluminum electrolytic capacitors	Electrical Safety
31.060.60	Variable capacitors	Electrical Safety
31.060.70	Power capacitors	Electrical Safety
31.100	Electronic tubes	Electrical Safety
31.120	Electronic display devices	Electrical Safety
31.160	Electric filters	Electrical Safety
31.180	Printed circuits and boards	Electrical Safety
31.190	Electronic component assemblies	Electrical Safety
31.220.10	Plug-and-socket devices. Connectors	Electrical Safety
31.220.20	Switches	Electrical Safety
31.260	Optoelectronics. Laser equipment	Electrical Safety
33.040.40	Data communication networks	Electrical Safety
33.050.10	Telephone equipment	Electrical Safety
33.060.20	Receiving and transmitting equipment	Electrical Safety
33.100.10	Emission	Performance
33.100.20	Immunity	Performance
33.160.20	Radio receivers	Electrical Safety
33.160.25	Television receivers	Electrical Safety
33.160.30	Audio systems	Electrical Safety
33.160.40	Video systems	Electrical Safety
33.160.50	Accessories	Electrical Safety
33.160.60	Multimedia systems and teleconference equipment	Electrical Safety

ICS No.	Title	Purpose
33.180.10	Fibres and cables	Electrical Safety
35.020	Information technology (IT) in general	Electrical Safety
35.160	Microprocessor systems	Electrical Safety
35.180	IT terminal and other peripheral equipment	Electrical Safety
35.260	Office machines	Electrical Safety
37.040.10	Photographic equipment. Projectors	Electrical Safety
39.040.20	Clocks	Electrical Safety
43.040.20	Lighting, signalling and warning devices	Electrical Safety
43.080.20	Buses (RV series)	Performance, Safety
43.100	Passenger cars. Caravans and light trailers	Performance, Safety
47.020.60	Electrical equipment of ships and of marine structures	Electrical Safety
53.020.20	Cranes	Performance Electrical Safety
53.040.10	Conveyors	Electrical Safety
55.040	Packaging materials and accessories	Safety
55.200	Packaging machinery	Electrical Safety
55.230	Distribution and vending machines	Performance & Electrical Safety
61.080	Sewing machines and other equipment for the clothing industry	Electrical Safety
65.060.80	Forestry equipment	Performance and Safety
67.250	Materials and articles in contact with foodstuffs	Performance and Safety
67.260	Plant and equipment for the food industry (Pertaining to the design, construction, performance, sanitation and health effects of equipment used in the processing, preparation, storage, handling and serving of food)	Performance and Safety
71.100.80	Chemicals for purification of water	Health and Safety
75.180.01	Equipment for petroleum and natural gas industries in general	Performance and Safety
79.120.10	Woodworking machines	Electrical Safety
83.080	Plastics	Performance and Health
83.140.30	Plastics pipes, fittings and valves	Performance and Health

ICS No.	Title	Purpose
87.100	Paint coating equipment	Electrical Safety
91.060.50	Doors and windows	Performance
91.080.40	Concrete Structures	Structural Safety Performance
91.100.30	Concrete and Concrete Products	Structural Safety Performance
91.140.40	Gas supply systems	Safety and Performance
91.140.50	Electricity supply systems	Performance and Electrical Safety
91.140.60	Water supply systems	Performance and Health
91.140.65	Water heating equipment	Performance & Safety
91.140.70	Sanitary installations	Performance
91.140.80	Drainage systems	Performance
91.140.90	Lifts. Escalators	Performance and Safety
91.160.10	Interior lighting	Electrical Safety
91.160.20	Exterior building lighting	Electrical Safety
93.080.40	Street lighting and related equipment	Electrical Safety
97.030	Domestic electric appliances in general	Electrical Safety
97.040.30	Domestic refrigerating appliances	Performance & Electrical Safety
97.040.40	Dishwashers	Performance & Electrical Safety
97.040.50	Small kitchen appliances	Electrical Safety
97.060	Laundry appliances	Performance & Safety
97.080	Floor treatment appliances	Electrical Safety
97.100.10	Electric heaters	Performance & Safety
97.100.30	Solid fuel heaters	Performance & Safety
97.100.40	Liquid fuel heaters	Performance &Safety
97.130.20	Commercial refrigerating appliances	Performance & Electrical Safety
97.140	Furniture	Electrical Safety

ICS No.	Title	Purpose
97.145	Ladders	Electrical Safety
97.170	Body care equipment	Electrical Safety
97.180	Miscellaneous domestic and commercial equipment	Electrical Safety
97.190	Equipment for children Including child safety requirements for other household equipment	Performance
97.195	Items of art and handicrafts	Electrical Safety
97.200.10	Theatre, stage and studio equipment	Electrical Safety
97.200.20	Musical instruments	Electrical Safety
97.200.50	Toys	Electrical Safety
97.220.20	Winter sports equipment	Safety
97.220.30	Indoor sports equipment	Safety

Certification Mark:

Product Certification Scheme:

ISO/IEC 17067, Conformity assessment - Fundamentals of product certification and guidelines for product certification schemes, scheme type 5 most closely resembles the product certification scheme operated by this organization. The surveillance part of this scheme allows for the choice between periodically taking samples of the product either from the point of production, or from the market, or from both, and subjecting them to determination activities to check that items produced subsequent to the initial attestation fulfil the specified requirements. The surveillance includes periodic assessment of the production process, or audit of the management system, or both. The extent to which the four surveillance activities are conducted may be varied for a given situation, as defined in the scheme. If the surveillance includes audit of the management system, an initial audit of the management system will be needed.

Scope of Accreditation:

The scope of accreditation for the above-mentioned legal entity limits the use of the certification mark shown, to products that meet standards classified by the following international classification coding:

ICS No.	Title	Purpose
91.040.99	Other buildings (Factory manufactured modular and panelized buildings and trailers intended for residential, commercial, or semi-commercial use.)	Building Safety (structural and occupancy) Electrical Safety Energy Performance Fire Safety Gas Safety Plumbing Safety

Certification Mark:

Product Certification Scheme:

ISO/IEC 17067, Conformity assessment - Fundamentals of product certification and guidelines for product certification schemes, scheme type 5 most closely resembles the product certification scheme operated by this organization. The surveillance part of this scheme allows for the choice between periodically taking samples of the product either from the point of production, or from the market, or from both, and subjecting them to determination activities to check that items produced subsequent to the initial attestation fulfil the specified requirements. The surveillance includes periodic assessment of the production process, or audit of the management system, or both. The extent to which the four surveillance activities are conducted may be varied for a given situation, as defined in the scheme. If the surveillance includes audit of the management system, an initial audit of the management system will be needed.

Scope of Accreditation:

The scope of accreditation for the above-mentioned legal entity limits the use of the certification mark shown, to products that meet standards classified by the following international classification coding:

ICS No.	Title	Purpose
23.080	Pumps	Energy Efficiency
23.120	Ventilators, Fans, Air-conditioners	Energy Efficiency
25.180.20	Fuel Furnaces	Energy Efficiency
27.060.30	Boilers and heat exchanges	Energy Efficiency
27.080	Heat pumps	Energy Efficiency
29.140.20	Incandescent lamps	Energy Efficiency
29.140.30	Fluorescent lamps. Discharge Lamps	Energy Efficiency
29.140.40	Luminaires	Energy Efficiency
29.160.30	Motors	Energy Efficiency
29.160.40	Generating sets	Energy Efficiency
29.180	Transformers. Reactors	Energy Efficiency
29.200	Rectifiers. Converters. Stabilized power supply	Energy Efficiency
33.160.25	Television receivers	Energy Efficiency
33.050.99	Other telecommunication terminal equipment	Energy Efficiency
33.160.99	Other audio, video and audiovisual equipment	Energy Efficiency
35.020	Information technology (IT) in general	Energy Efficiency
35.180	IT terminal and other peripheral equipment	Energy Efficiency
37.100.10	Reproduction equipment	Energy Efficiency
43.040.20	Lighting, signaling and warning devices	Energy Efficiency
55.230	Distribution and vending machines	Energy Efficiency
91.140.65	Water heating equipment	Energy Efficiency
91.160.10	Interior lighting	Energy Efficiency

ICS No.	Title	Purpose
91.160.20	Exterior building lighting	Energy Efficiency
93.080.40	Street lighting and related equipment	Energy Efficiency
97.030	Domestic electrical appliances in general	Energy Efficiency
97.040.20	Cooking ranges, working tables, ovens and similar appliances	Energy Efficiency
97.040.30	Domestic refrigerating appliances	Energy Efficiency
97.040.40	Dishwashers	Energy Efficiency
97.060	Laundry appliances	Energy Efficiency
97.100.10	Electric heaters	Energy Efficiency
97.100.20	Gas heaters	Energy Efficiency
97.100.30	Solid fuel heaters	Energy Efficiency
97.100.40	Liquid fuel heaters	Energy Efficiency
97.130.20	Commercial refrigerating appliances	Energy Efficiency