

SURFACING OR REHABILITATING STRUCTURES WITHOUT SUPPORTING FORMS

Field of the Invention

The present invention relates generally to a device and method for surfacing or rehabilitating concrete structures such as pipelines, manholes, monolithic structures and the like, and, more particularly, to a method for surfacing or rehabilitating concrete structures without having to use supporting forms or props to effect such surfacing or rehabilitation.

Background of the Invention

Concrete structures such as pipelines and manholes that are buried beneath the surface are difficult and costly to replace and, therefore, are repaired or rehabilitated when leaks develop in such structures. For example, repairing sewer pipes which have developed leaks has proven to be an expensive operation, normally involving disruption of sewer services. One of the most common solutions has been to dig up the section of leaking sewer pipe and then replace it with new pipe which is suitably attached to the existing sewer pipe. However, the expense of this method is readily apparent, especially in urban setting, as is the disruption of sewer service. The same holds true for the replacement of other non-subterranean structures that are formed from concrete that serve to enclose a fluid handling device such as a pump, pipeline, tank and the like.

Concrete structures are particularly susceptible to corrosion and erosion due to contact with or use in transporting liquids that are acidic in nature or that include some amount of solid component, respectively. Over time, the concrete structure subjected to such use will corrode and/or erode, causing wall portions of the structure to be eaten away and ultimately causing the structure to leak. As leaking liquid escapes from a subterranean pipe the ground surrounding the pipe serving as a foundation is eroded away from contact with the pipe, thereby leaving the already structurally weakened pipe without foundational support which may result in catastrophic structural failure.

Devices and methods for in-place surfacing or rehabilitation of concrete structures, to avoid the costly alternative of removal and replacement of such structures, have been developed and are known in the art. For example, United States Patent No. 2,794,758 discloses a method and apparatus for in-place lining of a pipeline to protect the pipeline from the effects of corrosion and erosion. The apparatus comprises a housing that encloses a reel of flexible liner therein. The housing is attached at an outlet end to one end portion of the pipe to be repaired. A liquid pressure source, such as water and the like, is connected to an inlet end of the housing. Liquid entering the housing from the liquid pressure source imposes a pressure against a backside portion of the liner that has been attached at one end

1 to a surface portion of the pipe. Continued exertion of liquid pressure against the liner
backside surface causes the liner to unwind from the reel and be displaced through the length
of the pipe. As the liner is displaced through the pipe the liquid pressure imposed against
the backside surface causes the liner to unfold and be pressed against the wall surface of the
5 pipe. Accordingly, this apparatus and method for repairing a pipeline relies on liquid
pressure to dispense and place a flexible liner against the pipe wall portion requiring repair.
This apparatus is, however, practically limited to the repair of pipelines only and, more
particularly, to pipelines having a relatively small diameter, e.g., on the order of from 5-20
inches in diameter.

10 United States Patent No. 3,132,062 discloses a method of in-place lining of conduit.
The method comprises using a version of the housing and reel apparatus disclosed in United
States Patent No. 2,794,758, discussed above, that has been modified to include adhesive
rollers disposed adjacent the housing end portion attached to the pipe. The method is an
improvement of the method recited in United States Patent No. 2,794,758, involving applying
15 an adhesive material to the backside surface of the folded liner as the liner is being dispensed
within the pipe to promote adhesion of the liner with an adjacent pipe wall surface. Again,
however, this apparatus and method is limited only to the repair of pipelines and, more
particularly, to pipelines having a relatively small diameter, e.g., on the order of from 5-20
inches in diameter.

20 United States Patent No. 4,170,248 discloses a method for repairing sewer pipes by
inserting a thin, flexible liner within the sewer pipe. The liner has an outside diameter that
is less than the inside diameter of the sewer pipe, thereby forming an annular space
therebetween. A top portion of the sewer pipe is removed at one location to expose the
liner disposed therein. Packing is inserted at each sewer pipe end portion to seal off the
25 annular opening between the liner and sewer pipe walls. The annular space between the
sealed off ends is filled with a low viscosity cement by pouring the cement into a hole
surrounding the removed top portion of the sewer pipe such that the cement can freely enter
and fill the annular space. The cement is poured to a level above the top of the sewer pipe
to provide a hydrostatic head to effect migration of the cement through the annular space
30 between the liner and pipe and to the sealed ends. A overflow tube drilled into the top
portion of the sewer pipe near each sealed end portion to provide an indication of whether
the annular space is filled. This method, however, is also limited to repairing only pipelines
and, more particularly, pipelines that are positioned in a horizontal orientation.

35 United States Patent No. 4,792,493 discloses a corrosion resistant coating and liner
combination used for repairing a water system pipe or reservoir comprising spray applying
a polyurethane coating to a surface to be repaired and then adhering a sheet of polyvinyl
chloride to the surface of the polyurethane coating. The polyvinyl chloride sheet is prepared
for bonding to the surface of the polyurethane by applying a polyurethane primer-activator

1 to the surface of the sheet. The polyvinyl chloride sheet is chemically bonded to the
polyurethane coating by reaction of the primer activator and the polyurethane coating to
provide a chemically resistant pipe liner. This method, however, does not provide long term
leak protection as further cracking of the pipe is transmitted to an adjacent polyvinyl chloride
5 sheet via the polyurethane coating, which causes the sheet to also crack and, thereby,
permitting the escape of liquid from the pipe.

United States Patent No. 5,101,863 discloses a method of rehabilitating underground
pipes with an expanding helical wound liner. The method involves forming a helical wound
liner made from a synthetic resin by winding a continuous strip of the resin around a virtual
10 cylinder, of smaller outside diameter than the inside diameter of a pipe to be repaired, and
interconnecting adjacent side edges of the strip together with a removable wire rod. The
liner is then inserted into the pipe to be repaired and the leading end of the liner is attached
to the inside wall of the pipe. The wire rod is removed, causing the liner to expand against
the inside diameter of the pipe. As the wire rod is removed from the liner a device inserted
15 between the outside diameter of the liner and the inside diameter of the pipe deposits a foam
back filling material onto the outside surface of the liner. The device deposits the back fill
material as it is retracted from the pipe so that such back fill material is applied
simultaneously to that section of the liner that is expanded against the pipe wall. This
method is also limited to use in repairing only pipelines and, more particularly, is practically
20 limited to repairing pipelines having a relatively moderate diameter in the range of from 12-
36 inches in diameter.

United States Patent No. 5,102,263 discloses a method of renovating and/or protecting
sewers and pipes comprising forming a liner from lengths of PVC panels, placing the panels
around the wall of the pipe, and butt-joining together end portions of panel. The panels are
25 configured having complementary edge configurations so that each panel portion that is butt-
joined together may be clipped together along edge portions with an adjacent panel portion.
The backside surface of each panel includes T-shaped formations that extend outwardly away
from the backside surface to contact an adjacent wall surface of the pipe. If needed, due to
corrosion that has eaten away a section of the sewer wall, holes can be drilled in the sewer
30 wall (post installation of the liner) and grout pumped into the cavity between the liner and
sewer wall to provide support to the liner. This method is limited in that it applies only the
renovation of sewer pipes and, more particularly, to the repair of an entire diameter section
of the pipe, due to the interlocking nature of the panels and the lack of attachment means for
supporting an individual panel against the sewer wall.

35 United States Patent No. 5,190,705 discloses a method for lining large-diameter pipes
comprising the steps of supporting a tubular lining within the pipe by using supporting props,
injecting a hardenable mass into a space between the liner and the inside pipe wall surface,
allowing the hardenable mass to cure, removing the props, and repeating the cycle for the

1 next tubular lining section. The tubular liner may include T-shaped formations that extend
outwardly away from a backside surface to anchor it solidly to the hardenable mass. This
method is limited in that applies only to the repair of pipelines and relies on the use of props
to temporarily support the tubular liner in position against the pipe wall surface while the
5 hardenable mass is injected and cured, thereby increasing repair difficulty and the time
associate with completing such repair.

It is, therefore, desired that a device be constructed and method be devised to use the
device to facilitate the surfacing or rehabilitation of a wide range of concrete structures,
including pipes, that serve to contain and/or transport a volume of liquid. It is desired that
10 the device and method be able to accommodate the surfacing or rehabilitation of structures
having different geometries and sizes. It is desired that the device and method facilitate
quick surfacing or repairs of such structures without having to use forms, props or other
specialized equipment to install and/or retain the surfacing or rehabilitating device into place.
It is also desired that the surfacing or rehabilitating device be capable of protecting against
15 leakage from the structure in the event of future structure damage.

Summary of the Invention:

There is, therefore, provided in practice of this invention a device for surfacing or
rehabilitating structures comprising a flexible liner formed from a resilient material that is
20 preferably chemical and/or corrosion resistant. The liner has a back side surface that
includes a number of ribs that project outwardly a distance away from the liner and that are
located positioned at repeating intervals. The ribs each have an enlarged profile that is
configured to provide a strong mechanical lock with an intermediate adhesion layer or
carrier applied to a surface portion of the underlying substrate in need of surfacing or
25 rehabilitation.

The flexible liner is installed to surface or rehabilitate a structure by applying a
thickness of the carrier to the wall section of the underlying substrate in need of repair,
positioning the back side surface of the liner adjacent the carrier, and pressing the liner
against the carrier so that the ribs are inserted and completely covered by the carrier. The
30 carrier is formed from a resinous material that has good thixotropic properties, thereby
allowing the user to release the liner after pressing it against the carrier. The carrier is
formed from a material that displays good chemical and/or corrosion resistance when cured.
The carrier cures to form a strong bond with the surface of the underlying substrate but not
with the back side surface of the liner. The ribs are disposed within the carrier and are
35 mechanically locked therein by curing action of the carrier.

The flexible liner of this invention allows for the surfacing or rehabilitation of
structures other than pipes that have a number of different geometries and sizes. The carrier
of this invention allows for the installation of the liner without the need for external

1 supporting means such as props, forms and the like, thereby reducing installation and/or
repair time and repair costs. The carrier of this invention also minimizes the possibility that
cracks or tears in the flexible liner will develop, due to subsequent cracks in the underlying
pipe wall, because the liner is not bonded to the carrier and, therefore remains flexible and
5 insulated from such underlying cracks.

Brief Description of the Drawings

These and other features and advantages of the present invention will become
appreciated as the same becomes better understood with reference to the specification, claims
10 and drawings wherein:

FIG. 1 is a perspective view of a flexible liner constructed in accordance with
principles of this invention;

FIG. 2 is an enlarged cross-sectional side elevation of a rib projecting from the
flexible liner of FIG.1;

15 FIGS. 3a-3d are cross-sectional side elevations of different embodiments of ribs
constructed according to principles of this invention.

FIG. 4 is a cross-sectional side elevation of the flexible liner of FIG. 1 installed
against an inside wall surface of a concrete pipe; and

20 FIG. 5 is an exploded perspective view of the flexible liner of FIG. 1 being installed
against an inside wall surface of a concrete pipe.

Detailed Description:

FIG. 1 illustrates a protection or rehabilitation device as constructed according to
principles of this invention in the form of a flexible liner 10. The flexible liner is configured
25 in the shape of a flat sheet formed from a resilient material. FIG. 1 illustrates only a section
of the flexible liner 10 for purposes of reference and clarity. It is to be understood that the
flexible liner may be configured in the form of a sheet having a dimension that is dictated
by the particular application. It is desired that the flexible material be formed from a
material that displays good chemical and corrosion resistance due to the formation acid
30 species within sewer pipes during use. The acid species are formed from hydrogen sulfide
gas (H_2S), that is emitted by sewage carried by the pipes, that combines with water to form
sulfuric acid (H_2SO_4). Because the H_2S gas exists mainly along the top portion of the sewer
pipes, the acid species that is formed also collects along the top portion of the sewage pipe,
resulting in corrosion damage along 90 to 360 degrees of the pipe. It is, therefore, desired
35 that the flexible liner be made from a corrosion resistant material so that, when installed
within the pipe, it can act to protect the pipe top portion from further corrosive damage.
Suitable materials for forming the flexible liner include thermoplastic polymers such as
polyvinyl chloride (PVC), polyethylene (PE), and polypropylene (PP).

1 A preferred flexible liner may have a thickness of approximately 1.6 millimeters (1/16
inch) and be formed from PVC. It is desired that the flexible liner have a thickness that both
facilitates flexibility, to accommodate a particular substrate geometry, and does not impact
the volumetric and/or hydraulic characteristics of the underlying substrate. It is desired that
5 the flexible liner be sufficiently flexible to permit its use in surfacing or rehabilitating
different geometrically configured substrates, such as pipes having different diameters,
rectangular or square structures having flat surfaces and the like. It is, therefore, intended
that application of the flexible liner 10 not be limited to surfacing or rehabilitating substrates
in the form of pipes.

10 The flexible liner 10 has a smooth front side surface 12 that, after installation on the
underlying substrate, forms the outer facing surface of the particular substrate. The front
side surface may, therefore, be placed in direct contact with the fluid being contained or
transported by the substrate. It is desired that the front side surface be smooth so as to not
adversely impact the hydraulic characteristics of the underlying substrate. The flexible
15 liner 10 has a back side surface 14 that includes a number of ribs 16 that each project
outwardly a distance away from the back side surface. The ribs 16 are positioned at
repeating intervals along the back side surface 14 of the liner and are configured having an
enlarged profile 18 at an end portion that facilitates a mechanically locking engagement with
an intermediate adhesion layer or carrier that is applied to the substrate surface, as will be
20 discussed in detail below. Accordingly, the primary purpose of the ribs is to provide a
mechanically locking engagement with the carrier, rather than to provide an offset from a
surface portion of the underlying substrate. In a preferred embodiment, the ribs are spaced
apart at approximately 63.5 millimeter (2-1/2 inch) intervals. Although the flexible liner has
been described and illustrated having a specific thickness and rib placement interval, it is to
25 be understood that the liner thickness and placement of the ribs may vary according to each
particular application.

In FIG. 1, the flexible liner 10 is illustrated having ribs 16 having an enlarged profile
18 configured in the shape of a solid arrow having a pointed end portion and flared edge
portions (as best shown in FIG. 2) to both facilitate insertion within the carrier and retention
30 of the rib within the carrier after being inserted to form a strong mechanical lock therewith.
The ribs 16 can also be configured having differently shaped enlarged profiles 18 such as
those shown in FIG. 3a (a hollow arrow shaped profile 20), FIG. 3b (a hollow circle shaped
profile 22), FIG. 3c (a "T" shaped profile 24), and FIG. 3d (a right angle or sheep leg
shaped profile 26). It is to be understood that the rib configurations specifically described
35 above and illustrated are intended to be representative of the different ways in which the ribs
may be configured for purposes of reference and clarity only and, therefore, are not meant
to be limiting. For example, the ribs 16 may have enlarged profiles 18 configured having
a square, rectangular, or triangular shape. In a preferred embodiment, the ribs 16 have an

1 enlarged profile 18 configured in the shape of a solid arrow, as shown in FIGS. 1 and 2.
In a preferred embodiment, each rib 16 projects outwardly away from the back side surface
14 a distance of approximately 9.5 millimeters (3/8 inch).

FIG. 4 illustrates the flexible liner 30 after it has been installed against a wall portion
5 32 of a concrete pipe 34, e.g., a sewer pipe. An intermediate adhesion layer or carrier 36
is applied to the wall portion 32 of the pipe in need of repair. A suitable carrier 36 can be
formed from a resinous, cementitious, polymer, gel-like material that demonstrates good
chemical and corrosion resistance upon curing to form a corrosion protective layer on the
substrate surface, strong adherence to the underlying substrate material under a variety of
10 different operating circumstances, and a strong thixotropic hold to the flexible liner upon
initial contact, while temporarily remaining soft or gel-like to accommodate placement of the
ribs therein during installation of the flexible liner. Other desired properties of the carrier
is that it be capable of adhering uncured wet or very damp concrete, brick, and other
surfaces that have been previously corroded and/or eroded.

15 It is desired that the carrier not slump on vertical surfaces and overhead surfaces, and
be sufficient thixotropic to carry the weight of the flexible liner while curing. It is desired
that the carrier be non-toxic, have low to zero volatile organic compounds, and be user
friendly. It is also desired that the carrier be capable of curing within a short amount of time
at ambient temperatures between 5°C and 38°C (40°F and 100°F). In a preferred
20 embodiment, the carrier can cure or harden completely at room temperature (25°C) in
approximately one hour. The cure reaction of the carrier is exothermic and is influenced by
the ambient temperature. Therefore, it is to be understood that the cure rate of the carrier
will vary depending on the ambient temperature.

It is desired that the carrier cure to form a strong bond with the surface of the
25 substrate but not with back side surface of the flexible liner so that the only mechanism
retaining the flexible liner against the carrier is the mechanical lock that is formed between
the ribs and the carrier. Although it is desired that the flexible liner adhere to the carrier
upon initial contact, to eliminate the need for temporary structural support or props, the
formation of a bond between the carrier and the flexible liner back is not desired so that the
30 flexible liner can remain flexible with respect to and independent from the adjacent wall
surface. This eliminates the possibility of the flexible liner cracking or tearing as a result
of cracks that develop in the substrate 24 and that are transmitted from the wall portion 32
to the carrier 36. Constructed in this manner, the flexible liner 30 is better able to protect
against fluid or gas leakage from the pipe due to the development of such pipe cracks.
35 Additionally, the flexible liner is better able to prevent ingress of ground water into the pipe
due to the development of such pipe cracks in applications where the pipe is buried at a depth
equal to or below the ground water level. In such cases the ground water passing through
the cracks in the pipe is trapped between the pipe wall section and the back side surface of

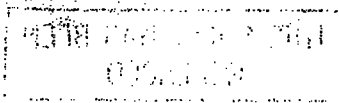
1 the liner, and is thereby prevented from entering the pipe.

A suitable carrier material is a two-part epoxy resin comprising a resin component and a hardener or catalyst component. A preferred resin component may include reaction products from combining an epoxide with a phenol, such as epichlorohydrin and Bisphenol A. A preferred hardener or catalyst component may include an amine and alcohol such as tetraethylenepentamine and benzyl alcohol. It is desired that the carrier material also comprise an amount of extender in the form of calcium silicate, silica sand, hollow glass spheres and the like. Use of the extender is desired for economic reasons, to decrease the amount of resin and hardener component that is needed to cover a particular substrate portion, i.e., make a particular repair. A preferred extender is in the form of hollow glass spheres, and a preferred carrier may include in the range of from 5 to 30 percent by weight extender. However, it is to be understood that the carrier can be prepared and used without the extender is desired. A particularly preferred carrier is manufactured by Jeffco Products of San Diego California under the product number 9912.

15 FIG. 5 illustrates a section of the flexible liner 38 as it is being installed within a pipe 40 to repair a corroded and/or eroded pipe wall section 40. The wall section 40 is first cleaned and then, if necessary, built up to its original wall thickness by applying mortar or other suitable concrete patch material. The intermediate adhesion layer or carrier 44 is applied to the wall section. The thickness of the applied carrier should be sufficient to accommodate the complete length of the ribs 46. The carrier 44 can be applied by conventional application techniques such as by hand application using a trowel and the like, or by pump application. Once the carrier is applied and adhered to the wall section 42 the liner 38 is placed with its back side surface 48 adjacent the carrier and is pressed against the carrier so that the ribs 46 projecting from the back side surface of the flexible liner are inserted into the carrier.

25 Alternatively, the carrier 44 can be applied to both the wall section 42 and the back side surface of the flexible liner 38, thereby eliminating the need to press the liner against the carrier to cause the ribs to enter the carrier. However, it is still necessary that the liner be pressed to some extent against the carrier on the wall section to ensure contact between the two adjacent carrier portions. Once the flexible liner is pressed into the carrier, the thixotropic qualities of the carrier serve to hold the liner into place, allowing the user to release the liner after being pressed into place and eliminating the need to use external supports, forms, or props and the like.

30 The flexible liner and method for applying the same can be used to surface or rehabilitate an entire circumferential wall section of a damaged pipe (as shown in FIG. 4) or can be used to repair only a discrete section along the pipe wall. The flexible liner can be configured in the size needed to accommodate a particular surfacing or rehabilitation application from one sheet or from a number of smaller liner sheets that are either joined



1 together by conventional techniques, such as by adhesive or hot air welding in the field or
by dielectric welding at the point of manufacture. Although the flexible liner and method
for applying the same has been described and illustrated for use in surfacing or rehabilitating
concrete substrates, e.g., sewer pipes and the like, it is to be understood that the flexible
5 liner and method of this invention may be used to surface or rehabilitate non-concrete
structures as well such as brick and other masonry structures.

Although limited embodiments of the device and method for surfacing or rehabilitating
structures have been described herein, many modifications and variations will be apparent
to those skilled in the art. Accordingly, it is to be understood that, within the scope of the
10 appended claims, the device and method for surfacing or rehabilitating structures may be
embodied other than as specifically described herein.

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1 **What is Claimed is:**

1. A device for surfacing or rehabilitating a structure for containing or transporting fluid, the device comprising:

5 a flexible liner formed from a sheet of resilient material, wherein the liner comprises a back side surface having a number of ribs that project outwardly a distance away from the liner;

10 an intermediate adhesion layer interposed between a surface of the structure and the back side surface of the liner, wherein the intermediate adhesion layer cures to form a strong bond with the surface of the structure but not with the back side surface of the sheet, and wherein the ribs are disposed within the intermediate adhesion layer.

15 2. The device as recited in claim 1 wherein the ribs are configured having an enlarged profile that facilitates the formation of a mechanical lock with the intermediate adhesion layer upon curing.

3. The device as recited in claim 2 wherein the ribs are configured having a enlarged profile selected from the group of geometric shapes consisting of an arrow, a circle, a square, a "T", and a right angle.

20 4. The device as recited in claim 1 wherein the intermediate adhesion layer is formed from a resinous material that adheres the surface of the structure and locks with back side surface of the liner, and cure at room temperature in the presence of moisture to form a chemically resistant protective layer on the surface of the structure.

25 5. The device as recited in claim 1 wherein the liner is formed from a resilient chemically resistant material selected from the group of thermoplastic polymers consisting of polyvinyl chloride, polyethylene, and polypropylene.

30 6. A device for surfacing or rehabilitating concrete structures comprising: a flexible liner formed from a sheet of resilient chemically resistant material, wherein the liner has a back side surface comprising a number of ribs that project outwardly a distance away from the back side surface;

35 an intermediate adhesion layer interposed between a surface of the concrete structure and the back side surface of the liner, wherein the intermediate adhesion layer cures to form a strong bond with the surface of the concrete structure but not with the back side surface of the liner, wherein the ribs are disposed within the intermediate adhesion layer, and wherein the ribs have an enlarged profile configured to form a mechanical lock with the intermediate adhesion layer upon curing.



1 7. The device as recited in claim 6 wherein the liner is formed from resilient materials selected from the group of thermoplastic polymers consisting of polyvinyl chloride, polyethylene, and polypropylene.

5 8. The device as recited in claim 7 wherein the intermediate adhesion layer is formed from a resinous material that is strongly adhesive to the surface of the structure and the back side surface of the liner, and cures at room temperature in the presence of moisture to form a chemically resistant protective layer on the surface of the structure.

10 9. A method for surfacing or rehabilitating a structure without using forms or props for support, the method comprising the steps of:

 applying an intermediate adhesion layer to a surface portion of the structure;
 positioning a back side surface of a flexible liner against the intermediate adhesion layer, wherein the back side surface of the liner includes a number of ribs that each project
15 outwardly a distance away from the liner;

 pressing the flexible liner against the intermediate adhesion layer to cause the ribs to enter and be surrounded by the intermediate adhesion layer; and

 forming a mechanical lock between the ribs and the intermediate adhesion layer.

20 10. A method as recited in claim 9 comprising applying an intermediate adhesion layer that is strongly adhesive to retain the flexible liner after being pressed against the intermediate adhesion layer without use of external supports.

25 11. A method as recited in claim 10 comprising applying an intermediate adhesion layer that when cured forms a strong bond with the surface portion of the structure but not with the back side surface of the flexible liner.

30 12. A method as recited in claim 9 comprising forming a mechanical lock between the intermediate adhesion layer and end portions of the ribs that are configured having an enlarged profile to resist outward travel from the adhesion layer and facilitate formation of the mechanical lock.

35 13. A method as recited in claim 9 comprising forming the mechanical lock between the ribs and intermediate adhesion layer by action of the intermediate adhesion layer curing.

 14. A method as recited in claim 9 comprising applying the intermediate adhesion layer in a thickness equal to or greater than the distance that the ribs project from the liner to ensure that the ribs are completely surrounded.



1 15. A method for surfacing or rehabilitating a structure comprising the steps of:
applying an intermediate adhesion layer to a surface portion of the structure;
inserting ribs that project from a back side surface of a flexible liner into the
intermediate adhesion layer, wherein the ribs are configured having end portions with an
5 enlarged profile to facilitates retention of the ribs within the intermediate adhesion layer; and
forming a mechanical lock between the ribs and the intermediate adhesion layer by
action of the intermediate adhesion layer curing.

10 16. A method as recited in claim 15 comprising applying an intermediate adhesion
layer that is strongly adhesive to retain the liner in place against the intermediate adhesion
layer without use of external supports after the step of inserting the ribs.

15 17. A method as recited in claim 15 comprising forming a strong bond between the
intermediate adhesion layer and the surface portion of the structure but not the back side
surface of the liner by action of the intermediate adhesion layer curing.

20 18. A method as recited in claim 15 comprising forming a chemically resistant
protective layer on the surface portion of the structure by applying an intermediate adhesion
layer having chemically resistant properties after curing.

25 19. A method for repairing a structure comprising the steps of:
applying an intermediate adhesion layer to a surface portion of the structure;
placing a surface portion of a flexible liner against the
intermediate layer so that ribs projecting outwardly away from the surface enter and are
completely encapsulated by the intermediate adhesion layer, wherein each rib is configured
with an end having an enlarged profile, and where the intermediate layer and surface portion
of the flexible liner are adapted to temporarily adhere to one another upon initial contact;
and

30 forming a mechanical lock between the ribs and the intermediate adhesion layer by
action of the intermediate adhesion layer curing, wherein the surface portion of the liner is
positioned adjacent the intermediate adhesion layer and is not adhered thereto by curing.

35 20. A method as recited in claim 19 comprising applying the intermediate adhesion
layer in a thickness equal to or greater than the distance that the ribs project from the liner
to ensure that the ribs are completely encapsulated.



1 21. A method as recited in claim 19 comprising forming a chemically resistant
protective layer on the surface portion of the structure by applying an intermediate adhesion
layer having chemically resistant properties after curing.

5 22. A method as recited in claim 19 comprising forming the mechanical lock by
curing the intermediate adhesion layer at ambient temperature for approximately one hour.

10 23. A method as recited in claim 19 comprising repairing a structure without the
use of external support to hold the liner into place during the steps of placing the liner
against the intermediate adhesion layer, and forming a mechanical lock.

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This Sheet Has Been Replaced



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