Abstract

A method and apparatus for repairing a damaged host pipe, such as a corrugated steel pipe or other conduit. A plurality of interlocking plastic planks are positioned within the invert of the host pipe forming a liner. Rebar is first installed and attached to the host pipe for supporting the planks. A cementitious grout non-shrink grout for concrete such as VELOSIT® NG 511 is installed in the spaces between the liner formed by the interlocking planks and the host pipe so that the rebar is encapsulated with the concrete and so that the planks are immovably secured.

METHOD AND APPARATUS FOR REPAIRING CULVERTS AND PIPES

Field

This invention relates generally to the repair and rehabilitation of pipes such as corrugated steel culverts and more particularly to a method of applying an interconnecting planks to line the inside of a host pipe.

Background

For more than a century, more than a third of the drainage culverts installed in the United States have been corrugated steel pipe (CSP) in round and pipe-arch shapes. The service life of a corrugated metal culvert varies, depending on factors such as coatings, thickness, climate, maintenance, PH on water flows, and the condition of the surrounding soil. However, this type of culvert came into widespread use in the 1950s, and many are now reaching the end of their useful life and need to be repaired or replaced or refurbished before they fail. Metal culverts can fail in different ways. For example, rust and corrosion can cause the pipe to leak, or even to disintegrate and collapse. Leaks can lead to erosion around the pipe and the resulting lack of structural support can cause the pipe to break. Pipe failure can wash out roads and bridges and cause environmental damage to the waterways they drain into.

Culverts can be repaired, or refurbished, by building a new culvert or digging the existing pipe up and replacing it. But these methods can be costly and time-consuming. Further, open cut methods may impractical because of traffic volume; the road will likely have to be closed during open cut operations, terrain, or climate. However, culverts can sometimes be refurbished without digging them up. This process is referred to in the industry as trenchless replacement technology. In this method, a new pipe is attached to a tool that is pushed or pulled through the existing damaged pipe. The tool head intentionally breaks or splits the old pipe as it drags the new liner pipe in behind it; this technique is also called "pipe bursting". These methods allow culverts to be replaced with minimal disruption to traffic flow on any roadway above the culvert and with less impact on the waterway the culvert drains into. However, it should be noted that such "pipe bursting" techniques are "destructive" to the host pipe, i.e., the old pipe being replaced, rendering the host pipe effectively useless to provide support or peripheral protection, for example, to a new liner pipe. Another technique is to use a slipliner wherein a plastic liner is pulled through the interior of the host pipe, however this method has it's associated difficulties with pulling the liner through a corrugated pipe.

Furthermore, the environmental cost of replacing rusted corroded or damaged metal corrugated steel pipes (CSPs) in the form of culverts is extremely large. Repairing damaged culverts, heretofore, has been difficult. Many solutions have been proposed but none have been without drawbacks. This invention provides a environmentally conscious, green solution wherein culverts of host pipes of different sizes can be repaired by the same method, using a same structure and components. It's essentially a one size fits all solution. The only difference in repairing host pipes with different diameters is in number of planks and amount of re-bar and cementitious mortar that must be used. Each repair or refurbish follows essentially a same method The environmental advantage, convenience, low cost and ease of installation of this system makes it highly desirable. Furthermore, corrugated culverts in need of replacement can be repaired and in some instances their life may be extended by up to 75 years or more.

Summary of the Invention

In accordance with an aspect of the invention a method is provided for repairing at least an inner portion of a host pipe having an inner and outer wall, comprising:

positioning a supporting metal framework within the invert of the host pipe adjacent to the host pipe inner wall;

placing a first plurality of longitudinal planks in a longitudinal direction within the invert and coupling the planks to the metal framework;

attaching adjacent planks to one another by sliding a coupling at or about an outer longitudinal edge of one plank into a complementary coupling at or about longitudinal outer edge of another plank thereby connecting neighbouring planks, wherein at least a plurality of adjacent coupled planks form a trough, and wherein a cross-section of the trough is at least a quarter-circle; and, installing a cementitious grout within spaces between the coupled planks and the host pipe to fill a space between the planks and the inner wall of the host pipe and encapsulate the metal framework, wherein the metal framework, the grout and the planks form at least a partial inner wall for providing additional strength and longevity to the host pipe.

In accordance with the invention there is further provided a method for repairing at least an inner portion of an invert of a host pipe having an inner and outer wall, in the form of a culvert or other conduit, comprising:

troweling with a first cementitious grout material to fill in corrugated indentations in the inner wall of the host pipe;

positioning a supporting metal framework within the invert of the host pipe adjacent to the host pipe inner wall and coupling said metal framework with adhesive, cement, connectors or ties to the host pipe;

placing a plurality of longitudinal interlockable planks in a longitudinal direction within the invert and coupling the planks to the metal framework, wherein adjacent planks are attached to one another by sliding a coupling at or about an outer longitudinal edge of one plank into a complementary coupling at or about longitudinal outer edge of another plank wherein neighbouring planks are interlocked and wherein at least a plurality of adjacent coupled planks form a water-tight trough, and wherein a cross-section of the trough is at least a half-circle; and,

installing a second cementitious grout within spaces between the coupled planks and the host pipe to fill a space between the planks and the inner wall of the host pipe and encapsulate the metal framework, wherein the metal framework, the grout and the planks form at least a partial inner wall for providing additional strength and longevity to the host pipe, wherein the first cementitious grout is different composition from the second cementitious grout.

In accordance with another aspect of the invention, there is provided, a refurbished culvert comprising: a corrugated steel pipe (CSP) having an outer corrugated wall and an inner corrugated wall; a layer of a first cementitious material filling recesses of the inner corrugated wall so that the inside diameter of the inner corrugated wall is substantially uniform;

a layer of a second cementitious filler material adjacent the first cementitious material and having encapsulated therein a framework of rebar including longitudinal lengths of rebar and circular hoops of rebar; and a plurality of interlocked plastic planks having protrusions on one face thereof imbedded within the second cementitious filler material, wherein the interlocking plastic planks form a visible inside liner of the CSP.

Brief Description of the Drawings

Exemplary embodiments will now be described in conjunction with the drawings in which:

FIG. 1A is a prior art isometric view of a corrugated steel pipe.

FIG. 1B is a flowchart depicting the general steps of this invention.

FIG. 2a is an isometric view of a plastic plank in accordance with the invention.

FIG. 3 is a cross-sectional view of the plastic plank shown in FIG. 2.

FIG. 4 is an isometric view of and coupling for coupling ends of two plastic planks.

FIG. 5 is an isometric view of a rebar support frame.

FIG. 6 is an illustration of an expanded view of a portion of FIG. 5.

FIG. 7 is a perspective view of a plurality of interconnected planks forming a sleeve.

FIG. 8 is an exploded view showing layers of the refurbishment of a host pipe in accordance with the invention.

FIG. 9 is a cross-sectional view of a refurbished host pipe or culvert.

FIG. 10 is an enlarged view of a portion of an cross section of the pipe shown in Fig. 9

FIG. 11 is an enlarged view of a portion of an cross section of the bottom portion of the pipe shown in Fig. 9

Detailed Description

Referring now to FIG. 1A a corrugated steel pipe 100, generally for use as a culvert is shown. Steel pipes of this type can range in size from as little as a fraction of a meter to many meters in diameter.

Repairing or refurbishing a corrugated steel pipe (CSP) of this type is done in accordance with this invention generally as depicted by the flowchart FIG. 1B, by cleaning the interior wall of the steel pipe, constructing a metal rebar support structure within the invert or the interior of the CSP; attaching a plurality of interconnected plastic planks to the metal framework and injecting a cementitious grout to fill the space and any voids between the plastic planks and the inner wall of the CSP.

FIG. 5 shows the support structure of interconnected rebar that forms a skeleton upon which a skin of planks is attached. The rebar structure 500 is comprised of numerous lengths of rebar 505 attached to rebar hoops 510 that conform to the inner opening of the host pipe. Various sizes and forms of attachments 515 are shown coupling pieces of the rebar together. This obviates welding rebar sections to one another and these connectors or attachments 510 provide enough strength for the structure to withhold and support the plastic planks that will be attached thereto. Once the cementitious grout is injected between the plastic planks and CSP the entire structure provides the integrity and strength to last for decades. Each section of the rebar cage includes 6m lengths of 10mm rebar placed at 3, 6 9, and 12 o'clock positions within the host pipe. Rebar hoops 510 are preferably spaced 300mm apart.

FIG. 2 is an illustration of a plastic plank 200 having an overall dimension of 4' x 9" or 4' x 12" and a thickness of about 150". Planks 200 are formed of an High-density polyethylene (HDPE)

Plastic or recycled plastic. Each plank has a first face 220a having a male coupling rail 202 along one edge and a complementary female coupling rail 204 along an opposite edge. T-shaped protrusions 206a, 206b and 206c are also shown on the upper face of the plank 200. These features on the first face 220a can be seen more clearly in FIG. 3 showing a cross section of the plank 200. The purpose of the protrusions 206a, 206b and 206c is to securely affix the plank to a cementitious grout applied, after it cures. Since each plank 200 is placed side-by-side with an adjacent plank 200, when the planks are placed into a corrugated steel pipe to be repaired, a male connector at an edge of a plank is coupled with a complementary female edge connector of an adjacent plank. The longitudinal male rail 202 slides into the longitudinal recess of the female connector 204 to form a grout-tight seal between the two planks. The planks are said to be locked together when they are coupled together. However, these interlockable planks can be unlocked if necessary before they are grouted in place by sliding them in a reverse direction. An opposite face 220b is smooth and the plank 200 is shown having slight pre-curve from extrusion design dyes. Since the cross-section array of interconnected planks that fill the interior of the host pipe to be repaired will form a circle, it is advantageous for the planks themselves to have a slight curve conforming more to the curved wall of the host pipe. Completely filling the interior of the host pipe with planks is optional, depending on the extent of the repair. In some instances planks may only be required in the bottom half of the host pipe and not completely around the interior of the host pipe. This is one advantage of using planks that can be coupled together; as many as are required, can be provisioned.

Assemble of the planks is done in steps. After a first plurality of planks 200 are inserted into the host pipe to be repaired and they are fastened to the rebar framework, a second plurality of planks 200 are placed in front of the first planks to extend the length of the repair and this is repeatedly done until the host pipe or repaired region is covered with planks 200. A coupling bridging member 400 shown in FIG. 4 is placed between each plank end of the first plurality of planks 200 and each plank end of the second plurality of planks 200 to tightly couple the plank ends and to prevent grout from seeping through. Coupling member 400 is curved to receive the curved plank ends as the planks are slightly curved as was described heretofore. As can be seen in FIG. 7, the planks are arranged so that they are staggered thereby ensuring that this is no contiguous circular seam around the inner circumference of the liner pipe formed by the planks. As planks are installed and coupled to one another, they are attached to the rebar framework.

In accordance with a preferred embodiment of the invention the following sequential steps should be performed to extend the life of a CSP by up to 75 years.

Prior to any work being initiated, site conditions should be surveyed for any abnormalities or additional problems that may exist on site and if any are found these should first be remediated. Preferably, LIDAR should be used to provide a LIDAR survey to provide evidence of conditions to be compared with final results. Key survey points to be studied are at 12 pm, 3 pm, 6 pm, 9 pm clock positions within the host pipe.

Next the substrate of the host pipe 100 must be cleaned and prepared using high pressure water blasting to remove all bond breaking substances. Preferably water pressure of at least 3000 and preferably 5000 psi. Dust and debris should be fully removed from areas to be treated, anchored or supported. Once the inner surface of host pipe has been cleaned it will serve as the substrate for the additional layers to be added to the invert. Resilient anchoring fasteners are attached to the interior wall of the host CSP. For example high-density polyethylene (HDPE) or Basaltic bar ties 1010 are affixed to the inner wall of the host pipe at 12, 3, 6 and 9 o'clock positions and spaced along the length of the host pipe to be repaired or refurbished. Mortar 910 shown in FIG. 9, preferably VELOSIT® RM 202 is applied to the inner culvert surface from at least the 5:00 o'clock to 7:00 o'clock position with a wet trowel, so as to partially fill the ribs of the host pipe. The term "substantially uniform is to mean more uniform than the diameter of the host pipe before applying the VELOSIT® RM 202 which is a cementitious repair mortar for many types of construction substrates and preferably 80% to 100% of the depth of ribs of the host pipe should be filled. It has good adherence to the host pipe creates a good surface for coatings and overlays. Filling in the corrugations in the interior of the host pipe allows the host pipe along with the cementitious VELOSIT® RM 202 to synergistically provide a outer shell with increased strength that will bond to the inner grout, rebar and planks to form a repair that can last up to 75 years or more. As will be described hereafter, a different type of grout VELOSIT® NG 511 is used to fill in voids and bond to the VELOSIT® RM 202 in a later step.
VELOSIT® NG 511 has minimal shrinkage, has slight volume increase in the plastic stage to ensure good bonding to metal, has corrosion inhibitor, adequate working time, 60 min. working

time and 1740 psi (12 MPa) compressive strength after 6 hours, excellent adhesion to properly prepared concrete and steel, and minimal water penetration.

Referring now to FIG. 11, the bottom portion of the host pipe is shown having a layer of cement at the 6 o'clock position. The purpose of applying this layer is to provide additional thickness and to obviate the corrugations as this is the location where liquid typically runs and sits and is most likely to corrode. Care should be taken to allow all bar ties 1010 to protrude so that they can be used to affix rebar thereto.

Once the inner surface of the host pipe is prepared as described heretofore, the 10 metre longitudinal rebars 505 running along the inner surface of the culvert are installed. The longitudinal bars 505 should be installed at every clock position along the interior. This is preferably done with resilient stainless steel Tapcon® fasteners. Less preferably, but alternatively, the bars can be installed into the mud slab applied into the previous step. After the long bars are installed basaltic bar hoops 510 are installed to support the application of planks 200. Each plank is approximately 4 feet long so that a person can insert their art to reach and assemble the planks together and end joints are staggered.

Once the planks 200 are installed grout is pumped into the annulus space between the planks and surrounding culvert once the planks and rebar have been installed. The preferred grout used is VELOSIT® NG 511 or an equivalent grouting solution. Ideally there should be no voids, leaks and no form movement of the plank during the applying of grout. The pumping takes place in multiple stages as groups of planks are inserted.

The final completed remediated host pipe is expected to have up to a 75 year life span without corrosion.

CLAIMS

What is claimed is:

1. A method for repairing at least an inner portion of a host pipe having an inner and outer wall, comprising:

positioning a supporting metal framework within the invert of the host pipe adjacent to the host pipe inner wall;

placing a first plurality of longitudinal planks in a longitudinal direction within the invert

attaching adjacent planks to one another by sliding a coupling at or about an outer longitudinal edge of one plank into a complementary coupling at or about longitudinal outer edge of another plank thereby connecting neighbouring planks, wherein at least a plurality of adjacent coupled planks form a trough, and wherein a cross-section of the trough is at least a quarter-circle;

coupling the planks to the metal framework; and,

installing a cementitious grout within spaces between the coupled planks and the host pipe to fill a space between the planks and the inner wall of the host pipe and encapsulate the metal framework, wherein the metal framework, the grout and the planks form at least a partial inner wall for providing additional strength and longevity to the host pipe.

2. A method for repairing at least an inner portion of an interior of the host pipe as defined in claim 1, wherein the step of attaching adjacent planks to one another is performed by sliding a longitudinal rail at an edge of one plank into a receiving longitudinal groove of another plank, and repeating this step for a plurality of planks, wherein the first plurality of planks forming the trough form an inner liner pipe, wherein said inner liner pipe has a circular cross section.

3. A method as defined in claim 1 or claim 2, wherein the planks have a smooth face and an opposing face having one or more projections projecting outward in a direction toward the host pipe for securing the planks to the cementitious grout after it cures.

4. A method as defined in any of claims 1 to 3 wherein the face of each plank is curved about its longitudinal axis.

5. A method as defined in claims 2 through 4 comprising placing a second plurality of longitudinal planks in front of or behind the first plurality of planks, wherein the second plurality of planks are coupled with the first plurality of planks so as to lengthen the liner pipe, wherein cementitious grout is placed in a space between the second plurality of planks and the host pipe wherein the supporting metal framework is between the second plurality of planks and the host pipe.

6. A method as defined in claim 5, wherein the first and second plurality of planks are coupled to one another by placing a coupling element between abutting adjacent plank ends.

7. A method as defined in claim 6, wherein the first plurality of planks are staggered so that ends of side-by-side adjacent planks are not coplanar.

8. A method as defined in claims 1 through 7, wherein each plank has a coupling along or near a side edge thereof and a complementary coupling along or near an opposite side edge thereof and wherein said each plank couplings and one or more projections are formed from a same piece of plastic.

9. A method as defined in claims 1 through 8, wherein the one or more projections are t-shaped in cross-section.

10. A method as defined in claims 1 through 9 including the step of troweling grout on the inside wall of the host pipe.

11. A method for repairing at least an inner portion of an interior of a host pipe having an inner and outer wall, in the form of a culvert or other conduit, comprising:

troweling with a first cementitious bonding grout material to at least partially fill in at least some corrugated indentations in the inner wall of the host pipe;

positioning a supporting metal framework within the interior of the host pipe adjacent to the host pipe inner wall and coupling said metal framework with adhesive, cement, connectors or ties to the host pipe;

placing a plurality of longitudinal planks in a longitudinal direction within the interior and coupling the planks to the metal framework, wherein adjacent planks are attached to one another by sliding a coupling at or about an outer longitudinal edge of one plank into a complementary coupling at or about longitudinal outer edge of another plank so that neighbouring planks are interconnected and wherein at least a plurality of adjacent coupled planks form a grout-tight trough, and wherein a cross-section of the trough is at least a half-circle; and,

installing a second cementitious grout within spaces between the coupled planks and the host pipe to fill a space between the planks and the inner wall of the host pipe and encapsulate the metal framework, wherein the metal framework, the grout and the planks form at least a partial inner wall for providing additional strength and longevity to the host pipe, wherein the first cementitious bonding grout is different composition from the second cementitious grout.

12. A refurbished culvert comprising:

a corrugated steel pipe (CSP) having an outer corrugated wall and an inner corrugated wall;

a layer of a first bonding cementitious material within a plurality of recesses of the inner corrugated wall;

a layer of a second cementitious filler material adjacent to and contacting the first cementitious material and having encapsulated therein a structural metal framework including longitudinal lengths of rebar and circular hoops, wherein the first and second cementitious materials have different properties; and

a plurality of interconnected plastic planks arranged side-by-side and end-to-end each having protrusions on one face thereof imbedded within the second cementitious filler material, wherein the interlocking plastic planks form a visible inside liner of the CSP spaced from the inner wall of the CSP.

13. A refurbished culvert as defined in claim 12 wherein the second cementitious material forms a layer between the host pipe and the plurality of interlocked plastic planks.

14. A refurbished culvert as defined in claim 12 or 13 wherein the a layer of a first cementitious material filling the plurality of recesses of the inner corrugated wall makes the inside diameter of of the filled corrugated wall substantially uniform

Statement: This application relates to a technology that if commercialized would resolve or mitigate the costly environmental impact of replacing deteriorating large corrugated steel pipes (CSPs) or culverts. Many of these culverts installed are at an end of their useful life. The invention provides a solution where a CSP can be repaired in-situ with little disturbance to the environment and with green technology. Otherwise, removing and retrenching would be at huge environmental cost.