A system and method for temporarily filling surface voids, such as cracks, potholes or other surface breaches includes a flexible container, such as a bag. The bag is filled with an engineered viscosity fluid. The fluid properties are chosen in accordance with a particular application in accordance factors including hole properties, anticipated traffic properties and ambient temperature. A bag with appropriate properties is placed in a void, and provides a temporary travel surface. Embodiments include fluids with engineered viscosity properties, including non-Newtonian fluids. Additional embodiments include selectively filled, selectively drained, or multiple bags. Another embodiment includes tubular, flexible containers cut to size in accordance with hole characteristics.
SYSTEM AND METHODS EMPLOYING
NON-NEWTONIAN FLUIDS

CROSS-REFERENCE TO RELATED
APPLICATIONS

[0001] This application claims priority to U.S. patent appli-
cation Ser. No. 13/785,714 filed Mar. 5, 2013 which claims
benefit of priority to U.S. Provisional Application No.
61/606,584 filed Mar. 5, 2012 and U.S. Provisional Appli-
cation No. 61/765,300 filed Feb. 15, 2013.

BACKGROUND

[0002] Currently there are many methods employed to
patch potholes, implemented by both consumers and city
workers. The only fully permanent solution is a complete road
resurfacing, which is not universally possible for both eco-

nomically and seasonally available. When a complete
repair is not possible, there is a need for temporarily mitigat-
ing the hazard resulting from the potholes. Currently there
are several relevant methods of repairing potholes similar in
function to the patch. These methods to temporarily repair
holes include fast curing concrete, asphalt mixtures, and
gravel patches. Recently more permanent methods involving
specialized trucks fitted with special spraying devices are
being implemented as well.

SUMMARY

[0003] In accordance with an embodiment of the subject
application, a system or method for filling openings of an
associated, generally horizontal surface includes implementa-
tion of at least one flexible container having a viscosity
engineered fluid associated with an opening in an associated,

generally horizontal surface. At least one flexible container
includes a viscosity engineered fluid. At least one flexible
container is associated with the opening such that a void
thereof is substantially filled by the at least one flexible con-
tainer.

[0004] In accordance with another embodiment, the flexi-
ble container is inclusive of a viscosity engineered fluid
comprised of a shear thickening fluid.

[0005] In accordance with another embodiment, the flexi-
ble container is comprised of a watertight sheet material.

[0006] In accordance with another embodiment, the flexi-
ble material is comprised of a watertight sheet material that
slowly dissolves in water over time.

[0007] In accordance with another embodiment, the flexi-
ble container has an exterior gripping surface associated therewith.

[0008] In accordance with another embodiment, the flexi-
ble container is comprised of a thin, flexible tubing which is
suitably cut to length in accordance with an opening size.

[0009] In accordance with another embodiment, excess
engineered fluid is removed from the container in accordance
with the property of the opening.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 illustrates a pothole patch in connection with
an embodiment of the subject application;

[0011] FIG. 2 illustrates an embodiment wherein a stretch-
able or deformable casing is employed around a non-Newto-

nian fluid;

[0012] FIG. 3 illustrates an embodiment wherein an elon-
gated or tube-like material filled with a non-Newtonian fluid
is used in connection with a pothole patching;

[0013] FIG. 4 illustrates an embodiment wherein flexible,
foam-like material is soaked or otherwise impregnated with
a non-Newtonian fluid or dilatant;

[0014] FIG. 5 illustrates an embodiment wherein a valve,
such as an overflow valve, is provided in a fluid casing to
allow for fluid egress to match volume with an opening such
as a pothole;

[0015] FIG. 6 illustrates an embodiment wherein a plurality
of smaller bags are used in conjunction with a pothole filling
or patching operation in accordance with the subject applica-
tion; and

[0016] FIG. 7 illustrates an embodiment wherein a non-
Newtonian fluid is used in conjunction with speed bumps that
are soft when a vehicle traverses at a sufficiently slow rate.

DETAILED DESCRIPTION

[0017] The subject application is directed generally to
applications for practical use of non-Newtonian fluids. More
particularly, the subject application teaches an embodiment
wherein non-Newtonian fluids are used to patch surfaces,
such as road surfaces, quickly, inexpensively, and easily.

Matter is defined as having both a mass, and a volume. Matter
exists in one or more phases, defined as a region of space
wherein all physical properties of matter are generally uni-
form. More common phases of matter included solid, liquid
or gas. Liquids or gases, which can flow, are referred to as
fluids. Fluid viscosity is a measure of its resistance to gradual
def ormation by shear stress or tensile stress. This forms what
is noted to be “thickness” in liquids.

[0019] Other, less well-known states include plasma or
mesophases wherein matter is transitioning such as from a
solid to a liquid. Fluids comprise matter in a state that
deforms, or flows, when placed under an applied shear stress,
and broadly defines matter in either a liquid or gaseous phase.

[0020] Newtonian fluids comprise those fluids most fami-
l iar to us. Newtonian fluids are defined as fluids wherein
no viscous stresses, which arise from flow, are proportional to
a rate of change of deformation over time. This latter property
is referred to as strain. Gaseous fluids, being compressible,
will behave somewhat differently than liquids, which are
largely incompressible, but both result in commonly encoun-
tered fluid behavior. If one squeezes a partially inflated bal-
loon, one readily expects the remaining balloon portion to
bulge proportionately. If one squeezes an ointment tube, one
expects a proportional amount to be exuded from the tube,
if opened, or cause an expansion elsewhere in the tube if it is
not. One does not expect any marked difference in behavior,
in either instance, whether the squeezing is done slowly or
at a more rapid rate.

[0021] There exists a class of fluids which are referred to as
“non-Newtonian.” That is to say, non-Newtonian fluids
("NNFs") do not behave as do their Newtonian counterparts.
There is no constant coefficient of viscosity. These fluids
deform or flow in accordance with a shear rate, or the rapidity
at which pressure, such as a squeezed tube, is applied.

[0022] There are two basic types of non-Newtonian fluids
that are encountered conventionally. A first type is referred to
as a shear thinning fluid. In such fluid types, fluid viscosity
decreases with increasing shear stress. A common example is
ketchup. If a ketchup bottle is opened and inverted, it may be
quite some time before the ketchup comes out. If the inverted bottle is accelerated rapidly, such as by shaking or striking upward, the ketchup comes out quite quickly.

[0023] A second type of non-Newtonian fluid is referred to as a shear thickening fluid, also known as a dilant. In this type of fluid, fluid viscosity increases with increased shear stress. Some may recall SILLY PUTTY®; a toy product currently supplied by Crayola Properties, Inc. The malleable product defoams and stretches a large amount, provided it is stretched slowly. If it is stretched rapidly, it will snap into two parts very quickly. If it is rolled into a ball and compressed slowly, it will form a pancake shape. If it is rolled into a ball and thrown against a hard surface, it will bounce.

[0024] The subject application teaches an embodiment implementing non-Newtonian fluids to solve several problems. The subject application teaches another embodiment wherein fluids of a sufficiently high velocity are also suitably used to solve the same or similar problems.

[0025] Potholes, or other road imperfections, pose a life threatening, multi-billion dollar problem which is particularly problematic in metropolitan areas. Damage to vehicles, safety concerns, and economic cost from traffic backups associated with these hazards demand a full time repair crew in many locations. There are many wasted man hours and capital expenditures from temporarily filling potholes, in addition to costs to drivers and insurers, as well as lost business productivity and increased fossil fuel usage due to accidents and associated backups.

[0026] The subject application includes an embodiment for repairing or alleviating road damage with the use of a non-Newtonian fluid. In one embodiment, a sealed bag or other flexible container is supplied with a non-Newtonian fluid. Such a bag is suitably implemented in connection with a temporary, or even more permanent, hole filler or patch.

[0027] Turning to FIG. 1A, illustrated is problematic surface area 10, such as a roadway, sidewalk or other pathway having a substantially horizontal orientation. Illustrated is a surface area 12 into which is disposed a recession or depression area, such as a pothole 14. While a pothole is used in connection with an illustrated embodiment insofar as it illustrates an intuitive, problematic situation encountered in everyday life, it will be appreciated that the subject teachings are applicable to any opening having undesirable properties relative to a surrounding surface. Illustrated also in FIG. 1A is particulate debris or rough, bottom projections 16 as may be expected in many imperfect surface areas.

[0028] With further reference to FIG. 1B, a flexible container, such as a bag or other flexible container 20, is filled, in whole or in part, with a shear thickening non-Newtonian fluid 22. Alternatively, the bag is suitably filled with a sufficiently viscous fluid to have supportive properties corresponding to a particular support need as will be appreciated by one of ordinary skill in the art and further detailed below.

[0029] The bag 20 is suitably sized, or available in multiple sizes, to fit within an existing depression, such as a pothole, as illustrated with further reference to FIG. 10. Given the pliable nature of a shear thickening fluid, a depression having a substantial horizontal component of orientation will allow a bag to be received and form against a bottom portion thereof. While it may be particularly advantageous to have a volume of the depression matched by bag volume, such that an exposed surface thereof is substantially flush with surface 12, it will be appreciated that any embodiment wherein a depression is at least partially filled will supply the advantages detailed below.

[0030] In the above-noted embodiment which addresses a pothole, a container, such as a bag, of a suitable, non-Newtonian fluid is placed in the pothole. Given the size, portability, relatively low weight and flexibility of such an encased fluid, it can be readily transported to a needed location. By way of example, drivers, or professionals such as police, firefighters, or city workers suitably keep one or more bags available for use once an obstruction is discovered. They are suitably stored in a cab or truck of any vehicle.

[0031] A suitable, viscous fluid for pothole placement is application specific, and dictated in connection with factors including hole size, external temperature conditions, anticipated traffic weight, and surface area as will be appreciated by one of ordinary skill in the art. By way of example, a vehicle may have hundreds of pounds per square inch or an equivalent amount of Newtons per square centimeter to be supported given the relatively small contact area from a small portion of a tire circumference relative to a total vehicle weight supported thereby. A pedestrian may only have a fraction of that weight divided over a similar surface area. Conversely, a vehicle travelling at a high rate of speed contacts a surface for a relatively short time as compared to a foot of a pedestrian. Design choices for viscosity of common-property fluids are chosen accordingly to the specific application.

[0032] Also of consideration for selection of fluid properties is acceptable settlement time, which settlement time may be associated with ambient temperature. If an immediate hole filling is required, that is to say, incoming traffic is imminent, then there may not be sufficient time for use of a highly viscous fluid that may take minutes to settle and conform to a pothole. Conversely, if an area is lightly travelled, or if it can be set apart for a period of time such as with a temporary barrier, then a more viscous fluid may suitably be selected. It will be appreciated that temporary installation conditions, such as recently mixed chemicals and/or addition of heat are also suitably implemented to facilitate installation.

[0033] A suitable, non-Newtonian fluid, in one embodiment includes a mixture of corn starch and water, in any suitable, relative concentration as will be appreciated by one of ordinary skill in the art. By way of example, one embodiment of a non-Newtonian fluid is suitably realized by including one to two cups of water (approximately 0.25-0.5 liters) to 1 pound of cornstarch (approximately 0.5 kilogram). Particular proportions are suitably dictated by particular application, such as road type, ambient temperature, anticipated vehicle traffic, or other external or environmental considerations.

[0034] It will be further appreciated that other suitable, non-Newtonian fluids, such as sand-in-water, sand-in-water-freeze, or any other non-Newtonian fluid is suitably applied to a particular environment and situation. Other suitable fluids may include:

2% Aqueous poly(vinyl alcohol) with 1% sodium borate

40 mM cetylpyridinium chloride and sodium salicylate

58.7 vol % dispersion of tyrene-ethyl acrylate copolymer particles with 280 nm average diameter in glycerol
carboxylatopolysoprene (Mn-21,000) in decachloronaphthalene in three polymer concentrations
HEUR (hydrophobically modified ethoxylated urethane) with short alkyl chains at both ends of poly(ethylene oxide) (PEO)
hydrolysed polyacrylamide in mixtures of glycerol and water
poly styrene of high molecular weight in decalin
Sodium Borate (Silly Putty®)
Silica and Silicone Oil (oil provided with a hydroxyl group at one terminal)
Alumina based fluids
Dilatant fluids
borated silicone polymers.
polyborodimethylsiloxanes (PBDMSs)
Fluid is suitably contained in any water-tight device that is not rigid enough to break under stress (i.e. ceramic, glass, wood), but sufficiently pliable to transfer the force of an impact through the container’s material to the non-Newtonian fluid inside. In the ideal application, a material with very robust and durable properties, while being water resistant would be used to contain the liquid. As an alternative embodiment, a container that is not fully sealed will also function as set forth herein. Recalling that a sudden application of force to a non-Newtonian fluid will cause it to be rigid, the subject applications will still function as intended with incomplete or porous casing, either by intentional design or by damage that may be incurred during use or installation. By way of further example, a dissolvable membrane, coupled with a biodegradable non-Newtonian fluid, such as a simple starch mixture, can suitably be used to accomplish the advantages of the subject application.
A suitable example of this material are silicone coated fabrics available from suppliers, such as CHEMFAB® materials supplied by Saint-Gobain. Other suitable materials include plastic film, such single ply or double-ply, suitably including one rough and one water resistant material would be the next best choice. In another embodiment, any suitable multi-ply container would be usable to house the non-Newtonian fluid. Still other, suitable bag constituents include:
Silicone Fabric
CORDURA® brand fabrics from Invista
Vinyl
Nylon, including sealed nylon
PVC coated fabric
poly vinyl
fire hose material
Latex
Polyethylene
Rubber
In any of the applications and embodiments outlined herein, the patch is suitably covered for multiple reasons, such as aesthetics, protection from the elements, wear and tear, abrasion, additional containment, or theft prevention. By way of example, a suitable covering may be a plastic, rubber or other flexible sheeting.
In another embodiment, the covering may be suitably adhered to another surface and/or the patch itself in order to secure the patch. By way of example, the covering is suitably designed so that the contact between the location of a force applied to the patch and the patch itself has an increased or decreased friction force provided by the covering’s material structure.
Suitable alternative fluid ports to contain the dilatant fluid in the bag or container may be sealed using one or a combination of the following apparatus:
Rough road shoulders
Ramp inflection points
Cable management/cover (plastic trapezoid cable covers at events)
Storm drain bevels
Temporary curb entrance (so machinery does not have to jump the curb at construction sites)
Tracks (liquid while it is moving over the top but solid when it is below)
Race track repair

Still further embodiments include:

Spaghetti tubing: This application involves filling a thin flexible tubing with non-Newtonian fluid. The tubing suitably kept on a role and extruded into large piles as needed for the repair. With reference to FIG. 3, illustrated is hole 14 wherein fluid containing, flexible tubing 50 is inserted such that it fills a selected volume thereof. Illustrated in FIG. 3 is a sending device, such as cooperating rollers 52, which are suitably powered or manually operated to propagate tubing. In one embodiment, tubing is transported on medium such as spool 54.

Foam: a highly flexible foam is soaked in the non-Newtonian fluid and used as a matrix to house the fluid. Once contained in the foam, the foam/sponge is sealed with a flexible and stretchy coating, thus keeping the mixture housed. With additional reference to FIG. 4, illustrated is a absorptive material 60 that is suitably exposed to a diluant fluid 62, such as that detailed above. Such impregnated material is suitably encased such as is illustrated by sealed unit 64.

Overfilled Bag: bags are made to be greatly overfilled and incorporate a bleeding valve so the excess material can drain allowing the bag to fit the hole perfectly. With additional reference to FIG. 5, illustrated is hole 14 relative to surfave 12, wherein a plurality of relatively low volume bags or flexible containers 70 into which fluid 72 is placed. A valve 74 is suitably incorporated into the bag 70. The valve 74 in a first embodiment is manually operable. In another embodiment, a check valve is suitably implemented. A bag 70 having a volume in excess of that of hole is associated therewith. A sufficient volume of fluid 72 is extracted, suitably before or after placement of the bag 70 in the hole 14, via the valve such that an appropriate fill level is achieved.

Small bags: Numerous small bags are suitably tossed into the hole as needed to form one large repair. With further reference to FIG. 6, illustrated is hole 14 relative to surface 12, wherein a plurality of relatively low volume bags or flexible containers 80 are placed to achieve a desired or acceptable fill level.

Urethane bags, made from sectioned tubes: A single long tube is used to create smaller bags from. Once the tube is filled, the sections are separated simply by raising that area, allowing the material to flow away so a heat closure can be made.

Vacuum Sealing: a method of removing excess air from the bags so they do not develop pressure under load.

Packs of a stretchable “film” material that expand when needed and yet do not tear apart. These are suitably placed in small “packs” in any rugged bag.

From the foregoing description, it will be appreciated by one of ordinary skill in the art that pothole patching is a single variant of applications for the subject teachings. While any opening is contemplated, a more exhaustive listing of applications includes:

Fissures and cracks

Manhole Recesses
Bridge Joints
Side Walks
Tarmacs
Mud Hole Covering
any temporary surface that is liquid or temporarily unstable with a solid base
Novelty Toy
Culverts
Railroad depressions (beneath an eroded tie)
Rough road shoulders
ramp inflection points
cable management/cover (plastic trapezoid cable covers at events)
storm drain bevels
Temporary curb entrance (so machinery does not have to jump the curb at construction sites)
Tracks (liquid while it is moving over the top but solid when it is below) & Tires
Neck Brace
Shipping padding
Punching bag
Race Tracks
Rubber

Turning now to FIG. 7, illustrated is a fluid 80 disposed in a container, such as flexible container 82. The container 82 is oriented relative to a flexible surface 84 such as to cause a projection 86 therein. The container 82 is suitably disposed in an opening 88 of a volume 90 to which the surface 84 is associated. This relative orientation teaches an embodiment particularly suited for orientation as a barrier having specified impact characteristics as will be appreciated from the description above when oriented in a generally vertical direction V or a speed bump when oriented in a generally horizontal direction H.

In any of the applications and embodiments outlined herein, the patch is suitably covered for multiple reasons, such as aesthetics, protection from the elements, wear and tear, abrasion, additional containment, or theft prevention.

A method for filling openings of an associated, generally horizontal surface, comprising:

determining at least one property associated with an opening in an associated, generally horizontal surface;

selecting at least one flexible container inclusive of a viscosity engineered fluid in accordance with the at least one property of the opening; and

placing the at least one flexible container in the opening such that a void thereof is substantially filled by the at least one flexible container.

2. The method of claim 1 wherein selecting the at least one flexible container comprises selecting a flexible container inclusive of a viscosity engineered fluid comprised of a shear thickening fluid.

3. The method of claim 2 wherein selecting the at least one flexible container comprises selecting a flexible container comprised of a watertight sheet material.

4. The method of claim 3 wherein selecting the at least one flexible container comprises selecting a flexible container comprised of a watertight sheet material that slowly dissolves in water over time.

5. The method of claim 2 wherein selecting the at least one flexible container comprises selecting a flexible container comprised of a flexible container having an exterior gripping surface associated therewith.
6. The method of claim 2 wherein selecting the at least one flexible container comprises selecting a flexible container comprised of a thin, flexible tubing, and wherein the method further comprises the step of cutting the thin, flexible tubing at a length corresponding to the property of the opening.

7. The method of claim 3 further comprising the step of removing a selected portion of the non-Newtonian fluid from the container in accordance with the property of the opening.

8. A system for filling openings of an associated, generally horizontal surface, comprising:
   at least one flexible container adapted to be received into an opening of an associated, generally horizontal surface;
   wherein the at least one flexible container includes a non-Newtonian fluid corresponding to a property of the opening disposed therein so as to substantially fill the opening.

9. The system of claim 8 wherein the non-Newtonian fluid is comprised of a shear thickening fluid.

10. The system of claim 9 wherein the flexible container is comprised of a watertight sheet material.

11. The system of claim 10 wherein the watertight material is dissolvable in water over time.

12. The system of claim 9 wherein the flexible container has an exterior gripping surface associated therewith.

13. The system of claim 9 wherein the at least one flexible container is comprised of a thin, flexible tubing, operable to be cut at a length corresponding to the property of the opening.

14. The system of claim 10 wherein the flexible container includes a re-sealable opening operable for removal of a selected portion of the non-Newtonian fluid in accordance with the property of the opening.

15. A method for temporarily patching holes in a roadway surface, comprising:
   determining at least one property associated with a hole in a roadway surface;
   selecting at least one flexible, watertight sealed container inclusive of a shear thickening, non-Newtonian fluid;
   placing the at least one container in the hole so as substantially fill a void associated therewith;
   receiving moving, vehicular traffic on an exterior surface of the sealed container disposed in the hole at an impact force such that the non-Newtonian fluid is sufficiently rigid to substantially support vehicle weight without substantial deformation in accordance with a physical property thereof.

16. The method of claim 15 further comprising selecting plurality of watertight, sealed containers in accordance with an aggregate volume corresponding to that of the hole.

17. The method of claim 15 further comprising removing a selected portion of the non-Newtonian fluid from the at least one container in accordance with the property of the opening.

18. The method of claim 15 further comprising receiving moving, vehicular traffic on the exterior surface inclusive of a gripping element.

19. The method of claim 15 wherein selecting the at least one flexible container comprises selecting a flexible container having a thin, flexible tubing, and wherein the method further comprises the step of cutting the thin, flexible tubing at a length corresponding to the property of the opening.

20. The method of claim 15 further comprising the step of removing the container from the hole after a selected duration.