

CBC Visits Big Sky Country to Aid Montana DOT with Buried Flexible Bridge / Culvert Program



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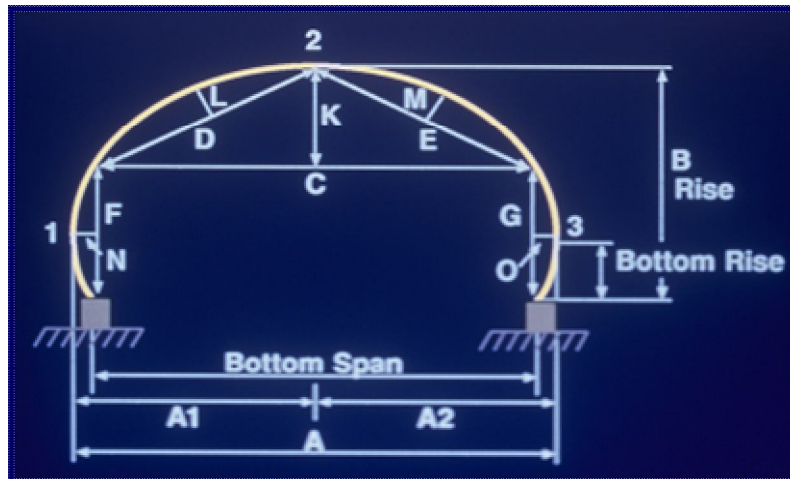
As part of Montana Department of Transportation's (MDOT's) comprehensive Culvert / Bridge Inspection Program, CBC Engineers & Associates, Ltd. was asked to inspect, evaluate and provide remedial action in required for some 30 Buried Flexible Culvert / Bridge locations that have been on the MDOT's watch list for several years. CBC was originally engaged by MDOT in 2005 when measurements were sent to CBC for analysis. The DOT recognized CBC's ability with the recommendations and evaluation of the data given and decided to include CBC in a comprehensive Buried Flexible Culvert / Bridge Inspection Program starting in 2006. To date, CBC has observed, evaluated and in some cases designed remedial solutions at some 30 locations for MDOT and today only a handful remain on the DOT watch list.



Montana Department of Transportation (MDOT), had been monitoring some 30 locations of Buried Flexible Culvert / Bridges across their state for a period of years. These structures became known as the watch list. It was obvious to MDOT that in many locations changes were occurring at many locations on this watch list, however, what to do about the changes or even if the changes constituted replacement was a hard call for the DOT. These changes were such things as corrosion, shape or deflection changes, and settlement of the roadway embankments containing these structures. As the DOT kept a watchful eye on these structures, they also knew eventually they were going to have to do something about them.

So the first call to CBC came in 2005 from MDOT inquiring on how CBC might be able to help them. We gave the DOT the evaluation process that is used to determine if a structure's geometry is of worry, or if the pipe wall corrosion was a problem, and how we take these measurements in the field to run the necessary shape and structural checks to determine if a structure could be rehabilitated or needed replacement. These structures consisted of 6" x 2" corrugated steel structural plate in the shapes of an Underpass, Round and Pipe-arch shapes. These crossings were used for both animal crossings under major interstates and state routes and in some case they acted as hydraulic structures as well. The majority of these locations were installed in the 1960's and 1970's making them 35 to 45 years old.

Of the 30 locations that have been measured and evaluated in some cases several times, 13 structures were deemed in need of some remediation to extend their useful service life. CBC used their field measurements of the locations in questions and compared different visits over time to see if any of the structures were moving and as a result structure geometry changes were obvious. The actual shape measurements were then used to draw a cross sectional shape in AutoCAD at each station in each structure. The Chords and Mid-ordinates (shown in picture below) comprising the structure geometry were then determined and then inserted into a computer program called MULTSPAN which gives the maximum deflection of the structure and information of what remedial action might be required until a permanent fix was decided upon. Personnel within CBC helped write this software program under a grant from Ohio Department of Transportation (ODOT) and the Federal Highway Administration (FHWA) in the late 1980's.



Through this process MDOT was able to let a project in 2008 that had CBC's designed permanent solutions to 9 of the 13 troubled sites. These locations again were comprised of all 3 shapes, the Underpass, Round and Pipe-Arch shapes. The solutions for long term stability and the extension or each of these 9 structures service lives varied from a simple concrete paved invert field poured in the bottom for abrasion protection, to more structural solution requiring the insertion of "Ring Beam Stiffeners" and concrete paved inverts to raise the inverts or flowlines up and over the newly installed stiffeners.

Rehabilitation Versus Replacement

Montana DOT through this program was about to rehabilitate 9 of 13 structures without digging up I-94 in at least 4 places to replace these structures which were all 100's of feet long. They were able to avoid costly construction and headaches to their traveling public by using these solutions in place of replacement. This also saved the State of Montana Taxpayers millions of dollars in the process as the rehabilitation of each of the 9 locations was about 20% of the replacement cost and the rehabilitated structures are good for another 30 to 50 years. This was a win-win for MDOT and the taxpayer traveling public. The remaining four structures are being watched closely by the DOT as they decide when to rehabilitate. CBC stands ready to assist them in their efforts.

Case Study

Inspection. Evaluation. Remediation.

Federal Aid Project IM 94-4(76)119 – Under Interstate I-94 (Site 7- Mile Post 167.1) Prarie County, Montana

Culvert Owner:
Montana DOT

Culvert Size, Type & Length:
Round Multi-Plate Pipe
180" Diameter x 344 feet

Year Installed:
1963

Inspection Engineer:
CBC Engineers & Associates

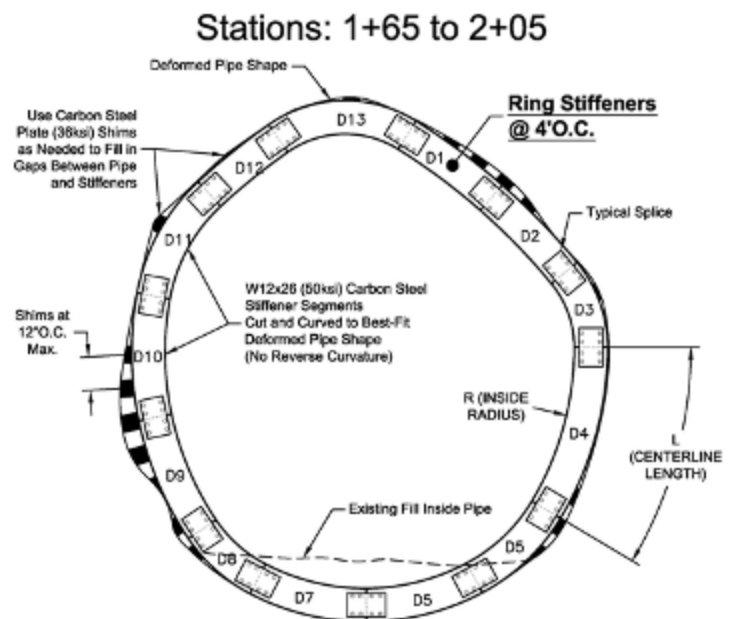
Evaluation Results:
Generally Fair Condition

Remediation Solution:
Plastic Hinging from Station 1+74 to 1+85 were required Ring Beam stiffeners to carry load. These stiffeners were used from Station 1+65 to 2+05 well past the affected areas.



The maximum deflection of any top mid-ordinate was 26.6%. Based on the MULT-SPAN program recommendations no remedial action due to shape was recommended for the structure. However MULT-SPAN did recommend reducing the legal load to 75%. CBC Engineers and Associates, however, did not believe this necessary because of the length of time the structure has been in place and the likely hood that deflection has ceased. It was recommended to monitor the structure again in 6 months to a year due to the mid-ordinates approaching critical magnitudes. Based on the rating of the structure, the structure has 33 points out of a possible 42. This rating is an equivalent to a 5 on the National Bridge Rating System. Plastic hinging of the structure had occurred in the top of the structure from Station 1+74 to 1+85 and remedial action was required in this area. The stiffeners used to repair the hinging were comprised of segments of wide flange beams cut and curved to best fit the in-situ shape of the

The segments of beam were spliced together at their ends to form a continuous ring stiffener around the entire periphery of the structures. All stiffeners were Grade 50 steel and hot-dipped galvanized. Any gaps between the ring stiffeners and the pipe walls were filled with galvanized steel plate shims as shown on the drawing (to right) to provide consistent contact between the stiffener and the pipe. The required size and spacing of the stiffeners was determined using SSTAN finite element structural analysis software developed by Dr. Marc Hoit of the University of Florida.



Case Study

Inspection. Evaluation. Remediation.

Federal Aid Project IM 94-4(76)119 – Under Interstate I-94 (Site 6- Mile Post 147.4) Custer County, Montana

Culvert Owner:
Montana DOT

Culvert Size, Type & Length:
Under Pass Multi-Plate Pipe
17'-3" span x 16'-6" rise x 116
feet

Year Installed:
1974

Inspection Engineer:
CBC Engineers & Associates

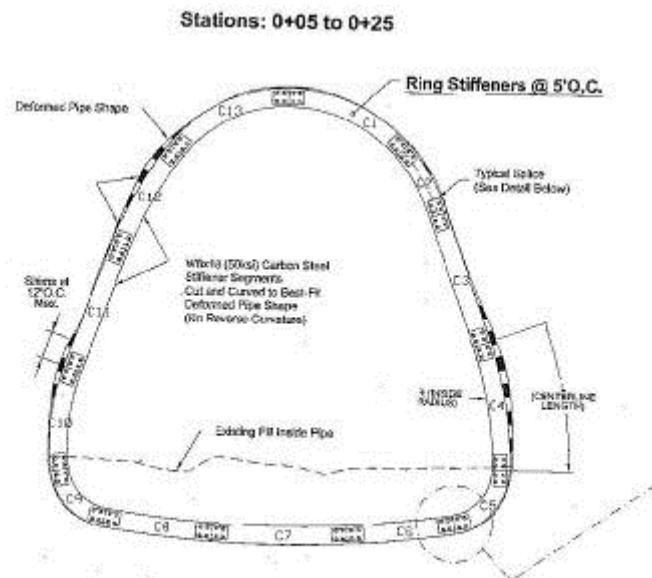
Evaluation Results:
Generally Fair Condition

Remediation Solution:
Plastic Hinging from Station 1+74 to 1+85 were required Ring Beam stiffeners to carry load. These stiffeners were used from Station 1+65 to 2+05 well past the affected areas.



The maximum deflection of any top mid-ordinate was 26.6%. Based on the MULT-SPAN program recommendations no remedial action due to shape was recommended for the structure. However MULT-SPAN did recommend reducing the legal load to 75%. CBC Engineers and Associates, however, did not believe this necessary because of the length of time the structure has been in place and the likely hood that deflection has ceased. It was recommended to monitor the structure again in 6 months to a year due to the mid-ordinates approaching critical magnitudes. Based on the rating of the structure, the structure has 33 points out of a possible 42. This rating is an equivalent to a 5 on the National Bridge Rating System. Plastic hinging of the structure had occurred in the top of the structure from Station 1+74 to 1+85 and remedial action was required in this area. The stiffeners used to repair the hinging were comprised of segments of wide flange beams cut and curved to best fit the in-situ shape of the

structures as shown on the drawings attached to this report. The segments of beam were spliced together at their ends to form a continuous ring stiffener around the entire periphery of the structures. All stiffeners were Grade 50 steel and hot-dipped galvanized. Any gaps between the ring stiffeners and the pipe walls were filled with galvanized steel plate shims as shown on the drawing (to right) to provide consistent contact between the stiffener and the pipe. The required size and spacing of the stiffeners was determined using SSTAN finite element structural analysis software developed by Dr. Marc Hoyt of the University of Florida.



Case Study

Inspection. Evaluation. Remediation.

Federal Aid Project IM 94-4(76)119 – Under Interstate I-94 (Site 8- Mile Post 197) Dawson County, Montana

Culvert Owner:
Montana DOT

Culvert Size, Type & Length:
Triple Multi-Plate Pipe Arches
11'-5" Span x 7'-3" Rise x 210 feet

Year Installed:
1974

Inspection Engineer:
CBC Engineers & Associates

Evaluation Results:
West Structure – Marginal Condition
Middle Structure – Poor Condition
East Structure – Poor Condition

Remediation Solution:
West Structure – New Concrete Paved Invert
Middle and East Structures – New Ring Beam Stiffeners & Concrete Paved Invert



These three Multi-Plate Pipe Arches upon field inspection showed various distresses from invert corrosion, poor shape geometry, bolt hole tearing, to raised invert plates with voids below in the structures bedding. The ratings for these structures were 29 (West Structure), 21 (Middle Structure) and 25 (East Structure). These culvert ratings equate to 4, 3 and 3 respectively on the National Bridge Inspection rating system. The West Structure rating was controlled by poor corrosion in the invert and the Middle and East Structure ratings were controlled by both poor shape geometry and same rust in the invert. This site was one of 9 total culvert rehabilitation sites let by Montana Department of Transportation as a result of CBC Engineers and Associates inspection, evaluation and remediation designs. These repairs were let by the State of Montana in 2008. A computer program (MULTSPAN) developed under contract to FHWA and the State of Ohio DOT was used to evaluate the shortening of mid-

ordinates of the structure, and to provide recommendations relative to the degree of "flatness". The program uses the shortening or lengthening of mid-ordinates of the structure and the deflected shape to determine the stability of the structure from a deflection point of view.

The MULTSPAN analysis provides recommendations for remedial action on the basis of the degree of flatness of top arcs within the structure. The ratings above as well as the remedial action taken came straight from the field measurements made by CBC Engineers and Associates and the output of the MULTSPAN program. From here The Montana Department of Transportation asked CBC Engineers and Associates for actual field repairs that would extend the lives of these structures in place without replacement.

In order to repair these structures in place, CBC Engineers and Associates designed the following. First the West Structure had significant rust in the bottom flowline area. The most practical solution to this rust was to concrete pave the flowline area with concrete. The Middle and East Structures required much more attention. In addition to requiring ring stiffeners at selected areas, these two structures had tears around the bolt holes, raised invert plates and significant invert corrosion. The bolt hole tears should be repaired by filling the tears with E70XX weld to completely fill the tears then coating the welded areas with 2 coats of Galvanox or other zinc-rich coating in accordance with the manufacturer's procedures. The invert repairs of the West Structure were then used as well once all new stiffeners were installed.