RECOMMENDED PROCEDURES FOR RAILWAY CULVERT INSPECTION

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ABSTRACT

This paper presents the highlights of the new AREMA Recommendations for inspecting railway culverts as outlined in Part 1.4.17 – Culvert Inspection of the current edition of the AREMA Manual for Railway Engineering. The paper focuses on the history of railway culverts, the definition of culverts (what sets them apart from bridges), what to look for when inspecting culverts, and adopting a regular inspection and maintenance program for these vital structures. A recommended inspection form and inspection frequency methodology is also presented. Unlike bridges, periodic culvert inspection is not mandated by most regulatory agencies, yet these structures are prone to serious problems if not inspected and maintained on a regular basis. Quite often culvert deficiencies are only detected when track surface irregularities are encountered; yet these potential problems can be detected and corrected long before deterioration of the track surface occurs. In the absence of mandated inspection procedures, AREMA Committee-1, Subcommittee-4 has developed Manual Part 1.4.17 to assist railroad owners and operators in developing minimum standards for railway culvert inventory and inspection.

Key Words: Culverts, Inspection, Inventory, Structures, Condition Assessment

INTRODUCTION

In 1992, Sub-committee-4 of AREMA’s Committee-1, was contemplating topics for a new assignment when one of the sub-committee members suggested, ”What procedures does the railroad industry have for culvert inspection?” That turned out to be a very good question. A quick search of the AREMA Manual for Railway Engineering revealed that the only mention of culvert inspection was in Chapter 8 under Inspection of Concrete and
Masonry Structures, which mainly suggested an evaluation of the culvert’s structural characteristics. On the other hand, the Manual contains very specific guidelines for bridge inspection in both Chapters 8 and 15 for both substructure and superstructure inspections with detailed requirements for annual and periodic inspections.

Our sub-committee conducted an informal survey of operating railroads to inquire as to what, if any, procedures they have in place for inspecting railway culverts. A relatively few number of railroads had regular culvert inspection programs. Some incorporated culvert inspection as part of track inspection, though most admit that a physical inspection is only performed if an irregularity occurs within the track surface. And, one respondent indicated, “Inspect them? We don’t know where half of them are!”

These mixed responses helped our sub-committee conclude that the AREMA Manual should include recommended procedures for inspection of these critical drainage structures. The result of sub-committee-4’s efforts in developing these procedures was published as Manual Section 1.4.17 – Culvert Inspection in 2001. The highlights of this important section are the focus of today’s presentation.

**DEFINITION OF A CULVERT**

First, it is important to understand exactly what a culvert is and how it performs, and secondly, how they are different from bridges. In the latter, those differences are not only structural but hydraulic as well.
Culverts can be defined as an opening or conduit passing through an embankment usually for the purpose of conveying water. Though this paper focuses primarily on hydraulic conduits, other short span structures such as a cattlepass or pedestrian underpass could also be classified as a culvert.

Structurally, there are essentially two types of culverts – flexible and rigid conduits. Flexible culverts rely upon the quality and stability of the surrounding soils to provide structural support. Examples of flexible culverts include corrugated metal pipe culverts and plastic pipe culverts. Rigid culverts are more self-supporting but still rely on some degree of interaction with the surrounding soils. Rigid culvert materials include reinforced concrete pipe, thick-walled metal pipe, and some composite pipe materials such as fiber reinforced resin pipe. Regardless of the conduit material, most culverts are considered embankment-supported structures where the quality of the backfill and degree of compaction affect the side support and foundation support of the conduit.

Bridges, on the other hand, are designed to transfer loads from the spanning elements to the abutments or piers to footings and/or pile foundations. Thus, applying most bridge inspection criteria to the inspection of culverts would serve no purpose.

Hydraulically, bridges and culverts are dramatically different. Culverts are designed to operate efficiently under submerged inlet conditions. The increase in water surface elevation at the upstream end causes an increase in head at the inlet end, and thus
increases the flow capacity of the culvert. Bridges are designed to have sufficient freeboard beneath the spanning elements to assure that floodwaters do not cause displacement of the bridge deck.

Some railroads make the distinction between bridges and culverts solely based upon span length. Traditionally, span lengths below 10-ft. were considered culverts and span lengths above 10-ft. were considered bridges. Making this distinction solely based upon span length adds an element of risk to the inspection process because the resultant inspection could potentially ignore some of the more important aspects of either type of structure. Sub-committee-4 recommends that all embankment-supported structures, regardless of span length, be inspected as culverts. Likewise, all free-spanning structures should be inspected as bridges.

Above all, it is important for every railroad’s maintenance-of-way department to make the distinction between bridges and culverts and to develop a regular inspection program for all structures that pass beneath the trackway.

**INSPECTOR TRAINING AND QUALIFICATIONS**

Prior to performing the actual inspection, it is important that all personnel be adequately trained to recognize the critical factors involved in the inspection. The inspector should have a working knowledge of how a culvert functions both structurally and hydraulically. He must be capable of making judgmental decisions about the culvert’s load bearing
capacity, its ability to interact with the surrounding soils, how it functions under surcharge conditions, and the significance of cracks, rust, spalling and other defects. In short, the inspector must be capable of evaluating the culvert as a total system necessary for the conveyance of water under the trackway and how that system performs relative to the track structure.

In addition to possessing the technical skills to assess the culvert’s performance, the inspector must be capable of meeting the physical demands of the job. Working in cramped conditions, climbing steep grades, working in and around flowing waters are only some of the challenges that the inspector will face.

Sub-committee-4 recommends the following minimum qualifications that the inspector should possess:

1. The ability to read plans, construction documents, and inspection reports.

2. A working knowledge of measuring systems and the ability to use a surveyor’s level.

3. A technical background and the ability to understand the critical structural and hydraulic aspects of culvert functionality.
4. A minimum of two years of culvert inspection assignments under the supervision of a qualified culvert inspector, and/or the completion of a comprehensive training program in culvert inspection.

SAFETY

The physical inspection of most culvert installations is inherently dangerous work. Prior to performing the actual inspection, it is strongly recommended that a safety assessment be performed at each specific site and a plan of action be prepared to include emergency preparedness procedures if not already covered by other requirements of the operating railroad’s own safety department. In addition, the inspectors must comply with all applicable Federal, State and local regulations pertaining to workplace safety.

It is further recommended that culverts with an equivalent diameter of less than 30-in. (76.2-cm) not be entered by inspection personnel. Internal inspections of culverts below this size are best conducted by using specialty equipment such as video cameras, and/or measurement devices to aid in the assessment of the physical condition. Only those inspectors specifically trained in working in confined spaces should attempt to enter culverts 30-in. (76.2-cm) in diameter and larger. In no circumstances should anyone attempt to enter a culvert unassisted and without the appropriate safety equipment and apparatus. Culverts, regardless of size, should only be entered during low flow conditions. Most importantly, inspectors should never enter culverts if any conditions, especially those relating to structural integrity, appear questionable.
INVENTORY AND INITIAL ASSESSMENT

Prior to establishing a regular culvert inspection program, it is important to obtain an accurate inventory of all culvert-type structures that pass beneath the track structure. It is critical to know the precise location (preferably by milepost), structural characteristics, age, skew angle, construction material(s), and general condition.

Many railroads possess accurate records and/or valuation maps, which may contain the desired information. However, even the most accurate records may not include changed conditions, particularly changes to upstream drainage areas or modifications to adjoining structures often located outside of the right-of-way. Thus, it is recommended that a reassessment of all existing culverts and upstream drainage facilities be performed prior to initiating a comprehensive culvert inspection program.

In the case of new railroad property owners, such as regional, commuter, and shortline operators, an updated inventory and baseline assessment may not exist; particularly, if the property was underutilized, out of service, or abandoned prior to the acquisition. In those instances, it is recommended that every embankment, particularly at low spots, be examined for the presence of some form of drainage structure. Once identified, all culverts should be located and measured using the inventory data section of the culvert inspection form contained on page 1-4-98 of the AREMA Manual for Railway Engineering.
In addition to locating the culvert dimensionally on maintenance-of-way records, track charts, and other forms of mapping, it is advisable to physically mark the culvert location along the trackway to facilitate the task of finding the culvert for re-inspection or in the event of an emergency. Marker posts at the top of the embankment along the centerline of the culvert at each edge of the right-of-way is one example. [CSXT Railroad paints the crosstie(s) above each culvert a contrasting color to mark their location.]

**FREQUENCY OF INSPECTION**

The frequency of culvert inspection is largely based upon the age and condition of the culvert. It is recommended that all culverts be inspected at least once every five years; however, local conditions may require more frequent interim inspections. In addition, it is advisable that interim inspections occur following major storms, heavy runoff, and high stream flows. Culverts that have identified problems or concerns should also be inspected more frequently. It is recommended that culverts that are susceptible to heavy drift, ice flow, or severe scour receive more frequent inspections.

**PHYSICAL CONDITION ASSESSMENT**

Determining when problems exist with a culvert is not always an easy task. Many problems associated with culverts are not obvious to the casual observer. While some culvert problems may be evident at track level, such as surface irregularities or alignment problems, this is not always the case.
While any irregularities in the track structure or surface conditions should be noted and investigated thoroughly, the inspector cannot simply rely on surface indicators as a measure of culvert performance. In addition, culverts can be in perfect structural and geometric condition, yet be undersized or otherwise inadequate from a hydraulic standpoint. Buildup of debris that could clog the entrance or exit of a culvert should be noted and eliminated, and any evidence of scour or undermining should be addressed.

Those familiar with bridge inspection may not understand what types of problems to look for when inspecting culverts. Often, the deficiencies noted by inspectors represent superficial concerns that are essentially insignificant to the overall performance of the culvert. On the other hand, inspectors often overlook items such as shape change, evidence of loss of backfill or foundation support, etc.

The following represent a partial list and description of some of the more common manifestations of distress in a culvert encountered during inspections:

- **Corrosion** – usually manifested by rusting of a metal pipe or spalling of the concrete combined with rusted reinforcing steel in a concrete culvert. The extent and locations of the corrosion should be noted. Corings to determine the extent of loss of wall thickness and the effect on the culverts capacity to carry design loads should be undertaken.
- **Abrasion** – this can lead to loss of wall thickness, loss of protective coatings and eventually lead to a reduction in structural capacity. Abrasion usually occurs in
culverts installed on steep gradients, combined with an aggressive bed load situation (i.e., rocks, sand and other materials capable of reducing the wall and/or coating thickness).

- **Coating Loss** – loss of protective coatings should be noted, with the location and extent of coating loss documented. This needs to be compared to past inspection records to determine if the condition is worsening.

- **Perforations** – again, the extent and location of the perforations should be noted. Often, such perforations are minor and more of a cosmetic problem. However, they should be investigated to determine if any reduction in structural capacity is indicated or if any repairs are warranted.

- **Cracks** – these may manifest themselves in the walls of culverts and need to be investigated to determine if there is any effect on the strength of the culvert pipe product as a result of these cracks. Minor cracks in a concrete culvert, for example, may not reduce its structural capacity, but may still represent a problem due to infiltration of water leading to freeze-thaw damage and/or corrosion of reinforcing steel. Cracks are usually not seen in corrugated metal culverts – yet absence of any cracks, by itself, is not a reliable indicator of the culverts integrity.

- **Shape Changes** – any dimensional changes, loss of symmetry, etc. should be noted. These need to be checked in subsequent inspections and compared to determine if the culvert stability is in question. Also, any changes in elevation of the culvert should be noted and may be indicative of foundation stability problems.
- **Seams** - if present, seams in a culvert should be inspected for uniformity, tightness and alignment. Open seams allow for loss of fill material and exfiltration/infiltration of flow. Quality seams representing properly aligned culvert segments should be evident.
- **Joints** – joints should be observed for alignment and uniformity. Misaligned joints contribute to loss of fill, and could lead to hydraulic problems such as washout and/or undermining
- **End Treatment** – proper end treatment is necessary to both hydraulic and structural performance of culverts. Protection in the form of cut-off walls, slope collars, headwalls, slope paving, rip-rap, etc. should be employed when necessary and practical. Deterioration of such end protection must be noted and addressed.

As mentioned above, it is recommended that, at the onset of a culvert inspection, certain baseline measurements be taken to serve as a benchmark for follow-up inspections. Such measurements should include:

- Span
- Rise
- Skew Angle, if applicable
- Elevations at crown and invert of culvert at points along the length of the culvert
- Elevations at top of rail and top of subgrade
- Length of culvert
- Distance from centerline of track to both ends of the culvert
- End treatment dimensions and configuration
- Location of any irregularities, changes in alignment, side laterals, etc.

The sample culvert inspection form printed on page 1-4-99 of the AREMA Manual for Railway Engineering outlines many of the recommended measurements that should be taken. This form can be used as a starting point for the culvert inspector and be modified to suit individual requirements.

**EVALUATION / RECOMMENDED ACTION**

It is the responsibility of the inspector to determine if any deficiencies exist and to notify the appropriate railroad’s engineering department of such problems when detected. Remedial action may be taken, depending upon the type and extent of the problems.

Possible courses of action include:

- *Speed Restrictions / Class Reduction* – problems leading to surface irregularities, track settlement or alignment changes may warrant a restriction on speed of train traffic and/or a reduction in load classification. If such restrictions become necessary, they should be placed immediately and left in place until more extensive investigation or repairs can be made.
- **Monitoring Program** – often inspection indicates a potential problem that needs to be evaluated based on future inspections. While this may require some repair or remedial action, often monitoring of the culvert on a more frequent inspection basis is indicated to determine if the problems are worsening and at what rate the culvert is deteriorating. The need for any corrective actions can then be assessed based on the results of this monitoring program.

- **Rehabilitation** – since the cost and loss of service time to completely replace a culvert can be prohibitive, repair or rehabilitation of the culvert is often a viable and more desirable option. Various methods are available, including sliplining, adding stiffeners, installing a concrete invert, etc. Refer to AREMA Manual for Railway Engineering, Part 1.4.14 Culvert Rehabilitation for more information.

- **Replacement** – if the results of the inspection and subsequent evaluation warrant complete replacement as the most viable alternative, then proper steps must be taken to ensure the safety and stability of the track structure during the replacement process.

**INSPECTION FOLLOW-UP**

Adequate efforts should be made to ensure that monitoring programs are being followed and that any necessary repairs have been completed. Monitoring programs should include scheduled inspections and evaluations. Repairs or rehabilitation efforts need to be inspected to ensure the work was completed properly. Culverts that have been replaced
also need follow-up inspection to determine if the replacement structure was properly installed and to ensure the track structure is stable and adequately supported.

CONCLUSION

Culverts within railroad rights-of-way are common and their performance is critical to the support of the track structure above. Culverts are different from bridges in functionality, structural design and inspection criteria. Inspectors must be trained to recognize the key aspects of culvert performance – both structurally and hydraulically. Culverts must be included in a regular inspection program. They need to be properly evaluated and proper follow-up is required to ensure that monitoring and repair programs are completed. The safety and stability of the track structure is dependent upon properly designed and functioning culvert structures.