REPAIR MANUAL FOR CONCRETE BRIDGE ELEMENTS

Version 2.0

Bridge Engineering Section
Technical Standards Branch
Alberta Infrastructure and Transportation

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Preface to Original Version 1.0

Technical Standards Branch

REPAIR MANUAL FOR CONCRETE BRIDGE ELEMENTS

(Version 1.0)

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1.0 Introduction

Concrete girders are frequently damaged by over-height impacts, fire or corrosion. Minor damage to the girders can consist of cracking or shallow spalls, whereas serious damage can extend to concrete, reinforcing steel and prestressing steel. Minor damage can affect the bridge's aesthetic appearance and long term durability, while severe damage can compromise the structural capacity of the bridge. Regardless of the degree of severity of damage, loose concrete from a damaged girder has the potential to fall onto the road and could result in injury to motorists or damage to vehicles.

This manual provides a guideline for assessing damage to concrete girders due to an impact by a high load collision, fire damage or corrosion. The manual also includes standard techniques and procedures that may be used to repair the damaged concrete bridge girders. An important part of dealing with damage to a concrete girder requires immediate attention, such as removing loose concrete from the damaged girder, putting up netting around the impacted area and determining if load restrictions for the bridge are required.

2.0 Immediate Actions Required After Damage to a Concrete Girder

When damage to a concrete bridge girder occurs, the first action is to remove all debris on the road. It is also necessary to remove loose concrete and debris from the damaged girders. It may be necessary to provide wire mesh netting on the bottom of the damaged girder flanges to retain any fragments that become dislodged due to subsequent live load deflection.

It may be necessary to post a load limit and utilize barricades or barriers to direct traffic away from the damaged area on the bridge. This is particularly necessary when the bridgerail is damaged, part of the bridge is no longer adequately supported by the girder, or there is structural damage to the deck. The requirement for barricades should be assessed at the time of initial inspection.

3.0 Investigation of Site and Assessment of Damage

An initial assessment of the bridge is required to identify the location, extent and degree of damage incurred to the girder(s). The spans and girders are to be numbered according to Department convention, increasing from south to north and from west to east along the general direction of the road. The bridge shall be inspected for unusual deflections and mis-alignments. It shall also be determined if the damages require load restrictions to be imposed. Damage may have occurred resulting in spalls or cracks in the concrete. There may also be damage to reinforcing steel, prestressing strands or other bridge components.

3.1 High Load Damage

High load damage may be classified as surface, minor, moderate, or severe. The assessment of the extent of damage to a girder is described below:

3.1.1 Surface Damage

These are surface scrapes and small nicks less than 6 mm deep. This type of damage does not warrant repairs unless it is associated with other bridge maintenance repairs.

3.1.2 Minor Damage

This is defined as isolated concrete cracks, nicks and spalls up to 30 mm deep with no reinforcing or prestressing strands exposed. Minor damage adversely affects the aesthetics, however the structural capacity is not reduced. It is important to restore concrete cover in order to prevent reinforcing steel from eventually becoming exposed and corroded.

3.1.3 Moderate Damage

Moderate damage consists of concrete cracks and wide spalls exposing reinforcing steel and prestressing strand. There is no immediate effect on the structural capacity. Although cracks and exposed reinforcement can reduce structure life due to corrosion and freeze thaw action.

3.1.4 Severe Damage

This includes exposed and damaged prestressing strands and reinforcing steel along with loss of significant cross section and possible lateral mis-alignment due to girder distortion.

3.2 Fire Damage

It is important to estimate the flame temperature in order to determine the extent of fire damage. The flame temperature can be estimated by assessing the damage on surrounding material, or it can be estimated more accurately with the use of available computer software.

3.2.1 Temperature Effects on Concrete

3.2.1.1 General

Moisture trapped in capillary and gel pores may form superheated steam and create a damaging force when it cannot escape. “Moisture clog spalling” occurs when moisture migrates from hot to cold through a relatively impermeable concrete. The resulting bursting pressure causes spalling at the hot surface. During fire suppression, water quenching exacerbates thermal shock resulting in micro-cracking and strength loss. The chemistry of concrete at various temperatures is described below:

- At 100°C - loss of free uncombined water from cement paste with little damaging effect.
- At 100° to 150°C - loss of chemically bonded water commences above 100°C. Dehydration and paste shrinkage occurs along with thermal incompatibility between paste and aggregate. Aggregate deterioration results in micro-cracking and worsening of physical properties.
- Above 400°C - calcium hydroxide in the cement paste dehydrates to calcium oxide that on contact with water, as in fire suppression, rehydrates to a damaging 14% increase in volume.
- From 400° to 800°C - gradual, irreversible dehydration of silicate in cement paste. The practical end point for concrete is approximately 540°C, beyond which the concrete becomes friable, porous and can usually be broken down easily.

3.2.1.2 Physical Properties

- Significant loss of compressive strength after cooling from elevated temperature; about 30-40% for siliceous aggregate concrete after heating to 300°C.
- Significant loss of modulus of elasticity; approximately 40% at 300°C and 50% at 540°C.
- Increased creep and stress relaxation at elevated temperature. At 300°C the observed creep rate was three times those at 125°C. Stress relaxation tests under constant strain for five hours resulted in stress reduction of 2, 32 and 74% at 24, 315 and 650°C respectively.

3.2.2 Temperature Effects on Reinforcing Steel

Normal reinforcing steel looses yield strength with increase in temperature; the loss is about 50% at 600°C. The modulus of elasticity also reduces significantly at elevated temperatures. However, the original properties are recovered on cooling provided the maximum temperature has not exceeded the austenitic transformation temperature of 720°C for a period long enough for significant grain size coarsening.

3.2.3 Temperature Effects on Prestressing Strand

Prestressing strands loose ultimate strength more sharply with an increase in temperature as compared to reinforcing steel. The loss is about 50% at 430°C. Creep and the potential for stress relaxation also increases with rise in temperature. Unlike normal hot-rolled steel, cold drawn steels do not recover the original properties, even on slow cooling because of the highly elongated grain structure which is responsible for its superior strength. The greater the magnitude and duration of the elevated temperature, the greater the weakening effect. Under rapid cooling, such as quenching by water in fire suppression, severe embrittlement can be induced by the formation of martensitic structure, which in the extreme case produces glass like brittle behavior.

3.2.4 Temperature Effects on Concrete-Steel Interaction

3.2.4.1 Bond

The bond between steel and concrete starts to deteriorate above 315°C. When areas of reinforcing steel have been exposed by spalling, bond in the adjacent covered steel may be adversely affected because of the much greater thermal conductivity of steel compared with the cover concrete.

3.2.4.2 Thermal Expansion Consideration

The coefficients of thermal expansion of concrete and reinforcing steel are similar at normal service temperature; however they become increasingly dissimilar as temperature rises. Differential thermal expansion between concrete and steel produces considerable tangential (bursting) stresses in prestressed concrete.

3.3 Corrosion Damage

It is vital to determine the full extent of corrosion damage on prestressing strands. When corrosion damage is suspected, concrete removal is required to visually assess the extent of damage to prestressing strands. There may be severe pitting or actual breakage of strand wires. Load carrying capacity may be jeopardized with strand damage. Due to stress corrosion phenomena, corrosion of stressed strand may accelerate much faster than corrosion of rebar. Pitting is not acceptable on prestressing strand.

4.0 Inspection

High load damage inspection and corrosion investigations are usually visual. For fire damage, visual inspection may be supplemented with non-destructive and destructive testing methods.

4.1 Visual Inspection

4.1.1 Spalls

Spalls are the removal or loss of concrete from the girder and may range in extent from being minor to severe. With minor spalls the aggregate within the concrete is exposed, whereas moderate spalls are deeper and the prestressing strands or reinforcing steel is exposed. With severe damage, spalls will be deep and the inner structure of the girder is not only exposed but may also be damaged.

Spalling is more prevalent in light weight concrete and the aggregate exposed is more porous, which can lead to freeze thaw damage that would not occur in normal concrete.

The location, size and severity of each spall on all the affected girders shall be identified.

4.1.2 Cracks

A crack is defined as a separation of parts. Cracks are identified according to their width as follows:

- Hairline – less than 0.1 mm
- Narrow – ≥ 0.1 mm and < 0.3 mm.
- Medium – ≥ 0.3 mm and < 1.0 mm
- Wide – ≥ 1.0 mm

The width, location and length of all cracks shall be noted.

4.1.3 Damage to Reinforcing Steel and Prestressing Strands

When a girder is severely damaged, the spalls are large enough to expose and possibly damage the reinforcing steel and prestressing strands. Damaged reinforcing steel, nicked, partially severed, or severed stressing strands shall be reported.

4.1.4 Other Bridge Components

In addition to damaging the precast concrete girders, a high load impact may also damage the diaphragms (steel or concrete), deck, grout keys and the bridgerail. Damages to other bridge components shall also be reported.

4.1.5 Changes in Concrete Damaged by Fire

It is sometimes possible to determine the temperature to which the concrete was heated by its colour. The common changes associated with dehydration of cement paste may occur as follows:

- Up to 100°C – Little or no concrete damage, no change in colour. Paste expands with loss of some free water.
- 250°C – Localized cracks. Paste is dehydrating with complete loss of free water causing about ½% decrease in volume.

- 300 to 600°C – Serious cracking of paste and aggregate due to expansion. Colour changes to pink.
- > 600°C – Cement paste is completely dehydrated with severe shrinkage cracking and honeycombing. Concrete may begin to be friable and porous. Colour changes to gray.
- 900°C – Colour changes to buff.
- 1200°C – Components of concrete begin to melt.
- 1400°C – Concrete is completely melted.

4.1.6 Destructive and Non-Destructive Inspection

Destructive and non-destructive test methods generally used for assessing fire damages are as follows:

4.1.6.1 Material and Strength Testing of Prestressing Strands

If the concrete temperature exceeded 1200°C, there will be severe damage and it may be necessary to retrieve a sample of the prestressing strand in the damaged area to determine the material and strength properties and compare them with the requirements of ASTM A416.

4.1.6.2 Hardness Testing

Limits of areas damaged by fire can be determined using an impact hammer. An average impact hammer reading should first be obtained in the un-damaged areas for each type of unit. Readings in the damaged areas will generally be substantially lower than those in the undamaged areas. By taking a large number of readings throughout the areas suspected of damage, the severely damaged areas can be identified.

4.1.6.3 Concrete Cores

To identify the extent of damage a sufficient number of cores, as determined by the Engineer, shall be retrieved from concrete areas distressed by heat to perform testing for compressive strength and pretrographic analysis. The areas to be tested can be determined by Hardness Testing.

In this document, the “Engineer” shall mean the Professional Engineer or Engineering Technologist designated by the Department to administer the work.

5.0 Repair Practices for Damaged Precast Concrete Girders

5.1 Traffic Accommodation

In addition to the Department's requirements for "Accommodation of Traffic" in the general specifications of the current version of the **Specifications for Bridge Construction** and the requirements of the current version of the **Traffic Accommodation in Work Zones** documents, the following specific requirements shall also be considered:

- Arrow boards, signs and barriers.
- Flag person(s) and night watchman.
- Vertical clearance and lane width.
- Hours and days not to disrupt traffic.
- Speed limit.
- Suspension of work.
- Traffic lights.

5.2 Repair Materials

5.2.1 Patching Products

All patching products shall be from the Department's current approved product lists and shall meet the requirements of the "Specification for the Supply of Concrete Patching Materials".

5.2.2 Sealers

Penetrating sealer shall be Type 1c, whereas pigmented sealer shall be Type 3. Sealers shall be from the Department's current approved product list meeting the requirements of the "Specifications for Concrete Sealers".

5.2.3 Concrete

Concrete shall conform to the original requirements of the element being repaired with the following modifications:

- Coarse aggregate size shall not exceed 10 mm.
- Standard weight concrete shall be used.

The concrete mix shall have a high slump obtained with a superplasticizer. The mix design shall be submitted to the Engineer for review prior to commencement of work.

5.2.4 Concrete Bonding Agent

The bonding agent used for concrete spall repairs shall meet the requirements of ASTM C1059 Type II.

5.2.5 Epoxy for Crack Injection

The epoxy for crack injection shall meet the requirements of ASTM C881 Type IV, Grade 1, Class B or C. The viscosity shall not exceed 500 CPS. Duralcrete LV or approved equivalent shall be used.

5.2.6 Reinforcing Steel

Reinforcing steel shall be weldable and meet the requirements of G30.18, Grade 400W. Epoxy-coated reinforcing steel shall be prepared and coated according to the requirements of ASTM A775 and the Ontario Provincial Standard Specification OPSS 1442.

5.2.7 Prestressing Strand

Prestressing strand shall be low relaxation and shall conform to the requirements of ASTM 416 or A421.

5.2.8 Dywidag Bars

Dywidag Threadbars shall be hot rolled conforming to the requirements of CSA G279. For external stressing, Dywidag Bars shall be hot dip galvanized conforming to the requirements of CSA G164.

5.2.9 Miscellaneous Steel

Miscellaneous steel shall meet the requirements of CSA Standard G40.21 300W or ASTM A36. The exposed steel shall be hot dip galvanized as per CSA G164.

5.3 Procedure for Restoration of Damaged Prestressed Concrete Girders

Repair of damaged concrete girders is undertaken to re-establish the structural integrity of the bridge, and to restore the original uniform appearance of the girder. The repair procedure depends on the extent of damage to the girder, as assessed by the Engineer.

The following steps shall be undertaken for a successful repair:

5.3.1 Removal of Unsound Concrete

All loose and delaminated concrete shall be removed from the girder by using hand tools (i.e. bush hammer, chisel etc.). The repair area shall be thoroughly cleaned of foreign material to provide a sound bonding surface. Care shall be taken not to damage adjacent areas of sound concrete, reinforcing steel, stressing strand or other bridge components. Stressing strand inadvertently damaged shall be removed and repaired. A netting or work platform shall be provided to catch all loose material. Concrete with fractured seams and fissures, which cannot be effectively epoxy injected shall also be removed. Where prestressing strands or reinforcing steel are exposed, sufficient concrete shall be removed to provide 20 mm exposure all around. The perimeter edges of all patch areas are to be saw cut to a depth of 20 mm depth to prevent feathered edges. Additional sound concrete may be removed for the purpose of repairs, when approved by the Engineer.

5.3.2 Restoration of Reinforcing Steel and Prestressing Strands

All damaged reinforcing steel shall be straightened or replaced. Broken reinforcing steel shall be spliced with a bar of equal diameter and provided with the minimum design lap length. Mechanical splice devices may be used provided the concrete cover requirement is not compromised. Welding shall be done only if the existing bars are weldable, and low hydrogen CWB approved procedures and certified welders are used. Care must be taken to ensure that all prestressing strands are protected from heat and spatter during welding. When corroded reinforcing steel or prestressing strand is exposed during chipping, further chipping is required until clean, non-corroded steel has been encountered. Additional reinforcing steel may be required to compensate for corrosion section loss. Prestressing strands with corrosion damage may need to be spliced and stressed or external systems such as Dywidag Bars may be required. A minimum of 25 mm cover on the reinforcing steel shall be maintained.

5.3.3 Splicing and Restressing Prestressing Strands

Damaged prestressing strands shall be spliced and restressed to an effective prestress of 60 % of ultimate strand strength (F_{pu}).

Sixty percent ultimate strength (0.6 F_{pu}) for 0.5” diameter / 270 K strand is 111.2 kN (25,000 lbs).

Details of specialized equipment and procedures for restressing of broken strand shall be carried out as follows:

Preparation for Splicing

- Chip out and remove all unsound concrete. The minimum length of the “concrete blockout” required to attach and operate all the devices is estimated to be approximately 1.7 m.
- Saw cut the broken strand to remove any frayed or distorted areas. Leave at least 100 mm of strand exposed beyond the edge of the concrete “blockout” (See Figure 1).
- Figures 2 and 3 show a coupler, stressing gauge and tensioning device placed in this sequence. The arrangement for these devices may be

changed if it is more convenient. The stressing gauge requires a 570 mm (22.5”) length of exposed strand. The stressing gauge may be mounted either on existing or on new replacement strand.

Coupler Assembly (Fig. 2 & SK1)

- The coupler assembly consists of threaded chucks, wedges, tapered springs, threaded barrel and a plastic cap.
- Place strand coupler over one end of existing strand at Damaged Girder End “A”.
- Place the new strand from the other end of the coupler until it butts with the end of the existing strand. Tighten the threaded chucks.

New Strand

- The length of new strand shall be determined by holding the new length of strand against the existing exposed strand at Damaged Girder End “B”. Mark and cut the new strand to achieve a gap of 550 mm between the ends of the new strand and the existing strand (See Figure 2).

Tensioning Device Assembly (Fig. 3 & SK2)

- The tensioning device “Grab It” has threads of very close tolerance. This device must be handled carefully as the necessary tension cannot be obtained with damaged or dirty threads. It consists of chucks, wedges, springs, coupler bolts and a coupler nut.
- Insert the existing and new strand into the wedges encased in the chuck body. The strand should project about 6 mm beyond the wedges prior to being loaded. Hand-tighten until all slack is removed.

Stressing Gauge (Fig. 3 & SK3)

- The stressing gauge consists of a 430 mm (17”) long steel rod mounted on a steel plate c/w hook bolts (sub-assembly “C”), 457 mm (18”) long plastic tube, and a dial gauge mounted on a steel plate c/w hook bolts (sub-assembly “D”).
- Mount sub-assembly “C” on to the strand using the hook bolts. Slide the plastic tube over the steel rod and mount sub-assembly “D” on to the strand using the hook bolts. The plastic tube must be fitted over the two sub-assemblies each pushed tightly against the ends of the plastic tube, as the hook bolts are tightened.
- Orient the complete assembly such that the dial indicator can be easily viewed during stressing.
- This operation moves the dial and should be done gently to avoid damage. The dial and the rod portion of the stressing gauge should be aligned by eye until they are parallel to each other.
- Ensure both sets of hook bolts are finger tight. Do not use pliers or other mechanical means. Loosen the set screws and set the face of the dial indicator such that “0” is opposite to the pointer. After this operation is

complete, do not touch the stressing gauge until the strand has been stressed and it is time to remove the device. Twisting or changing the dial indicator will affect the load measured.

Stressing Operation

- Turn the tensioning nut while the tensioning bolts are held by wrenches until the wrenches jam against the girder or another strand. Begin tightening the tensioning nut.
- Once the slack is taken out of the system and the anchors are set, 4.448 kN (1000 lbs) of tension will be added for every 0.1 mm (0.004") movement registered on the dial gauge. To obtain the necessary 111.2 kN (25,000 lbs), the needle of the dial gauge must make one full revolution (100 thousands of an inch) back to zero. A four foot long snipe should be used on the handle of the wrench due to the stressing device not being easy to turn near the full load. Tightening of the stressing device is time consuming since only a fraction of a turn can be obtained for each position of the wrench.
- If it is not possible to obtain the 111.2 kN (25,000 lbs) load, read the dial indicator to determine the load obtained. The Engineer will determine whether the load is acceptable or if the stressing must be redone.
- Once the stressing is complete and accepted, remove the two portions of the stressing gauge. The remaining devices are cast into the new concrete.

Where splicing of several prestressing strands is required, it is important to stagger the couplers in order to avoid congestion. Straight and deflected prestressing strands must be restored to their original positions. Modified deflection brackets may be required and shall maintain required positions until the concrete has been cast.

5.3.4 Preload

The damaged girder(s) shall be preloaded when the damage is assessed as "Moderate" or "Severe" or as determined by the Engineer to open up the cracks and to create compression in replacement concrete after unloading. The preload shall be applied prior to restressing. The required preloading mass will vary. It should be sufficient to achieve the following approximate deflections:

Span (m)	Deflection (mm)
24	10
30	15
36	20
42	25

The preloading mass shall be uniformly distributed over the centre half of the girder and the Engineer must be present to monitor the preloading operation in order to make necessary adjustments as deemed necessary. The preload must stay in place until all the concrete patching or recasting, and any crack injection is completed. The above Span – Deflection table is provided as a guide. The Engineer must provide the actual load and deflection values.

5.3.5 Brush Blasting

Concrete restoration areas including reinforcing steel and prestressing strands shall be brush blasted prior to recasting.

5.3.6 Formwork

Recasting of the damaged portion of the girder shall be done by using steel forms or new plywood material, such as “Coated Formply”, “Pour Form 107”, “Ultraform” or approved equivalent. The formwork must be water tight when high slump concrete is used. The formwork and bracing system shall be adequately designed to withstand concrete pressures. The method of formwork attachment, including the bracing system must be approved by the Engineer. The formwork shall be of such quality that the recasting shall be to the original girder lines. The preferred method of attachment is to suspend the formwork with supports from inserts installed in the deck underside rather than drilling holes through the deck or in the girders.

5.3.7 Casting Concrete

All large damaged areas shall be re-cast to accurately restore the original lines of the girder. High slump concrete shall be pumped through the pour access holes. Spacing for pour access holes shall not exceed 600 mm. Smaller pencil vibrators which will get between the prestressing strands shall be used to achieve proper consolidation. The maximum time allowed for the concrete to be delivered to the site and discharged shall not exceed 70 minutes.

The concrete casting shall not commence if the ambient air temperature is or is expected to be below 5°C unless suitable heating and hoarding and insulated tarps are employed.

5.3.8 Formwork Removal

Curing requirements may be waived when the formwork is left in place for 72 hours or more. Formwork shall not be removed until the poured concrete has attained 80% of the 28 day strength.

Straightness of the cast surfaces shall be measured by the use of straight edge or string line placed parallel to and 10 mm away from the surface to be measured. The tolerance for straightness in any direction along the finished surface shall be 0.3L + 3 mm where L is the length of repairs in meters. Chipping and re-casting will be required in the event surface trueness exceeds this requirement.

5.3.9 Thin Patches

The damaged concrete surfaces must be cleaned of all loose material. All edges of patches shall be squared by saw cutting to a minimum depth of 20 mm. If reinforcing steel has not been exposed and spalls are deeper than 40 mm, galvanized wire mesh attached to 6 mm diameter drop-in anchors for extra anchorage shall be installed. A bonding agent shall be applied immediately prior to placing the patch. Approved patching materials shall be used. The finished surfaces are to be smooth and straight without visible marks from trowelling. If necessary, all repaired areas shall receive an approved pigmented sealer which matches the colour of the adjacent concrete.

5.3.10 Crack Repair

All cracks shall be repaired. Cracks $\geq$ 0.2 mm shall be injected full depth with an approved epoxy resin. Shrinkage cracks on the perimeter of the patches shall be injected. Cracks shall be temporarily caulked to prevent ingress of any contaminant when repairs are not expected to be done within 90 days of the damage. Cracks may require flushing if there is evidence of any contamination.

Injection ports shall be removable and insert type. The pressure capacity of the injection ports shall be at least equal to the maximum operating pressure of the pump. All injection ports shall be equipped with caps or other mechanical means of closure under pressure. The spacing between the ports along the length of the crack shall not exceed 150 mm. Ports shall be alternated from one side of the crack to the other for full depth cracks. An epoxy mortar binder shall be applied between the injection ports to temporarily seal the crack surface. The temporary sealer shall be capable of containing the injected resin system. The gel shall be allowed to harden before proceeding with grouting.

Injection shall be performed from one side for a full depth crack with the back side used only for inspection ports. Injection shall begin at the lower entry port and continue until there is evidence of the adhesive at the port directly above or adjacent to the port being pumped. Injection pressures shall be attained prior to opening subsequent injection ports to assure complete penetration of the epoxy resin with the entire crack area. The injection shall then be discontinued on the port being pumped and the port shall be sealed. The injector shall be transferred to the next port and injection shall be continued until the crack is completely filled. The manufacturer's recommendations for the epoxy adhesive shall be strictly followed as to the requirements for safety precautions in handling the epoxy, storage of the material, mix proportions of the two components and application temperatures.

Cracks smaller than 0.2 mm shall be sealed twice with 150 mm wide application of an approved penetrating sealer. However for exterior girders the penetrating sealer requirements shall be omitted, when surfaces are to be coated with pigmented sealer.

5.3.11 Surface Finish

Holes left following the removal of injection ports shall be filled with non-shrink grout. When all work associated with a crack repair is completed and the materials have dried and cured, the crack repair areas shall be ground smooth to match the surrounding concrete.

Concrete surfaces shall be finished immediately after form removal. All exterior surfaces shall be given a Class 2 rubbed finish.

5.3.12 Site Clean-Up

All debris, forms and other waste material shall be removed. The site and the surrounding area shall be left in the same condition it was prior to the damage and repair work.

5.3.13 Testing

Concrete shall be tested for air, slump, temperature and compressive strength. Six cylinders are to be cast (three for testing requirements for form and preload release and three for 28 day strength test requirements).

6.0 Inspection Requirements

The Engineer is required to inspect the repairs to ensure compliance to Department standards and specifications. The following is a list of the inspection requirements:

- Coordinate and conduct a pre-job meeting and other milestone meetings.
- Review and approve all traffic accommodation proposals and ensure safety requirements are maintained.
- Conduct survey of deck to establish profiles of damaged and undamaged girder lines.
- Ensure field repair is carried out in accordance with approved procedures.
- Monitor application of preload.
- Ensure approved materials are used for each phase of construction.
- Monitor the repair of the damage for the entire girder section.
- Monitor epoxy injection into cracks.
- Inspect coating application.
- Check final clean up.

7.0 Contact

Questions or further information on this manual may be directed to Abdul Waheed, P. Eng., Bridge Fabrication Standards Specialist, Alberta Transportation, (780) 415-1019.

High load damage assessment needs to identify the full extent of damages. Barricades may be required to direct traffic from damaged areas. Load restrictions may be required.

Loose fractured concrete needs to be removed from girder sections and concrete rubble needs to be removed from the roadway.

Netting may need to be installed to ensure that loosened concrete fragments do not fall onto the roadway below.

Fractured / displaced concrete sections need to be recast to original girder sections.

Damaged girders shall be preloaded to open cracks and create compression in replacement concrete after unloading.

Preload mass is set centered over the damaged girder sections. Fractured and spalled sections of concrete are removed.


Loose, delaminated concrete shall be removed using small tools – care exercised to ensure that prestressing strands are not damaged.


Displaced deflected strands must be positioned according to design details. Modified deflection brackets may be required to achieve design attributes.


Damaged strands shall be spliced and re-stressed to initial design tension of 128.5 kN. Splices shall be staggered to avoid congestion.


Strand repair tension loads are applied to initial design values using dial gauges and devices to monitor elongations at accuracy of 1/1000 of an inch or 0.100”.


Damaged portions of girders shall be recast to restore the original lines. Forming shall be new plywood materials such as “Coated Formply” Evans 107, or approved equivalent – or steel forms.


Showing steel form fabrication for recasting girder leg section.

Pumping concrete into plywood formed leg section. Spacing of pour access holes shall not exceed 600mm.

Concrete shall be vibrated to ensure consolidation around strand congestion.

Transit mix and concrete pump. Concrete must be placed, pumped within 70 minutes of being batched.

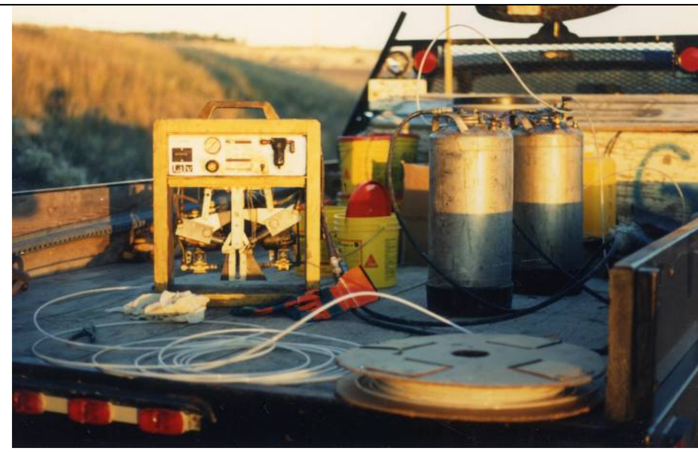
During cold weather, forms must be insulated.

Suitable heating and hoarding are required.

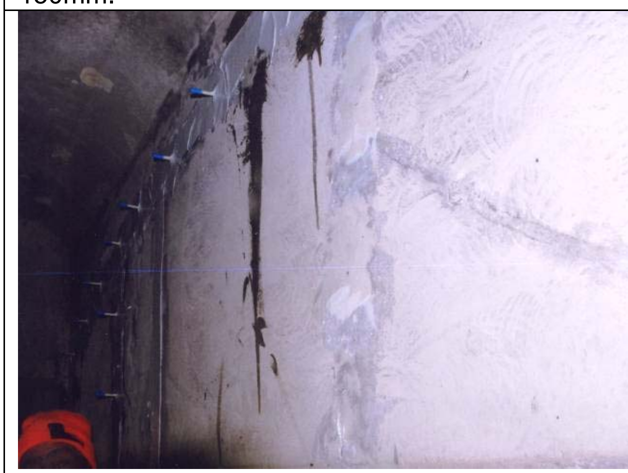
Cracks in concrete sections ≥0.3 mm shall be full depth pressure injected with approved epoxy resins.

Pour / cast perimeter lines shall be full depth pressure injected with epoxy resins.

Cracks shall be temporarily sealed and injection ports installed – spacing of the ports shall be maximum 150mm.



Epoxy resin pressure injection pump and component injection tanks.

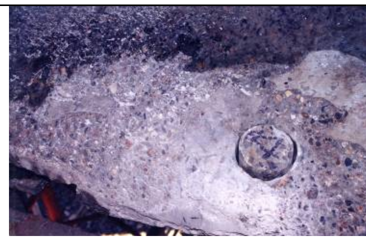


Following curing of the epoxy resin, ports and crack sealant shall be completely removed.

Concrete surfaces are to be finished to Class 2 rubbed finish and a matching pigmented sealer is to be applied to match existing finishes on exterior girders. Interior surfaces to receive an application of concrete sealer.

Corrosion damage to prestressed strands affects girder capacity. Investigate corrosion spall cracks to assess the extent of corrosion damage.

The effects of corrosion damage can result in loss of prestressing forces.

 Strand corrosion damage restored. Determine the extent of damage, splice and tension strands.	 Corrosion repairs to strands may be addressed by external post tensioning. Above, corbel block.	 External, galvanized Dywidag bars are post tensioned – strand corrosion repair.
 An assessment is required when concrete components have been damaged by fire. The color of concrete may indicate maximum exposed temperatures.	  Concrete cores may be required to determine color changes and to perform petrographic analysis and compressive strengths.	 Delamination sounding may be required on concrete elements. Hardness testing will aid to determine the extent of severe damage.
 Rebound hammer and core testing is performed to determine the extent of fire damage.	 Shotcrete repairs performed to restore the pier shaft.	 Prequalified contractors and quality inspection can produce excellent repairs.

PROCEDURE FOR SPLICING BROKEN STRANDS

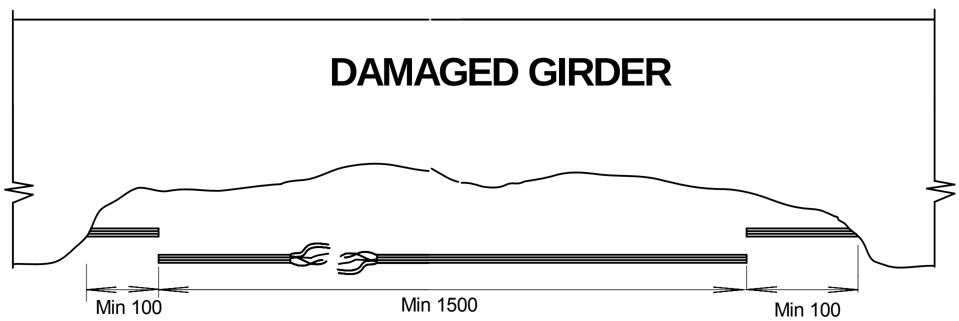


Fig 1

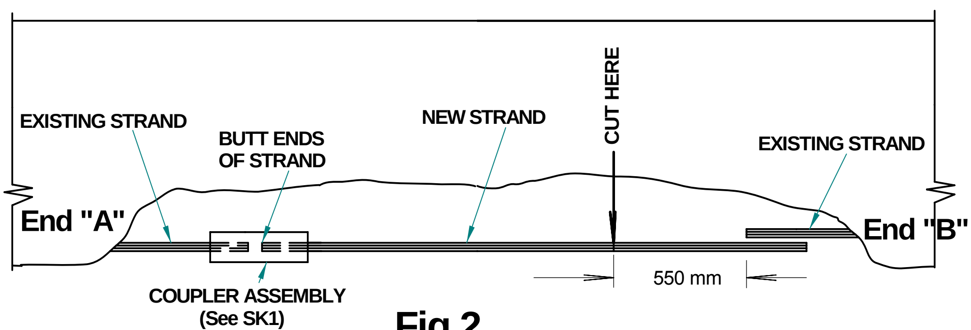


Fig 2

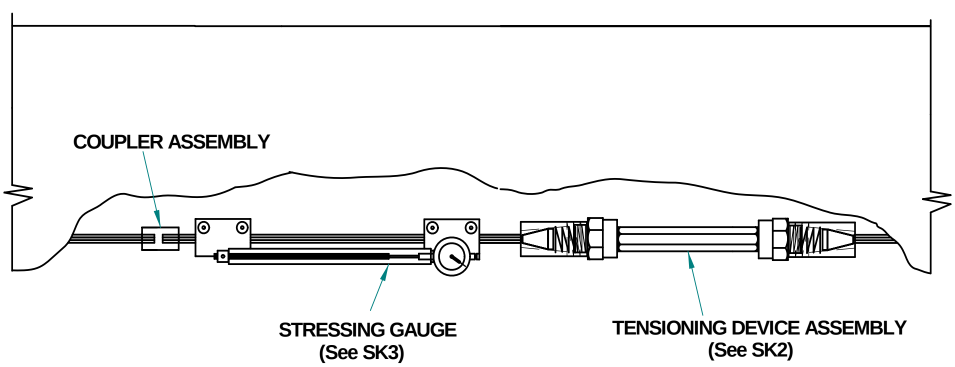
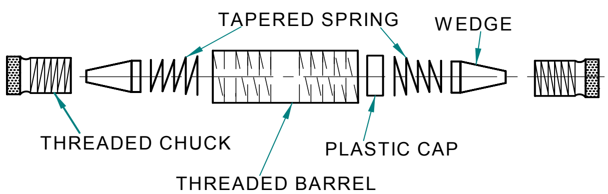
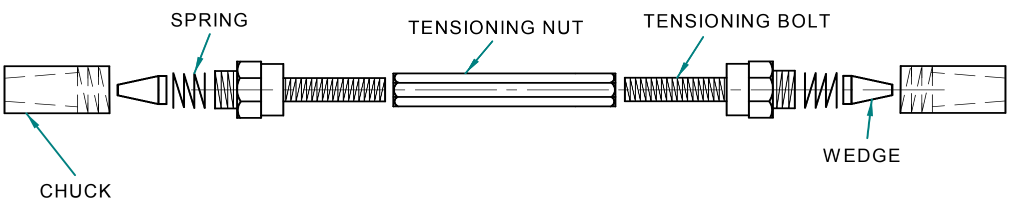


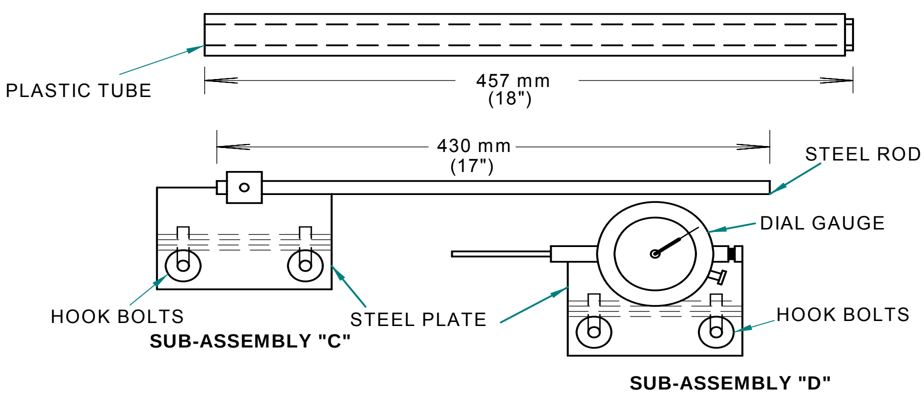
Fig 3



**COUPLER ASSEMBLY
(SK1)**



**TENSIONING DEVICE ASSEMBLY "Grab It"
(SK2)**



**STRESSING GAUGE
(SK3)**