3.0 CHAPTER 3 – COPPER SULFATE ELECTRODE TESTING (CSE2)

3.1 INTRODUCTION AND BACKGROUND

The Level 2 Copper Sulfate Electrode (CSE) test is a repeatable, non-destructive field test that measures the electrical potential between the steel reinforcement of the bridge and a reference electrode. CSE testing is performed on concrete decks that have a top mat of electrically continuous reinforcing steel.

3.1.1 THE CORROSION PROCESS

Corrosion of reinforcing steel in concrete is an electrochemical process. In new concrete where the pH is greater than 12, the reinforcing steel is in a passive state. However, concrete is a permeable material and chloride ions from de-icing salts diffuse into the concrete. Rebar corrosion begins once the concentration of chloride ions at the rebar is sufficient, or when the carbonation front reaches the rebar.

Numerous chemical corrosion cells develop on the surfaces of the reinforcing steel. Each corrosion cell has an anode and a cathode. The anode appears pitted, where iron ions are dissolving from the rebar. The cathode is oppositely charged and has no apparent corrosion, but is an essential component of the corrosion cell.

Chemical oxidation reactions occur at the anodes, where iron and oxygen chemically react. Hydrogen gas is given off as a byproduct of the chemical reduction reactions at the cathode. The cathodes and anodes must be electrically connected in order to act as a battery and generate electrical potential. The corrosion cells may be microcells, small and isolated on individual rebars, or large macrocells, such as an entire deck, where the top reinforcing mat is the anode and the bottom mat is the cathode.

The process of corrosion generates electrical potentials and corrosion currents. When numerous small cells are present within a given area, the resulting potentials represent an overall electrical picture. Electrical potential reflects the probability that corrosion is occurring, while current reflects the rate of the chemical reaction that is corroding the steel.

3.1.2 CSE TESTING IN ALBERTA

Since 1977, Alberta Transportation has been using CSE testing to help evaluate the condition of concrete bridge decks. Several structures were tested repeatedly to determine the cause of any variations in electrical potential. During these early years, the test method was refined and evolved into an economical procedure with highly repeatable results.

In the late 1970's and early 1980's an annual testing program was developed. Bridge sites were tested every few years on a rotation basis. Test results were collected and compiled in mainframe computers. This allowed the Department to observe historical trends and create prediction models. The quick and cost-effective nature of the test allowed 100 to 150 bridge sites to be tested annually by a single crew.

Today, approximately 500 bridge sites are regularly tested across Alberta and a tremendous database of test results has been collected. Several agencies outside Alberta use CSE testing to evaluate bridge decks just prior to rehabilitation, however, Alberta Transportation remains one of the few agencies that use CSE testing as a predictive tool for preventative maintenance programs.

3.1.3 THE PURPOSE OF CSE TESTING

CSE testing, also referred to as half-cell testing and copper-copper sulfate electrode testing, is used to determine the potential of corrosion in reinforcing steel. A CSE test at an individual location cannot determine whether corrosion is occurring at that particular location. Rather, it is the cumulative results of a number of tests over the deck that provides an indication of the underlying condition of the reinforcement. A group of active half-cell readings indicates a high probability of the presence of active corrosion, but they do not indicate a corrosion rate.

Test results from one year to another are compared to assess the advancement of corrosion and predict the future deck condition. Prediction models based on the CSE data are used to help determine the ideal time to rehabilitate a deck, use preventative maintenance (prior to any visible damage), or help evaluate the condition of a deck that is not visible, such as a deck that is covered with ACP or another protection system.

CSE data is also used to evaluate the effectiveness of various rehabilitation methods and protection systems such as membranes and overlays. CSE testing is ideally suited to testing large surfaces such as bridge decks as it is non-destructive, quick, and cost-effective in evaluating the deck condition.

3.1.4 INTERPRETATION OF CSE TEST RESULTS

CSE tests measure the electrical potential of the steel reinforcement within the bridge deck. The half-cell, also known as a reference electrode, acts as a reference point from which electrical potential measurements are made. The more negative the potential, the higher the probability that the steel is experiencing corrosion.

Alberta Transportation has been performing CSE tests since 1977. By combining CSE testing experience with field experience in repairing bridge decks, Alberta Transportation has developed a data interpretation scale:

0.000 V to -0.300 V = Inactive (very low probability of active corrosion)
-0.301 V to -0.400 V = Transition (good probability that corrosion is initiating)
-0.401 V to -0.800 V = Active (very high probability of active corrosion)

Note that -0.800 V is theoretically the most negative test result possible.

ASTM-C876, “Standard Test Method for Half-Cell Potentials for Reinforcing Steel in Concrete”, also describes CSE Testing and discusses the probability of corrosion relative to the CSE readings and defines inactive, uncertain, and active ranges in CSE test results. The ASTM ranges used are slightly different than those used by Alberta Transportation.

3.1.5 TESTING CYCLE

CSE testable concrete bridge decks in Alberta are generally tested on a four or five year rotation. Primary highway sites may be tested more often and isolated local road sites with low traffic volumes may be tested less often.

Sites may also be tested just prior to deck rehabilitation as well as shortly after rehabilitation. This testing can help establish baselines for predictive modeling and programming priorities.

3.2 ESSENTIAL TEST EQUIPMENT

The equipment used in CSE testing can vary depending on the size and number of the bridge decks being tested. Items such as drills, files, shovels, and extra water containers will aid the testing crew, but are not essential. Other equipment, including the copper-copper sulfate electrode half-cell, the voltmeter and the electrical lead wire are essential to CSE testing. This essential equipment is further described in the sections below.

Note that old test equipment, such as frayed electrical lead wires must be repaired regularly or replaced. Low voltmeter batteries can produce erroneous results. The batteries must be checked and charged regularly. It is recommended that spare batteries and chargers be available on site whenever possible.

3.2.1 THE COPPER-COPPER SULFATE ELECTRODE HALF-CELL

The copper-copper sulfate electrode half-cell is also called the reference electrode or the half-cell. The cell is a container that is filled with saturated copper sulfate solution. To ensure it is saturated, there should be solid blue crystals visible in the solution after mixing. Only use distilled water in the copper sulfate solution.

The cell should also have a porous base, typically made from unfired ceramic or porcelain, that remains wet through capillary action, and a copper rod or copper coil submerged in the solution at all times. The top of the copper rod is connected to a lead wire that plugs into the voltmeter.

If testing is done in cold conditions where the copper sulfate solution may begin to freeze, at approximately 5 ºC, add isopropyl alcohol (15% by volume) to the solution.

Copper sulfate, like all chemicals, should be treated as potentially hazardous. Wear gloves when directly handling copper sulfate. Do not ingest copper sulfate as it is toxic. The inspector must always have a Material Safety Data Sheet (MSDS) available for all crew members when dealing with copper sulfate.

3.2.1.1 Maintaining the Half-Cell

Check the half-cell regularly to ensure there is sufficient saturated copper sulfate solution. Examine the half-cell for leaks in the porous base and corrosion on the copper rod that is in the solution.

The solution should be changed after two months of regular use or when erroneous readings are observed. The solution should also be changed if the cell has not been used or agitated for several months.

If the copper rod requires cleaning, submerge it in a dilute solution of hydrochloric acid (HCl) for several hours, then rinse and wipe it clean. Never use steel wool or other abrasives or contaminants on the copper rod.

3.2.2 THE VOLTMETER

A high-impedance voltmeter is required for CSE testing. ASTM-C876 recommends that the voltmeter be “battery operated and have +/- 3% end-of-scale accuracy at the voltage range in use. The input impedance shall be no less than 10 million ohms when operated at a full scale of 100 mV. The division scale used shall be such that a potential difference of 0.02 V or less can be read without interpolation.”

The better the specifications of the voltmeter, the less likely that it will pick up stray currents from nearby power lines or other sources. Ensure the voltmeter is calibrated as specified by the manufacturer.

3.2.3 ELECTRICAL LEAD WIRE (GROUNDING WIRE)

The electrical lead wire used in CSE testing must be such that the electrical resistance for the length used may not have an internal resistance of more than 0.0001 V. It should be coated with a flexible, direct burial type of insulation.

3.3 TEST METHOD

The CSE test methods presented here have evolved from the Department’s procedure BT009 “Test Procedure for Evaluating Corrosion of Reinforcing Steel in Bridge Decks (Copper Sulfate Electrode (CSE) Testing)”. This chapter presents all of the information found in BT009 in more detail, and is intended to replace it.

3.3.1 LOCATE THE CSE TEST ORIGIN

There is a very specific way to determine the origin point for CSE testing. It is important to locate the origin correctly so that the CSE test data correlates with all previous and subsequent test years.

The CSE origin is located by referring it to the north arrow. The exact direction of the north arrow is very important in locating the origin correctly. The simplest, most accurate method to get an accurate north arrow is to reference the General Layout drawing for the bridge. Orient the plan view of the deck to be tested so the traffic would travel up and down on the page, then find the north arrow on the drawing. Assume that the 'up' direction on the page (parallel to traffic) is 0º, right is 90º, down is 180º, and so forth. Note the angle that the north arrow is pointing. The CSE origin is located at the top-left corner of the bridge if the north arrow is from 1º to 180º inclusive. It is located at the bottom right corner of the bridge if the north arrow is from 181º to 360º inclusive. This is illustrated in Figure 3.1.

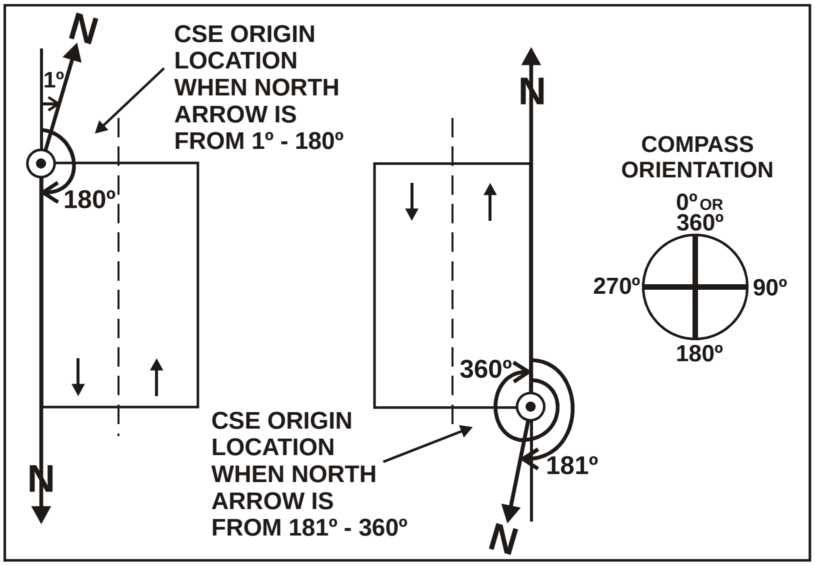


Figure 3.1 – CSE Origin in Relation to North Arrow

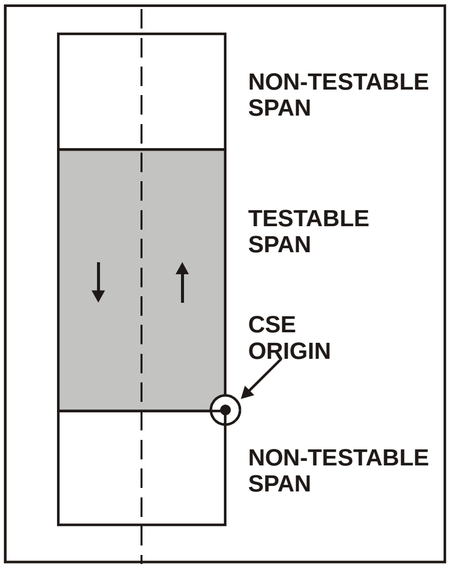


Figure 3.2 – CSE Origin with Non-Testable Spans

If the General Layout drawings are not available, and the direction of the north arrow is not known, the inspector may place a compass at one of the two possible locations for the origin (Figure 3.1). Note the direction the compass defines as north to determine which of the two corners is the CSE origin. This method is a last resort. The preferred method is to reference the drawings as described above, as the arrow on the drawing is thought to be more accurate. Previous CSE reports will also show the CSE origin.

If an end span is not testable, the CSE origin is in the corner of the span that is testable (Figure 3.2). To ensure the procedure to locate the CSE origin is clear, several examples are provided that show the location of the CSE origin in relation to several different north arrow configurations. Refer to Figure 3.4.

3.3.1.1 Skewed Bridges

The CSE origin is not always located on the deck. If the bridge has a positive skew (RHF), the origin will be located on the approach road, prior to the bridge, as shown in Figure 3.3. The origin will be on the deck for negative (LHF) skews.

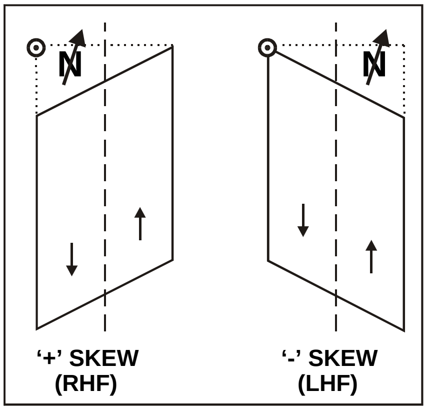
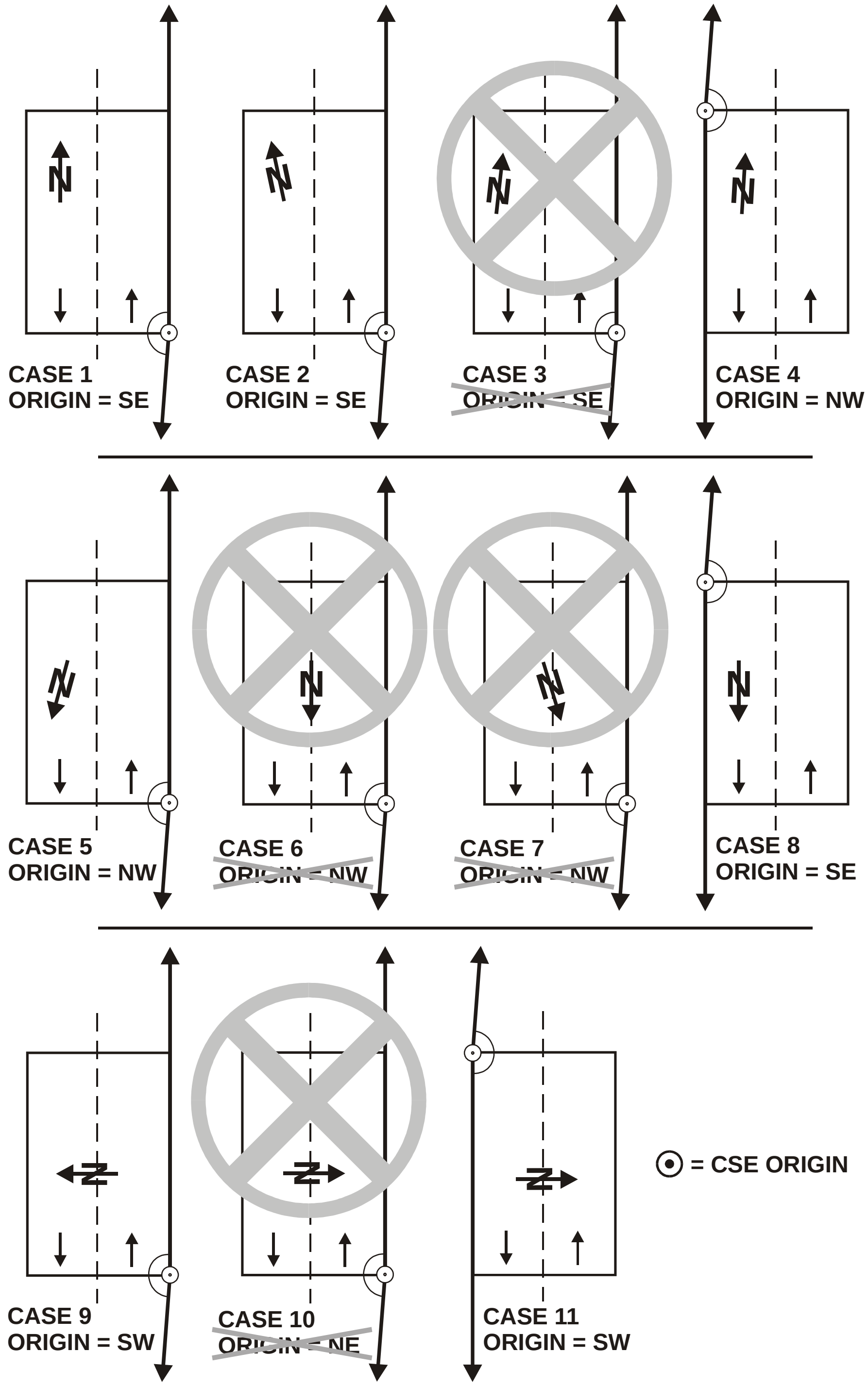


Figure 3.3 – Location of CSE Origin on Skewed Bridge Sites, Plan View



Case 1 - North arrow is parallel to curb. Origin is in SE corner, as in Case 8.

Case 2 - North arrow is slightly west of being parallel with curb. Origin is in SE corner.

Case 3 - North arrow is slightly east of being parallel with curb. Origin is **NOT** in SE corner. See Case 4.

Case 4 - North arrow is slightly east of being parallel with curb. Origin is in NW corner. Same as Case 5.

Case 5 - North arrow is slightly east of being parallel with curb. Origin is in NW corner. Same as Case 4.

Case 6 - North arrow is parallel with curb. Origin is **NOT** in NW corner, see Case 1 and 8.

Case 7 - North arrow is slightly west of being parallel with curb. Origin is **NOT** in NW corner. See Case 2.

Case 8 - North arrow is parallel with curb. Origin is in SE corner, as in Case 1.

Case 9 - North arrow is perpendicular to curb. Origin is in SW corner, as in Case 11.

Case 10 - North arrow is perpendicular to curb. Origin is **NOT** in NE corner. See Case 9 and 11.

Case 11 - North arrow is perpendicular to curb. Origin is In SW corner, as in Case 9.

Figure 3.4 – The Origin Point for CSE Testing, Detailed Examples

3.3.2 CSE TEST LOCATIONS

The CSE test locations are on the deck in a 1200 mm by 1200 mm grid, out from the origin as defined in Section 3.3.1. The last stations will be 1200 mm or less in length since the length or width of bridge decks are rarely a multiple of 1200 mm. There will always be a reading taken in each gutter along the curb.

When the bridge is skewed, the test locations are not aligned with the skew. The grid is laid out parallel to the curbs in the X direction (the length) and perpendicular to the curbs in the Y direction (the width). Therefore, the test length of a skewed deck is the length of the bridge as shown on the drawing or in BIS plus the skew length. Refer to Figure 3.5.

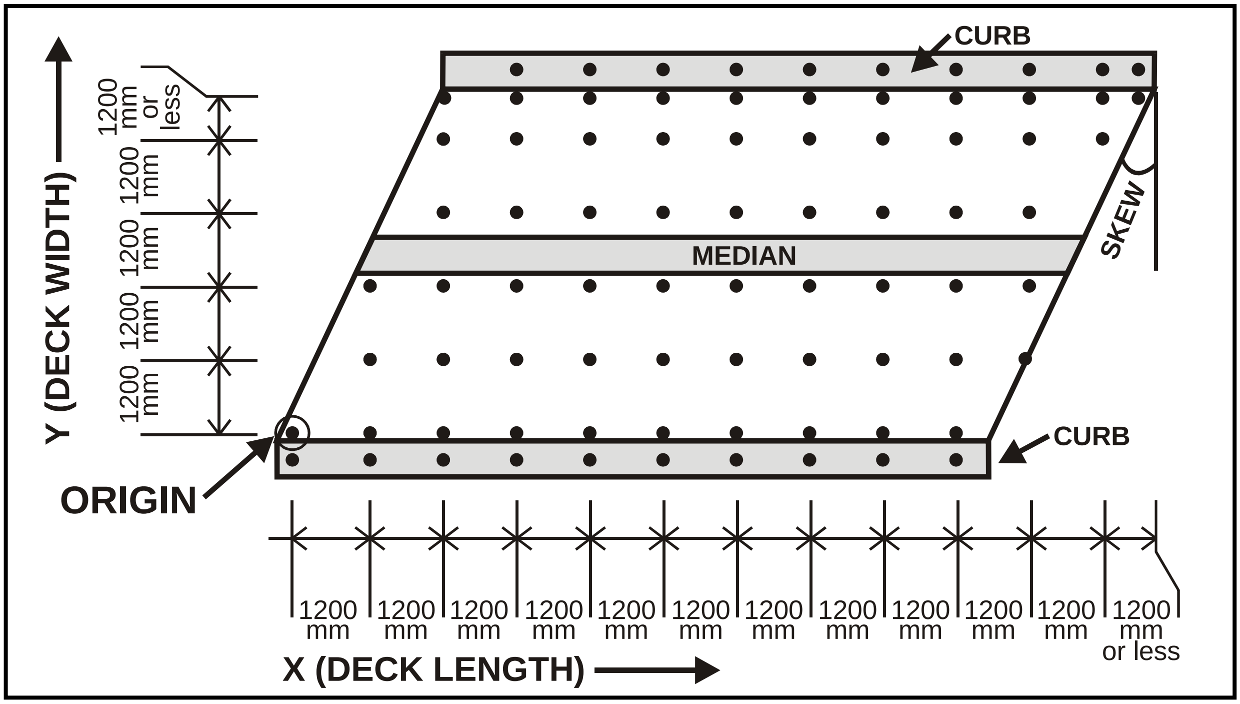


Figure 3.5 – CSE Test Locations

3.3.2.1 Marking Out Test Locations

Mark the test location grid points clearly on the deck with spray paint or similar markings. Ensure the grid points are accurate to a tolerance of 100 mm.

3.3.2.2 Test Locations on Curbs, Medians, and Parapets

Curb tops are tested, while the vertical face of the curbs is not tested. The CSE test locations on curbs are in-line with the grid pattern as shown in Figure 3.5. The test location should be in the center of the curb top when possible. However, bridgerail posts and the rail itself can make it difficult for the test to be in the centre of the curb. In this case, the test location should be just inside of the rail or rail post.

Medians are generally not tested. The presence of a median does not affect the grid layout on the deck. The test grid is still based on the single origin point. If the median is wide enough that more than one test location falls on the median in the Y direction (width), then readings can be taken from the median if desired. If readings are taken from the median, they should not be considered in the analysis of the deck results (i.e. average deck readings), and should be kept separate from the deck readings.

Parapets are also generally not tested. Parapets are only tested if they were tested along with the last CSE deck testing or if specifically requested by the Department. The inspector is required to verify whether the parapets were previously tested. If the parapets are to be tested, readings should be taken on the same grid spacing as for the deck. Take the readings approximately 200-300 mm up from the deck surface along the inside parapet face. Ensure that the surface is wet and that the parapet is connected to the deck electrically or else the readings will not be valid.

Sidewalks are not tested unless specifically requested by the Department.

3.3.3 CLEANLINESS OF TEST LOCATIONS

On primary highway bridges the curb tops and gutter lines can accumulate debris. On more remote local roads, the entire deck may be covered. All test locations must be cleaned down to the wearing surface. The half-cell must contact the wearing surface for accurate test results.

When the gutters have debris in them, they must be cleaned down to the wearing surface using a shovel at each test location. If the deck is covered in debris then it should be cleared of excessive dirt prior to laying out the testing grid. If the site is known to be covered in dirt well in advance of testing, it should be cleaned using mechanical means and then washed using a low pressure, high volume water spray.

3.3.4 WETTING THE DECK

Moisture content in a concrete bridge deck is constantly changing. Several tests were performed in the late 1970's and early 1980's, and it was noted that results (and the ability to take readings) varied depending on the moisture content of the deck. Decks with a higher moisture content such as a few days after rain, had stable CSE readings. Decks will always have different moisture contents due to weather conditions and resistance (IR) losses. Therefore the deck is to be flooded with water (and a wetting agent to speed up penetration) prior to testing. This creates constant moisture content in the deck.

The concrete deck should always be pre-wetted prior to CSE testing. When the half-cell is placed at a test location and the voltage result does not fluctuate at all, then the deck has sufficient moisture content. Do not test without pre-wetting the deck, even if the voltages do not fluctuate prior to wetting.

The concrete surface should look wet during testing. If the surface dries prior to testing, the concrete must be made wet again. Do not take CSE tests in standing or ponded water.

The time it takes for the water to penetrate into the concrete to allow for CSE testing varies. Generally 10 minutes should be sufficient for the water to penetrate into the deck enough to allow testing. It is acceptable to wet the deck several times, if necessary, during testing. The time required for water to penetrate into the deck sufficiently will vary with the amount of water used, the initial moisture content of the deck, deck protection systems, and current weather conditions. This time can be greatly decreased by using a wetting agent in the water.

3.3.4.1 Wetting Agent

Adding a wetting agent to the water will speed up the penetration of the water into the deck. Household detergents can be used, but do not use soaps that create suds when agitated. There is no formula for the amount of wetting agent to use since the properties of different products vary, although ASTM–C876 does provide some guidelines. However, more wetting agent should be used if the water is beading on the deck, and less wetting agent should be used if there are suds or white soap visible on the deck after wetting.

3.3.5 ELECTRICAL CONTINUITY

The main components necessary for CSE testing in bridge decks are a mat of reinforcing steel in the concrete, and the means to connect to this mat electrically. CSE testing is based on the reinforcing steel mat being in tight contact to conduct the voltage readings.

Decks with asphalt, chip seal, and polymer (epoxy) wearing surfaces are deemed to be testable. Polymer overlays have been designed to be breathable and are therefore sufficiently permeable to be tested with CSE.

Small gaps between bars can introduce errors in the CSE test results. This can occur with precast girders with longitudinal grout keys. Waterproof deck protection systems such as membranes, polymer modified asphalt, and epoxy coated steel can also make decks non-testable. CSE cannot be used with watertight barriers until the barrier starts to break down. Therefore the electrical continuity of the steel has to be verified prior to CSE testing.

Some potentially non-testable situations include:

- Decks with impermeable membranes and/or epoxy coated reinforcement. If the membrane or coating is in good condition, these sites will not be testable because of the barrier between the steel and the electrode.
- Many precast girders are not testable because the reinforcement is not electrically continuous between multiple girders.
- Decks with cathodic protection systems are not testable due to the presence of the current from the cathodic protection system.
- Bridges with galvanized reinforcement are testable. However, the results must be interpreted differently due to the presence of the zinc.

Examples of where the non-testable situations listed above may be testable include:

- Decks can become testable if membranes that were originally impermeable have been placed incorrectly or have aged.
- Decks with epoxy coated reinforcement where the epoxy coating has deteriorated sufficiently to allow continuity to exist in the reinforcing steel can be testable. Epoxy coated bars where the epoxy has chipped at bar intersection points due to construction practices have also been found to be testable on some sites.
- Precast girders that are electrically connected through deck joints that are connected to the reinforcing steel in the girders can be testable.
- Decks with cathodic protection can be tested if the cathodic protection has been turned off for at least a month prior to testing.

3.3.5.1 Verifying the Electrical Continuity

Verify the electrical continuity with resistance measurements from one end of a deck span to the opposite end, typically corner to opposite corner. To validate electrical continuity, perform continuity checks on each span for simple span bridges, and at each deck joint for continuous bridges. A measured resistance of less than 0.004 ohms indicates good continuity, while 0.003 ohms or less is ideal.

The ultimate source for continuity checks are at the deck rebar itself. This is not practical however since the rebar is embedded in the concrete. Verify continuity using steel elements that may be electrically connected to the reinforcing steel. Possible locations include anchor bolts at bridgerail posts, deck joints (gland or fingerplate), or deck drains. Testing directly to the reinforcing steel is considered a last resort, used when other locations have failed. Refer to Section 3.3.6.2, ‘Verifying CSE Test Results’, for additional information.

3.3.5.2 The Ground Connection

A proper electrical connection between the voltmeter and the reinforcing steel in the deck is one of the most important aspects of CSE testing. Without establishing a proper ground connection, testing will not produce accurate results, if any.

A ground connection that is connected directly to the reinforcing steel would be ideal, however the deck reinforcement is not readily accessible. Chipping down through the concrete to connect directly to the steel is used only as a last resort as it is time consuming and destructive. A non-destructive method of electrically connecting to the steel is to ground to another steel element that is electrically connected to the rebar.

The ground connection point must be a location that has an electrical resistance below 0.004 ohms, as described in Section 3.3.5.1. Any location that meets this criteria can be a valid ground connection location. Thus bridgerail anchor bolts, drains, expansion assemblies, exposed rebar, and snow grates are all possible ground connections.

Tight, solid connections are required between the voltmeter's grounding cables and the ground connection. A clamp at the end of the grounding cable is typically used. Ensure that the connection between the clamp and the ground location is free of rust and other debris. Verify the connection is solid by checking the resistance of the clamp.

3.3.5.3 Multiple Ground Connections

If the entire length of the bridge is not electrically continuous, but each separate span has electrical continuity within itself, then multiple ground connections can be used to CSE test the bridge. If this is the case, verify each ground connection prior to testing and pay special attention to ensure that no parts of the bridge are tested using the incorrect ground location.

3.3.5.4 Connecting the Voltmeter

A high-impedance voltmeter should be used to collect the CSE readings as described in Section 3.2.2. The better the equipment used, the less chance of picking up stray current from nearby power lines or other influences.

Alberta Transportation has modified the voltmeter connection procedures described in ASTM-C876. The inspector is to connect the negative terminal of the voltmeter to the grounding cable and the positive terminal of the voltmeter to the half-cell. This will result in negative CSE test results.

3.3.6 CSE TESTING

Watch for significant variation in the CSE readings. If suddenly the readings become higher, lower, or do not settle at the same rate, the ground connection may be broken, the voltmeter connections may have worked loose, or the grounding wire may be broken. Stop and verify the validity of the ground connection whenever this situation occurs.

Other causes of erroneous readings include, but are not limited to: the half-cell solution not being saturated, an insufficient amount of solution in the half-cell, the copper in the half-cell is dirty or corroded, or the deck is not wet enough for accurate results.

3.3.6.1 Concrete Patches

The inspector should attempt to avoid testing on small patches in the concrete deck. Whenever possible, take the CSE reading approximately 150 mm from the patch, but as close to the grid point as possible. This is to avoid high point readings that can be associated with concrete patches. CSE testing can be done on larger patches that have several grid points on them. The patches will generally have higher CSE readings, but this is an accurate representation of the deck condition since macro corrosion cells can be set up between the patched and unpatched areas.

3.3.6.2 Verifying CSE Test Results

In situations where the CSE readings are questionable or require additional verification due to protection systems such as very thick asphalt or polymer modified asphalt, the inspector can perform CSE tests on a few representative points through the protection system. The CSE results may then be verified by drilling through the protection systems at these locations and re-testing them. If the readings at the representative locations are the same as those obtained before drilling then the deck is considered testable.

ACP is considered to be testable even when over 50 mm thick, as long as sufficient water is used. Test holes should be drilled in the ACP to verify the results whenever verification is requested, the CSE readings look incorrect, or the values do not settle quickly.

This verification method can also be used when it is suspected that a membrane is interfering with CSE readings. However, the inspector must receive permission or clarification from the Department prior to drilling any holes in the membrane.

All holes must be patched with a Department approved patching material, consistent with the protection system that was drilled into.

3.4 THE CSE2 FORM – STRUCTURE INVENTORY INFORMATION

The inventory information found at the top of the Level 2 CSE Testing form (CSE2) contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields are found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the CSE2 form.

3.4.1 ADDITIONAL STRUCTURE INVENTORY INFORMATION

In addition to the inventory data in the header of the form, the CSE2 form provides additional information about the bridge structure. This section is located immediately below the header information on page one of the CSE2 form and is shown in Figure 3.6. Refer to Section 1.4 for a complete description of the Structure Information fields.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m    Total Length: .....m
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Figure 3.6 – CSE2, Additional Structure Information

3.5 WEATHER INFORMATION (WEATHER CONDITIONS, TEMP __ ºC)

Enter the weather conditions at the time of testing in the Weather Conditions field as shown below in Figure 3.7. Record the general weather (i.e. sunny, overcast with high winds, light rain, etc.). Also record the ambient temperature in degrees Celsius.

Weather Conditions: ____ Temp: __ ºC

Figure 3.7 – CSE2, Weather Conditions at Time of Testing

3.6 SITE AND TESTING EQUIPMENT INFORMATION

Immediately below the Weather Condition field on page one of the CSE2 form, there is a section for the inspector to input specific information on the bridge site and the test equipment, as shown in Figure 3.8.

Equipment Make and Model No.: ____

X Increments (Length): Number: ___ Length of Each: ___ m Length of Last: ___ m
Y Increments (Width): Number: ___ Length of Each: ___ m Length of Last: ___ m

Origin For Data: ____

Electrical Ground Location and Type: ____

Figure 3.8 – CSE2, Site and Testing Equipment Information

3.6.1 TEST EQUIPMENT MAKE AND MODEL NUMBER (EQUIPMENT MAKE AND MODEL NO.)

This text field allows the inspector to describe the test equipment used in obtaining the CSE test results. Specific information on the voltmeter is required in this field, including the model number.

3.6.2 X INCREMENT (LENGTH) INFORMATION (NUMBER, LENGTH OF EACH, LENGTH OF LAST)

There are three numeric fields in this section that describe the dimensions of the deck area that was tested. The X increments describe the length of the test area (parallel to the curbs).

Number - The total number of X increments (full or partial length increments).

Length of Each - The length of a full X increment in metres to the nearest 0.1 m. This increment will always be 1.2 m, unless specifically directed by the Department prior to CSE testing.

Length of Last - The length of the last X increment in metres to one decimal point. It will always be less than or equal to the 'Length of Each' field. To be consistent with historical data, this is given to the nearest multiple of 0.3 m (the nearest foot).

3.6.3 Y INCREMENT (WIDTH) INFORMATION (NUMBER, LENGTH OF EACH, LENGTH OF LAST)

The three numeric fields found in this section are the same as the X increments defined in Section 3.6.2 above, except these fields are for Y increments (width), perpendicular to the curbs.

3.6.4 ORIGIN FOR DATA

This is a text field for the inspector to define which corner of the bridge is the CSE origin. The number of increments and the length of the last X and Y increments are based on this point. The method to locate the origin is defined in detail in Section 3.3.1. This field describes the origin point that was used so future testing can start at the same point.

The inspector may describe the origin by relating it to the compass direction. For example, the origin may be defined with respect to the southeast corner. The origin may also be defined with respect to the river flow, such as ‘The origin is in the back-right corner when facing downstream’. Do not relate the origin in terms of a landmark that could be moved or changed, such as a sign.

3.6.5 ELECTRICAL GROUND LOCATION AND TYPE

The inspector records the location of the electrical ground connection and the type of bridge element that the ground is connected to in this text field. For example, the ground connection may be described as ‘Clamp on to deck joint over Abutment 2’ or ‘ South curb anchor bolt, 5th rail post from east end’.

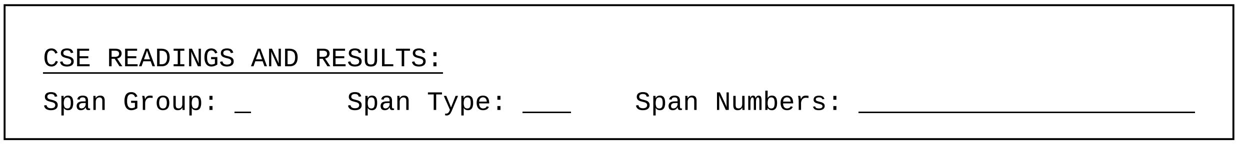
If more than one ground connection is used, identify all ground locations.

3.7 CSE READINGS AND RESULTS

The CSE Readings and Results section is found at the bottom of page one of the CSE2 form. This section shows summaries and calculations from the recorded test data. The raw data is not presented in this section.

3.7.1 SPAN INFORMATION (SPAN GROUP, SPAN TYPE, AND SPAN NUMBERS)

The span information fields are at the top of the CSE Readings and Results section of the CSE2 form as shown in Figure 3.9.



CSE READINGS AND RESULTS:

Span Group: _ Span Type: ___ Span Numbers: ______________________

Figure 3.9 – CSE2, Span Information

The Span Group is a numeric field. If the Department makes a special request to subdivide the CSE test results into different groups of spans, this field would define each group numerically, beginning with number 1. Typically all CSE results at a bridge site are presented in one analysis group, even if there are different span types within the group. Therefore the Span Group is typically the number 1. If the Department identifies the need to present multiple span groups, an additional CSE Readings and Results section is required for each group.

Identify all Span Types that are included in the Span Group. This is only the Span Types that were actually tested. For example, if CSE tests were performed on the welded girder (WG) main span and not the HC girder approach spans, the Span Type field would only be WG. If multiple Span Types were tested in the Span Group, then all Span Types would be identified, with the main span first and each following span separated by a slash.

All of the spans are numbered from south to north or from west to east, beginning with number 1. Note that span number 1 is not necessarily the same span as the CSE test origin. The origin location is defined in Section 3.3.1. Identify all of the span numbers that were tested in the Span Group in this field, separated by commas. For example, if the site had 3 spans, and all of them were tested, the Span Number field would be ‘1, 2, 3’.

Year	Wearing Surface Type	Percentage of Deck Area In The Range Indicated				
		Inactive Area			Transition	Active
		0.00-0.10	>0.10-0.20	>0.20-0.30	>0.30–0.40	>0.40

Figure 3.10 – CSE2, Percentage of Deck Area In The Range Indicated

3.7.2 CSE TEST YEAR (YEAR)

Identify the year that CSE testing is completed at the bridge site. The inspector is to use the first blank row. The additional rows are for historical data if the Department requests that it be brought forward.

3.7.3 WEARING SURFACE TYPE

Identify the wearing surface of the span group using the typical BIS codes. If multiple layers of wearing surfaces have built up over time, identify all wearing surfaces that have been placed (and are still present) on the concrete deck. The first wearing surface listed is the newest or top wearing surface.

For example, if the concrete deck had a high density concrete overlay placed on it, followed by an epoxy wearing surface and a chip coat, the Wearing Surface Type would be ‘R/E/H’.

3.7.4 PERCENTAGE OF DECK AREA IN THE RANGE INDICATED

Show the percent of deck area in the Inactive (0.00 to 0.30 V), Transition (>0.30 to 0.40 V), and Active (>0.40) fields. The Inactive range is further subdivided into three ranges; 0.00 to

0.10 V, >0.10 to 0.20 V, and >0.20 to 0.30 V. Keep in mind that these are just numerical ranges, as the true ranges would be negative values.

Because the values that go in these fields are percent areas, the values are more complicated than one would think. It is **not** just a matter of dividing up the test results into the separate categories and dividing the number of readings in the category by the total number of test points.

Additional test results are interpolated between the grid points at 0.3 m intervals using a linear distribution, thus creating a 0.3 m by 0.3 m grid of values. Once this is done, then the total number of test values in each range can be determined. The total number of values in a particular CSE range (based on the 0.3 m by 0.3 m grid spacing) are then divided by the total number of values to determine the percent of deck area in each range.

Do not include any curb readings or median readings in this calculation. Also take care not to interpolate test points that are located off of the bridge deck due to a skewed end.

Year	Wearing Surface Type	Average Deck Reading (Volts)	Standard Deviation of Deck Reading	Average Curb Reading (Volts)	Standard Deviation of Curb Reading
Comments:					

Figure 3.11 – CSE2, Average Reading and Standard Deviation for Deck and Curbs

3.7.5 AVERAGE READINGS AND STANDARD DEVIATION FOR DECK AND CURBS

The bottom section of the CSE2 form, page 1 contains fields for the Average Deck Reading, the Standard Deviation of Deck Reading, the Average Curb Reading, and the Standard Deviation of Curb Reading as shown in Figure 3.11. There are also columns for the test Year and the Wearing Surface Type. The values in these two columns will be the same as described in Section 3.7.2 and 3.7.3.

To obtain the Average Deck Reading, add the values from the actual test results (no interpolated results) from the deck and divide by the total number of readings. Do not include any curb or median readings. Record the Average Deck Reading in volts to 3 decimal places. The value is a negative.

Calculate the Standard Deviation of the Deck Readings and record it in the proper field. This is also given to 3 decimal places. Only use actual test results in this calculation, no interpolated values. Do not include any curb or median results.

Calculate the Average Curb Reading, and the Standard Deviation of Curb Reading as described in the previous two paragraphs, only using the curb readings instead of the deck readings.

3.7.5.1 Comments

At the bottom of the page there are four lines provided for the inspector to make any additional comments that relate to the testing or the results.

3.8 OTHER CSE2 DATA – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the CSE2 form. The last page shares a common format with the other Level 2 forms.

3.9 SUPPLEMENTARY INFORMATION

The CSE test method used by the Department is very similar to ASTM-C876 “Standard Test Method for Half-Cell Potentials for Reinforcing Steel in Concrete”. There are subtle differences in the procedures, but the ATSM document can be referenced for additional background information.

In addition to the Level 2 CSE2 form, contour maps are an effective visual method of presenting the CSE test results. When the Department requests a contour map to be submitted with the CSE test results, it should have contour lines at 0.100 V intervals. The area between the contour lines should have solid colour backgrounds. The Inactive range should be white or light yellow, the Transition range is coloured bright yellow, and the Active range is red.

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ALBERTA TRANSPORTATION

BIM LEVEL 2 REPORT - 2004
CSE TESTING

FORM ID: CSE2
Bridge File: .....
Page: 1

Bridge File Number : ....

Legal Land Location: ...-..-...-..-.

Latitude/Longitude : ..../........

Road Auth./Region : .../R.

Bridge or Town Name: ....

Stream Name : ....

Highway #:Cntrl Sec: ...:...

Road Classification: ....-...

AADT/Year : .-....../..

Detour Length : ...km

Structure Usage : ..

Year Built : ../..

Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)

Insp. Req’d Date : ____/__/__ (YMD)

(based on ____________________)

Current Insp. Date: ____/__/__ (YMD)

Inspector’s Code : ____

STRUCTURE INFORMATION:

No. of Spans: .. Span Types: .../... Substructure Types: .../...

Span Lengths: ....-....-....-....-.....m Total Length: .....m

Weather Conditions: ____ Temp: __ °C

Equipment Make and Model No.: ____

X Increments (Length): Number: ___ Length of Each: ___ m Length of Last: ___ m

Y Increments (Width): Number: ___ Length of Each: ___ m Length of Last: ___ m

Origin For Data: ____

Electrical Ground Location and Type: ____

CSE READINGS AND RESULTS:

Span Group: _ Span Type: ___ Span Numbers: ______________________

Year	Wearing Surface Type	Percentage of Deck Area In The Range Indicated				
		Inactive Area			Transition	Active
		0.00-0.10	>0.10-0.20	>0.20-0.30	>0.30–0.40	>0.40

Year	Wearing Surface Type	Average Deck Reading (Volts)	Standard Deviation of Deck Reading	Average Curb Reading (Volts)	Standard Deviation of Curb Reading

Comments:

LEVEL 1 INSPECTION (INFORMATION ONLY)   Level 1 date: ____/__/__

Structural Condition Rating: __%   Sufficiency Rating: __%
Estimated Remaining Life of Structure: __ years

Special Comments for Next Inspection:

Next Scheduled Level 1 inspection: ____/__/__   Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __   Lift: __   Traffic control: __   Boat: __   Ladder: __
Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default)
Recommended Additional Cycles: _ (blank for default, 0 for discontinue)

Inspector’s Code: ___	Inspector’s Name: __________________________	Class: _
Assistant’s Code: ___ Assistant’s Code: ___	Assistant’s Name: __________________________ Assistant’s Name: __________________________	Class: _ Class: _

Comments: ____
____

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default)
Approved Additional Cycle: _ (blank for default, 0 for discontinue)\

Reviewer’s Code: ___	Reviewer’s Name:____________________________	Class: _

Comments: ____
____

Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__