

ALBERTA TRANSPORTATION
TECHNICAL STANDARDS BRANCH

B375-JULY 2000

**SPECIFICATION FOR THE REPAIR OF SPCSP CULVERTS
WITH FIBRE-REINFORCED SHOTCRETE**

1.0 GENERAL

1.1 INTRODUCTION

This specification is for the structural repair of Structural Plate Corrugated Steel Pipe by constructing pneumatically applied steel fibre-reinforced concrete mortar beams along cracked longitudinal seams. The work shall be done by the dry process shotcrete method using an approved pre-bagged mix. Drawing S-1476 shows the typical dimensions of the shotcrete beam to be constructed.

1.2 WORKERS' QUALIFICATIONS

The work shall be performed by qualified personnel. The crew foreman and nozzleman shall each have at least five years of experience in shotcreting. The low bidder will be required to complete the "Shotcrete Experience" form which must meet the Engineer's approval before the tender will be accepted. The form shall include the names and phone numbers of past supervisors and employers, as well as brief descriptions of the type and extent of the foreman and nozzlemen's shotcrete experience, and any related certification or training. The approved foreman and nozzlemen shall not be replaced by others without the prior written approval of the Engineer.

1.3 PRE-QUALIFICATION OF NOZZLEMEN AND PRE-BAGGED MIX

At least two weeks prior to commencement of the work, the Contractor shall shoot shotcrete test slabs of 400 x 400 x 75 mm minimum size on unenclosed plywood forms. The shooting of these pre-qualification test slabs will be observed by the Engineer, and it is the responsibility of the Contractor to give the Engineer at least 48 hours notice. Test shooting not witnessed by the Engineer will be deemed invalid. One test slab will be required for each proposed pre-bagged mix, with an additional slab required for each nozzleman.

Contractor shall field cure the test slabs in accordance with Section 5.3.2, "Field Curing", of the current CAN/CSA-A23.2 Specifications for 24 hours, and deliver the slabs to a certified engineering laboratory for testing. Cubes shall be cut from the test slabs and tested for compressive strength in accordance with the current CSA-A179 Specification.

A 7-day compressive strength of at least 40 MPa will be required in order for the proposed pre-bagged mix and nozzlemen to be approved. Shotcreting shall commence only after the required 7-day compressive strength is achieved, the cubes are found to be free of sand pockets, voids, and other defects, and the pre bagged mix and nozzlemen have been approved by the Engineer.

ALL costs of pre-qualification testing will be considered incidental to the Contract, and no separate or additional payment will be made.

2.0 MATERIALS

2.1 CEMENT

Normal Portland Cement, Type 10, conforming to the current CSA/CAN3-AS, Specification shall be used in the pre-bagged mix.

2.2 SILICA FUME

Silica fume shall meet all the requirements for Type U material, as specified in CAN/CSA-A23.5 "Supplementary Cementing Materials".

2.3 FINE AGGREGATE

The maximum allowable aggregate size is 6 mm, and the aggregate shall comply with the current CSA/CAN3-A23.1 Specification, "Section 5.3, Fine Aggregate". The aggregate shall be dried to a moisture content of 0.1% by mass or less.

2.4 STEEL FIBRE

Ribtec fibre shall be used. The fibre length shall be 25 mm and shall not contain any trace amounts of aluminum.

2.5 WATER

Mix water shall be of drinking water standards, free of chemical and organic impurities, and comply with the current CSA/CAN3-A23.1 Specification, "Section 4, Water".

2.6 MIX DESIGN

The mix design of the pre-bagged mix shall be submitted for approval to the Engineer prior to the mix being used on any of the work. The design minimum 28-day compressive strength shall be 50 MPa and the flexural strength 10 MPa. The pre-bagged mix shall contain a uniform concentration of 60 kg/m³ of an approved steel fibre. The mix may contain dry silica fume in the amount of 5 to 10% by weight of the cement. The mix shall be designed to allow for the addition of water at 3 to 6% by weight of dry mix prior to pumping. Strength accelerating admixtures will not be permitted, and other admixtures shall require the approval of the Engineer. The Contractor shall provide written reports, from an independent CSA certified testing laboratory, showing compliance with the following:

- (1) petrographic durability number for the aggregates shall be 115 or less.
- (2) CSA/CAN3-A23.1, 1-M77 regarding organic impurities, gradation of particle size, and durability.

The Contractor shall ensure that the pre-bagged mix meets the requirements of the approved mix design.

3.0 CONSTRUCTION

3.1 REINFORCING STEEL

U-brackets and reinforcing steel shall be supplied, fabricated and installed as shown on the drawings.

3.6 HOARDING AND HEATING

The pre-bagged mix and mixing water shall be stored in a heated enclosure so that a mix temperature of between 15°C and 25°C during shooting is obtained.

Hoarding and heating of the culvert shall be provided to maintain the air temperature between 15°C and 25°C, and the bond surface temperature between 50°C and 100°C during shooting and wet curing. These temperatures shall be maintained for at least 72 hours after the shooting is completed.

3.3 SURFACE PREPARATION

Light sandblasting of all bond surfaces and rusted reinforcing steel is required. Care shall be taken to not remove or damage the culvert plate galvanizing. Surface preparation shall be approved by the Engineer prior to shotcreting.

Before shotcreting on previously hardened shotcrete, the surface of the hardened shotcrete shall be sandblasted to remove all surface laitance and non-consolidated surface material to provide adequate bond.

Shotcreting shall not be done on frozen, icy, dirty, muddy or improperly prepared surfaces.

The bond strength between the shotcrete material and the galvanized steel plate, and between successive passes of shotcrete material, shall be at least 2.5 MPa at 7 days.

3.4 APPLICATION

Application procedures shall conform to requirements of the current ACI 506.2 "Specification for Materials, Proportioning, and Application of Shotcrete", and ACI506-R "Guide to Shotcrete".

The mix shall be uniformly pre-moistened prior to pumping, by the addition of water at 3 to 6% by weight of the mix.

The shotcrete shall be placed in such a manner that there will be no voids around the U-brackets or reinforcing steel. The Contractor shall expose the reinforcing steel or U-brackets for examination in randomly selected 150 mm x 150 mm areas of freshly placed shotcrete near the beginning of each shotcrete operation, or as directed by the Engineer. The presence of voids or sandpockets will result in rejection of the work. Shotcreting shall not resume until the nozzleman has satisfied the Engineer that all application procedures have been corrected. All test areas shall be repaired with shotcrete.

The thickness of the final lift of shotcrete shall be not less than 25 mm. Shotcrete shall not be placed on surfaces covered with rebound material.

All construction joints shall be cut vertical and square before the shotcrete has hardened. Before depositing new shotcrete against the hardened shotcrete, all overspray and rebound material shall be removed from the culvert surface and reinforcing steel, and the joint face shall be sandblasted.

3.5 DEPTH OF SHOTCRETE

The depth of shotcrete placed shall be as shown on the drawings. U-brackets with depth control rods (type "B") shall be installed to define the correct depth to which the shotcrete is to be placed. The type "B" U-brackets shall be placed at approximately 0.5 to 0.7 m intervals and are to be entirely covered by the shotcrete material. Additional type "B" U-brackets shall be installed as necessary to obtain the required curvature and straightness of the final surface.

During shotcreting, the Engineer will check the encasement of reinforcing bars and the shotcrete thickness by probing at random locations. Any shotcrete that falls off as a result of these measurements shall be replaced immediately by the Contractor.

3.6 SURFACE FINISH

The shotcrete surface finish shall be a natural gun finish. Exposed steel fibres will be acceptable. No further finishing will be required unless the final surfaces do not meet the trueness requirements of paragraph 3.7.

3.7 TRUENESS OF FINAL SURFACES

Final shotcrete surfaces shall be smooth, curved in the vertical direction and straight in the horizontal direction. The vertical curvature shall parallel the culvert plate being repaired. In order to achieve the required dimensions, the Contractor shall provide and use a template and other techniques as necessary. The tolerance for trueness of the final surface shall be plus or minus $(2L + 3)$ mm where L is the test length in metres. Finishing or grinding will be required to correct surfaces that do not meet this requirement.

3.8 PROTECTION FROM OVERSPRAY

The Contractor shall protect adjacent areas from overspray and rebound material. All overspray and rebound material shall be cleaned off as soon as possible before the material has set up. All damages resulting from overspray shall be repaired.

3.9 CURING

The Contractor shall provide continuous wet curing to the shotcreted surfaces for 60 hours, beginning no later than four hours after the fresh shotcrete has been placed, or when directed by the Engineer. The use of curing compound will not be permitted.

3.10 SITE CLEANUP AND ENVIRONMENTAL PROTECTION

The Contractor shall remove and dispose all overspray, rebound and other waste material, and leave the repair site and surrounding area in the same condition it was in prior to his work. Material shall not be permitted to enter the stream or be left on the ice surface. When shooting is done in the vicinity of a flowing stream or ice surface, the Contractor shall provide tarps, platforms and other enclosures to prevent all material except possibly fine dust from falling into the water or onto the ice surface.

Adequate environmental protection, to the satisfaction of the Engineer, shall be implemented by the Contractor prior to and during shotcreting.

Site clean-up to the Engineer's approval and evidence of adjacent landowners' approval of the clean-up where appropriate, will be required before final payment for the work will be made.

4.0 INSPECTION

4.1 BY DEPARTMENT

Inspection by the Department shall not relieve the Contractor of his responsibility for quality control.

4.3 NOTIFICATION

The Contractor shall notify the Engineer at least 48 hours in advance of shotcreting to allow for inspection and testing. Shotcreting shall not commence without the Engineer's approval of the surface preparation and ambient conditions.

4.3 COMPRESSIVE STRENGTH TESTING

The Contractor shall shoot test samples of at least 400 x 400 x 75 mm in size on plywood forms at varying nozzle angles, at the beginning of each shooting operation, and at 5 m intervals along the length of the culvert seam repair, or at intervals as directed by the Engineer. The Contractor shall field cure the test samples for 48 to 96 hours in accordance with Section 5.3.2, "Field Curing" of the current CSA Standard A23.2-3C, or as directed by the Engineer.

The Contractor will transport the field cured samples to a certified engineering testing laboratory where cubes will be cut from the samples, moist cured at 23±2°C and tested for 28-day compressive strength in accordance with the current CSA A179 Specification. Cubes will be immersed in water at room temperature for 48 hours prior to testing.

The Contractor will supply the plywood forms, deliver the samples to the testing laboratory, and assume all costs for lab curing, cutting and testing. All other costs associated with testing, such as shooting and field curing the test slabs shall be the responsibility of the Contractor.

4.4 CORING

The Contractor may be allowed to extract core samples from any shotcrete which has failed to meet the required 50 MPa 28-day compressive strength. If coring is approved by the Engineer, arrangements shall be made by the Contractor, through the Engineer, to employ an independent, qualified testing lab.

The Engineer will identify the core locations to ensure that the cores represent the same shotcrete as the test samples. The cores shall be tested within 7 days of the 28-day cube tests. The average compressive strength of three adjacent cores taken from one location shall constitute a test. Cores shall be tested in accordance with the CSA/CAN3-A23.2-14C Specification. The core test will be considered representative of the shotcrete tested by the original cubes.

Shotcrete core strength results, whether higher or lower, shall over-rule the cube test results, and shall be used as the basis for acceptance of and payment for the shotcrete.

If the core strengths indicate the shotcrete in question meets the 50 MPa strength requirement of this specification, the Department will assume the cost of the coring and core-testing, however if the shotcrete fails to meet the 50 MPa strength requirement, the Contractor shall be responsible for all costs of coring and core testing.

All core holes shall be patched with an approved 50 MPa concrete patching material and properly cured at the Contractor's expense.

4.5 RIGHT OF REJECTION

The Engineer reserves the right to reject any unacceptable work including shotcrete that has low bond strength or has debonded, surface cracks, voids, sand pockets or trapped rebound, or is flawed by incorrect method of encasing reinforcing bars with shotcrete, does not meet minimum thickness requirement, or does not meet the 50 MPa compressive strength requirement. The Contractor shall immediately correct all deficiencies, including supplying and replacing the reinforcing steel and anchors and U-brackets if required, at no cost to the Department.

5.0 PAYMENT

5.1 MEASUREMENT AND PAYMENT

Payment for "Shotcrete Beam" will be made at the unit price bid per lineal metre, and shall include full compensation for the cost of pre-qualification testing, all materials, tools, equipment, forms, labour, de-watering, de-icing, heating, surface finishing, cleanup, and all other items of expense required to acceptably complete the shotcrete beam as shown and specified.

The number of metres of "Shotcrete Beam" to be paid for will be the total number of lineal metres of shotcrete beam satisfactorily placed as specified or directed by the Engineer, and conforming to the required dimensions as shown on Drawing S1476.

If shotcrete fails to fully meet the specified strength requirements, the Engineer, at his discretion, may either reject the shotcrete, or accept it at a reduced payment, in accordance with the following schedule.

**28-Day Compressive
Strength Attained**

50 MPa and Over.....	Full Bid Price
48 MPa up to 50 MPa.....	Bid price less \$120/lin. metre
46 MPa up to 48 MPa.....	Bid price less \$240/lin. metre
44 MPa up to 46 MPa.....	Bid price less \$360/lin. metre
42 MPa up to 44 MPa.....	Bid price less \$480/lin. metre
40 MPa up to 42 MPa.....	Bid price less \$600/lin. metre
All shotcrete below 40 MPa will be rejected.	

The reduced payment shall apply to the 5 m length of shotcrete beam represented by the strength test. Where the shotcrete beam length does not divide evenly into 5 m segments, a strength test will be made to represent the remaining length of shotcrete beam.

SHOTCRETE EXPERIENCE

Site Foreman (minimum 5 years required)

Name: _____

Summarize and describe total relevant experience: _____

Shotcrete History:

<u>Company Name</u>	<u>Position</u>	<u>Duties</u>	<u>Dates</u>	<u>Supervisor's Name</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Nozzleman (minimum 5 years required)

Name: _____

<u>Company Name</u>	<u>Position</u>	<u>Duties</u>	<u>Dates</u>	<u>Supervisor's Name</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____