Westfall Fiberglass Bridge Drain Pipe System
South Burlington, Vermont
Initial Report

June 2007

Report 2007 - 7
Reporting on Work Plan 2000-R-2

State of Vermont
Agency of Transportation
Materials and Research Section

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1. Report No. 2007-7	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Westfall Fiberglass Bridge Drain Pipe System** South Burlington, VT		5. Report Date June 2007 6. Performing Organization Code
7. Author(s) Nicole Crum, Jennifer Fitch		8. Performing Organization Report No. 2007-7
9. Performing Organization Name and Address Vermont Agency of Transportation Materials and Research Section National Life Building Drawer 33 Montpelier, VT 05633-5001		10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Highway Administration Division Office Federal Building Montpelier, VT 05602		13. Type of Report and Period Covered Initial (2003-2007) 14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

Runoff on bridge decks produced by various forms of precipitation can result in a safety hazard with respect to the traveling public through hydroplaning or icing. Additionally, ponding water, along with corrosive contaminants, may penetrate through a concrete deck through means of capillary transport potentially resulting in freeze/thaw and subsequent spalling. The penetration of road deicing salts may lead to corrosion of the reinforcing steel.

The intent of this investigation was to assess the durability of a material that is reportedly inert to oil, gas and deicing salts known as fiberglass. Installed in 2003, the six fiberglass drainage systems were found to be performing well four years following installation. Minor fisher cracking typically caused by fatigue, movement and expansion stressing was observed inside a few catch basins located at the outlet of the trough. Iron-oxide staining was also visible inside the catch basin most likely resulting from runoff containing rust. The bolts connecting the supporting system for the drainage pipe to the pier column were deformed as a result of wind and vibratory forces. This along with apparent section loss will most likely result in some type of shear or stem failure in the future. Periodic site visits and a subsequent final report will be prepared 2012.

17. Key Words Fiberglass Bridge Drain		18. Distribution Statement No restrictions	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. Pages 11	22. Price

INTRODUCTION:

Bridge drainage systems preserve concrete decks and reinforcing steel while reducing the potential for vehicular incidents caused by hydroplaning or icing. Specifically, drainage systems remove runoff from the surface of the bridge deck produced by precipitation or other sources. When properly constructed and maintained, a drainage system will provide efficient water removal resulting in enhanced public safety. Through the conveyance of runoff, these systems also impede the onset and rate of concrete delamination and deterioration of structural members caused by corrosive contaminates, such as deicing road salts.

Historically, the Vermont Agency of Transportation (VTrans) has installed bridge drainage materials comprised of metallic members. Over time, these materials are subjected to corrosive atmospheric conditions including precipitation containing varying degrees of acidity or alkalinity, dissolved gases and salts resulting in the deterioration of the metal. Other viable alternatives include PVC (polyvinyl chloride) and fiberglass. While lightweight, rust resistant and cost effective, PVC is sensitive to UV and oxidative degradation. In addition, it displays low impact strength. Conversely, fiberglass is inert to oil, gas, deicing salts and other corrosive chemicals. According to a representative from the New York Department of Transportation (NY DOT), fiberglass is resistant to impact and permits compatible steel support bracing allowing for existing hangers and supports to be reused when the system is replaced. However, fiberglass drainage systems generally cost 20 to 25 percent more than their PVC counterparts.

In an effort to assess a corrosive resistant drainage system, VTrans installed six – 8 inch diameter fiberglass bridge drain systems on Bridge # 68 on I-89 in the town of South Burlington. The following initial report provides a brief overview of the product, installation details, a cost comparison to other commonly installed drainage systems and preliminary observations regarding durability.

PRODUCT DETAILS:

According to the manufacturer, the Westfall Company, "all drainage pipes and fittings are to be a reinforced thermosetting resin pipe system which shall meet the requirements of ASTM D 2996, 'Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe,' with at least 30,000 psi short time rupture strength hoops tensile stress, and accelerated ultra-violet weathering performance requirements of ASTM G154, 'Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.' All pipes and related fittings shall be a color of standard concrete-gray or a designated color which blends with the aesthetics of the bridge."

Drain pipes, with a wall thickness of 1/8", are available in variety of outside diameters ranging from four to eighteen inches. The manufacturer specifies that straight pipe sections should be supported by a standard sling, clamp, and clevis hangers typically used with the traditional steel pipes which shall maintain no less than 120 degrees of contact between the pipe and support at all times. Minimum strap width varies from 1 ¼" to 2 ½" for pipe diameters ranging from three to sixteen inches, respectively. The thickness of the hanger supports shall be 3/16". All cleanouts shall be manufactured with a threaded PVC plug for removal.

Adhesive material used for bonding the elbow and other joints shall be composed of a vinyl ester resin based product with silica filler, polyester pigment, and a methyl ethyl ketone peroxide catalyst. Formulation of the adhesive must be certified and proven to be suitable for the intended application. The resin material must not retain any additives that may leach out, catalysts which remain active, or other corrosive ingredients which could lead to deterioration.

INSTALLATION:

Installation of the referenced fiberglass bridge drain system began on Saturday, July 13, 2003. In accordance with the Category II Work Plan, WP 2000-R-2, six – 8 inch diameter fiberglass drain systems including elbows, cleanouts, and custom catch basins were installed in association with the South Burlington IM DECK(36) project on Bridge #68 over I-89 by the contractor, J.A. McDonald Inc. The structure, 261 feet in length by 88 feet 5 inches in width rail to rail, is a four span rolled beam bridge with three concrete piers. Six drainage systems, along with drain troughs located inside the bridge joint, were installed on each side of the three piers. A minimum liner of 40-mil resin-rich one and one half ounce glass mat was used for all elbows. The minimum total wall thickness was 0.125 inches for the pipe, and the strap width was 1 ½". Please refer to Attachment A for a copy of the drain layout.

A total length of 254 feet of fiberglass bridge drain was installed. Due to a communication error, researchers were not onsite during the initial installation of the downspouts. As stated previously, installation of the drain trough and downspouts on pier #3 began on Saturday, July 13, 2003. Installation of the drain trough on pier #1 began on Wednesday, August 13, 2003. There was no record for installation of the trough and downspouts on pier #2. Drain troughs were cleaned from Tuesday, August 26 through Thursday, August 28, 2003. All the drain systems were found to be functioning properly during a site visit conducted on Tuesday, December 2, 2003. Figure 1 and 2 display various sequences of the installation process. Please refer to Attachment B for a copy of the applicable project plans.

According to the adhesive manufacturer, Grace Composites of Lonoke, AR, the glaze found on fiberglass pipes must be removed in order for the adhesive to bond to the pipe. This can be accomplished by trimming the pipe with an aluminum oxide blade on a power saw and thoroughly sanding all fittings and pipe bonding surfaces immediately prior to bonding. The adhesive is then applied to the machined area inside the fitting and the sanded area on the outside of the fitting, thick enough that a bead of adhesive is formed around the entire exterior circumference of the joint when assembled. Any adhesive on the outside of the joint should be smoothed out to form a fillet between the pipe and fitting. Once assembled, the downspout can be mounted to a fixed object with the installation of the hangers.

Additionally for this project, Type 1 Stone Fill was installed at the outlet of the downspout to assist in draining the runoff away from the pier. Fill was added to a minimum of 18 inches deep in a 6 foot wide area at the base of the pier underneath the downspout. There are also drainage basins in the medians on both sides of the piers, although the exact location could not be determined.

Figure 1 – Installation

Figure 2 – Installation

OBSERVATIONS:

A site visit was conducted on Tuesday, December 19, 2006 to monitor the performance of the fiberglass downspouts. Personnel from the Research and Development Unit were met onsite by Peter Bergeron of the Bridge Inspection Unit from the Structures Section. Weather conditions were slightly windy with temperatures hovering around the freezing point and snow beginning to precipitate. The site visit included a visual inspection of the fiberglass system which included an examination of the downspouts, catch basin and connections. In addition, the outlet of the drainage systems and troughs were also assessed. All observations were recorded as well as photo documentation.

Upon inspection, leakage along most of the pier caps was noted. According to Peter Bergeron, this was most likely attributed to a tear or puncture within the troughs. Peter also stated that the leakage could be caused by something plugging the drains, which frequently occurs at the intersection of the troughs and downspouts, known as a hopper or catch basin. Adjacent to the drainage system, all of the weeping tubes, a mechanism that discharges water between the bridge deck and curbing, were found to be frozen and not functioning properly.

Pipe fittings were also examined. While found to be in good condition, external flaking of the resin adhesive, used to bond and seal the elbow pieces to the straight pipe section, was observed as shown in Figure 3. This raised concerns regarding the potential for water infiltration between the connections potentially resulting in freeze thaw damage during winter months. Immediately following the site inspection, the Westfall Company was contacted to discuss this phenomenon. They explained that the resin adhesive will not adhere to the glazed finish on the exterior of the pipe. Furthermore, the resin is only needed for the bond between fittings and is not intended to be applied beyond the joint.

Figure 3 – Flaking of Adhesive

All lower supports were examined during the site visit and found to display signs of distress. As shown in Figure 4, the bolts that secure the drainage system to the pier were slightly deformed. This is most likely caused by shear forces generated from wind currents and bridge vibration. Section loss resulting from rust was also observed. Both will likely contribute to some form of stem or shear failure. When assessed by Peter Bergerson, he stated that the bolts were too small in diameter to withstand shear and vibratory forces.

Figure 4 – Bolt Deformation

Following an exterior examination, the interior of each catch basin and associated trough was assessed. Some iron-oxide discoloration, shown in Figure 5, was noted on the inside of the catch basin and drainage pipe most likely resulting from a discharge of runoff containing rust subsequently washed from the bridge deck into the trough and drain pipe. This may also indicate that there was some plugging and the water pooled in the catch-basin causing the orange colored ring around the top. Peter also noticed what he referred to as “fissure cracking” within some of the fiberglass structure, a term referring to the miniscule cracks in the fiberglass caused by fatigue, movement and expansion stressing.

Figure 5 – Iron-Oxide Discoloration

During the inspection, runoff from the downspout was pooling around the bottom of the pier columns rather than draining away. This indicates that the stone fill drainage has failed. Figure 6 and 7 provide a comparison between the condition of the drainage system at the base of the piers at the time of installation and during the site visit conducted in December 2006. According to the Portland Cement Association, concrete absorbs water, which expands when it undergoes a freeze-thaw cycle and builds pressure. This internal pressure can cause damage to the concrete such as scaling and spalling. The infiltration of water also provides a mechanism for the penetration of destructive materials such as chloride and sulfate ions increasing the likelihood for concrete delamination and corrosion of reinforcing steel. Maintenance of the drainage system on at least an annual basis is recommended at this time.

Figure 6 – Drainage on Dec. 2, 2003

Figure 7 – Drainage on Dec. 19, 2006

<u>COST:</u>

According to the work plan for the fiberglass bridge drain system, the cost for 254 feet of eight inch diameter pipe was $2200.00, or $8.66 per foot, in 2003. A recent estimate supplied by the Westfall Company indicates that the current cost for 8" diameter pipe is now $15.00 per foot resulting in a total estimated cost of $3810.00 dollars for the pipe alone. In comparison, according to an estimate from United States Plastic Corp., the cost of 254 feet of 8” diameter Schedule 40 PVC pipe is $12.41 per foot, resulting in a total cost of $3152.14. Finally, according to an estimate from Federal Steel Supply, Inc., the cost of 8” diameter steel pipe is $15.10 per foot, resulting in a total cost of $3987.80 for 254 feet.

<u>SUMMARY:</u>

Runoff on bridge decks produced by various forms of precipitation can result in a safety hazard with respect to the traveling public through hydroplaning or icing. Additionally, ponding water, along with corrosive contaminants, may penetrate through a concrete deck through means of capillary transport potentially resulting in freeze/thaw and subsequent spalling. The penetration of road deicing salts may lead to corrosion of the reinforcing steel. Therefore, adequate drainage is vital for both traveling public and life span of the bridge structure. Today, most design plans include drainage structures intended to convey runoff from the surface of the bridge deck to some type of drainage swale or catch basin. Historically, design plans have specified the use of steel, a material that breaks down in the presence of corrosive atmospheric conditions.

The intent of this investigation was to assess the durability of a material that is reportedly inert to oil, gas and deicing salts known as fiberglass. Installed in 2003, the six fiberglass drainage systems were found to be performing well four years following installation. Minor fisher cracking typically caused by fatigue, movement and expansion stressing was observed inside a few catch basins located at the outlet of the trough. Iron-oxide staining was also visible inside the catch basin most likely resulting from runoff containing rust. Although there were concerns raised regarding flaking of the resin adhesive found at joint connections, the Westfall Company assured that this is common when adhered to the glaze finish of the fiberglass. The bolts connecting the supporting system for the drainage pipe to the pier column were deformed as a result of wind and vibratory forces. This along with apparent section loss will most likely result in some type of shear or stem failure in the future. As a final aside, inadequate drainage was noted below the fiberglass drainage system indicating that the stone fill basin has failed generating a ponding effect around the adjacent concrete piers. This will cause premature concrete spalling and corrosion of reinforcing steel if left unaddressed. Maintenance is recommended at this time. This could be accomplished by cleaning the stone fill or by extending the discharge drainage pipe away from the column. With regards to cost, fiberglass is certainly cost effective when compared to other typically utilized materials. Overall, preliminary results are favorable. Figure 8 and 9 display the drainage system immediately following installation and three years following installation.

Figure 8 – After Installation

Figure 9 – On Dec. 19, 2006

FOLLOW UP:

Periodic site visits will be conducted over the next 5 years. A final report will be published at this time.

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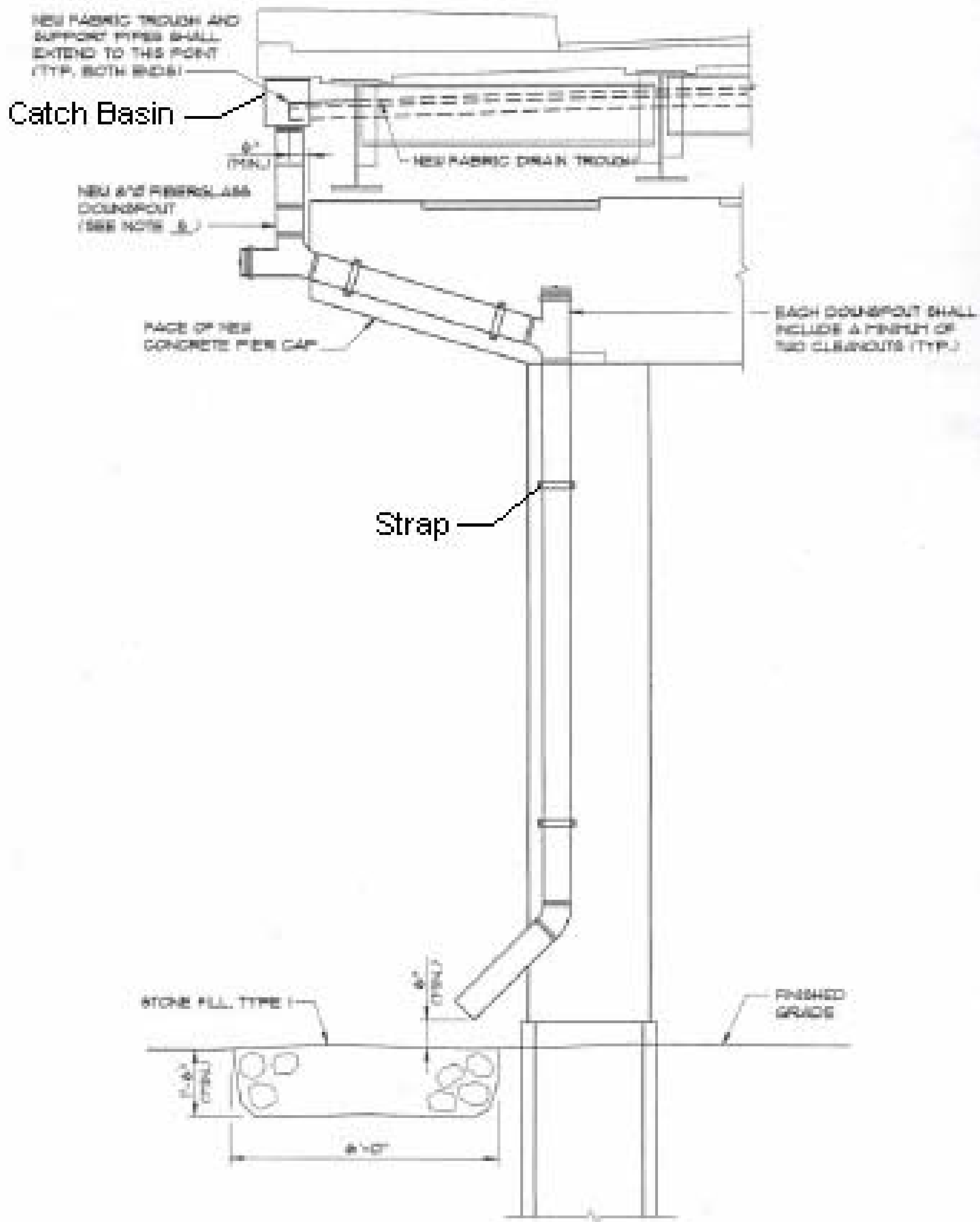
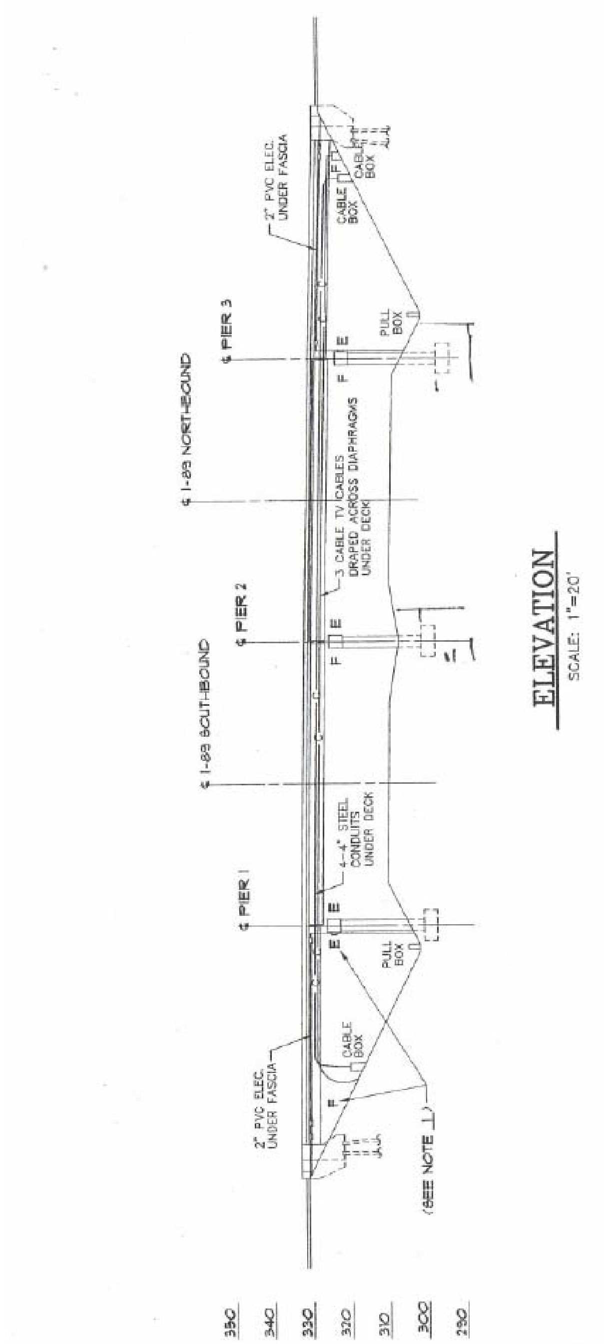
ATTACHMENT A



TYPICAL ELEVATION VIEW OF
NEW DRAIN TROUGH & DOWNSPOUT
NTS

ATTACHMENT B


ELEVATION
SCALE: 1"=20'
℄ I-89 NORTHBOUND
℄ I-89 SOUTHBOUND
℄ PIER 1
℄ PIER 2
℄ PIER 3
2" PVC ELEC. UNDER FASCIA
CABLE BOX
PULL BOX
4-4" STEEL CONDUITS UNDER DECK
3 CABLE TV CABLES DRAPED ACROSS DIAPHRAGMS UNDER DECK
(SEE NOTE 1)
350
340
330
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310
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290