

IMPROVEMENTS RELATING TO DRAINAGE OF MATERIAL

Technical field

The present invention relates to the field of loading, storage and offloading of
5 cargo stored on a vessel, in particular cargo that is in the form of material that
may be fluidised and/or handled as a slurry. Such material may comprise
particles such as sand or the like.

Background

10 In activities that require a volume of material to be handled, for example to
insert into or remove material from a storage space, it can be convenient for
the material to be handled in fluid form. For example, material can be
fluidised by combining the material with a fluid to produce a mixture, e.g. a
slurry, which is able to flow to facilitate handling of the material. This practice
15 is sometimes applied for offloading of cargo material from a storage space on
a vessel or for loading of the material onto a vessel, and is used for instance
in activities such as dredging in order to handle dredged materials.

In the context of dredging and land reclamation activities, there can be a need
20 to recover material from the earth, e.g. the seabed, and transport that material
from one location to another. In such activity, the material may typically
comprise unconsolidated solid particles such as for instance grains of
minerals or rock, sedimentary particles, or other earth particles. It may also

include organic matter, such as coal. Moreover, the material may be obtained from the seabed or dry land.

The material may be carried on a marine vessel, and stored in a storage space of the vessel.

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The term “vessel” is used herein to include self-propelled or towed barges, ships in the form of bulk carriers, e.g. “dry bulk carriers”, and dredgers, or other floating platforms.

- 10 Materials may be dredged from the sea and directed in a fluid mixture with seawater onto a nearby vessel arranged to store the cargo in the storage space. For compliance with requirements for the cargo to be dry during travel on a bulk carrier, seawater that has been brought onto the carrier may be removed to leave behind dry material. In order to offload the material, the
- 15 material may be fluidised so that the material can be transported out the storage space in a flow through an outlet. Liquid such as water may be jetted through nozzles at high energy to fluidise the material.

- A self-unloading hopper dredger is another well-known form of vessel used in
- 20 the field of dredging.

Another form of vessel is described in the publication WO2012026808 where material is dumped through a chute that extends through the bottom of the

hull. Such a solution can suffer from complexity, cost and challenges to meet regulatory compliance.

In a further development of the field, publication WO2011028129 describes
5 providing a dry bulk carrier where sand is fluidised at the base of the storage space and suction is applied to draw the fluidised material across the base to offload the sand through an outlet.

It is known to transport sand in this manner across the floor of a storage
10 space of a vessel, such as on a tank top deck, but while transportation in this manner can be advantageous, the inventors have noted challenges in that the amount of injection water and energy needed to fluidise and transport the material as a slurry can be significant. The sand may also form structures that may inhibit drainage of the sand, such that it can be difficult to mobilise
15 the sand even when jetting water at high pressure and/or velocity. This may in turn place high demands on equipment design, availability, and/or cost. For example, a high density of jet nozzles or suction pipe inlets may be required in order to drain the cargo.

20 **Summary**

According to a first aspect of the invention, there is provided an arrangement for draining material from a storage space of a vessel, the arrangement comprising:

at least one injector for injecting a carrier fluid into the storage space;

and

a topography arranged to define at least one drainage course at a base of the storage space, the topography being configured to concentrate the injected carrier fluid in the drainage course for carrying the material on the drainage course to at least one outlet.

In this way, the material may be carried on the drainage course in a mixture with the carrier fluid to the outlet.

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The material to be drained may comprise solids. The material may typically be unconsolidated material. More generally, the material may be a material capable of fluidisation. Typically, the material may comprise particles or grains, such as sand, shale, clay, mud, organic matter, or mixtures thereof.

15 The material may comprise grains of rock, sediments and/or minerals. The material may be recovered from the earth, e.g. in a dredging or land reclamation operation, e.g. from the seabed.

The carrier fluid may typically comprise a liquid, and more typically the carrier fluid may be water.

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The mixture may typically be a slurry of solids in the carrier fluid. The mixture may comprise particles suspended in the carrier fluid. The carrier fluid may

operate to fluidise the material to be drained. The material may be drained while being stored in the storage space. It may be appreciated that not all of the stored material in the storage space may be drained at once. Accordingly, a portion of the stored material may be carried on the drainage course, at a given time. The carrier fluid may be operated to fluidise part of the stored material at or adjacent to the base. The mixture may thus be fluidised material.

The material is configured to be carried across the floor in the drainage course.

The topography and/or the drainage course may be provided on a surface, platform or floor, e.g. retrofitted thereupon, at the base of the storage space. The topography and/or the drainage course may preferably be provided on a flat portion of floor or a flat, planar surface. Typically, the floor may be substantially entirely flat. The floor may be a deck e.g. a tank top deck, or platform.

The vessel may be dry bulk carrier or a barge.

The topography and/or the drainage course may be provided on a floor, e.g. retrofitted thereupon. Topography and/or the drainage course may preferably be provided on a flat portion of floor.

The topography may typically comprise surfaces sloping in opposition to one another toward a bottom of the drainage course.

- 5 The material to be drained and/or stored may be substantially dry before drainage. The topography and/or drainage course may be arranged to collect material in the drainage course, e.g. under gravity as part of the material at the base drains in mixture with the carrier fluid. The material when initially dry, and prior to drainage, may be static and resistant or not susceptible to flow,
10 e.g. until injection of the carrier fluid. Upon drainage using the carrier fluid, the material may be mobilised, as part of the material may then be drained in the drainage course in a flow in mixture with the carrier fluid.

The injector may comprise at least one nozzle for injecting the carrier fluid.

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The topography may comprise a catchment region for collecting injected carrier fluid, or a fluidic mixture of the injected carrier fluid and an amount of the material.

- 20 The topography may comprise at least one valley or channel defining the drainage course in a bottom of the valley or channel. The topography may comprise at least one peak or ridge for defining the valley or channel. The valley or channel may have a V or U shaped section. The channel or valley

may be constructed using adapted tubing, e.g. culvert pipe. The topography and/or the channel or valley may be constructed using a construction material comprising any one or more of: geofom, polystyrene foam such as expanded or extruded polystyrene foam, foam glass, foam concrete, aerated material,

5 biomass, earth materials such as bark, earth, gravel or sand, or waste materials such as tyres, etc. Preferably, the topography and/or the channel or valley may be constructed using concrete comprising lightweight elements therein, e.g. embedded and/or distributed in a structure, for example a matrix, e.g. a cement matrix, of the concrete. The respective lightweight elements

10 may be provided in the form of beads or balls, although in general may have any suitable geometric shape. The lightweight elements may comprise chemical foam or the like, or another lightweight material. Typically, the density of the material of the respective lightweight elements is less than that of the material of the structure in which the elements are embedded. For

15 example, the respective lightweight elements may comprise polystyrene, e.g. expanded polystyrene. The matrix may comprise Portland cement. The respective lightweight elements may be treated e.g. coated, e.g. to enhance their strength properties and/or maintain their shape against compressive forces and/or to ensure that the elements distributes homogenously in the

20 concrete. The lightweight elements may comprise expanded polystyrene beads such as those of the aggregates marketed under the product name Polyterm Blu™ by Editeco S.P.A. The lightweight elements may typically contain air or gas, e.g. may be aerated elements, being aerated with air or

gas. The lightweight elements in the concrete may have an average diameter in the range of around 1 to 6 mm.

The construction material or at least one block of the construction material
5 may be provided with a layer, e.g. a wear layer, against which the material in the storage space, and/or the material being carried on the drainage course, may bear against. The layer may comprise a surface of the channel or valley, e.g. of a bottom and/or side of the channel or valley. The layer may be a coating e.g. a chemical coating. The construction material or block thereof
10 may for instance be coated with a layer of polyurea material or a hybrid of polyurea material to obtain at least one coated surface section on the construction material or block thereof, and may be disposed such that the coated surface section at least partially defines the channel or the valley. The wear layer may be provided for resisting wear by the material in the channel
15 or the valley upon being carried away therealong on the drainage course. The layer may comprise cement, plating, e.g. a steel plate, or a coating. The layer may comprise metal such as steel. The layer may comprise a layer of polyurea material or a hybrid of polyurea material. The layer may comprise a layer of epoxy or cement applied onto a block of the concrete. A surface
20 section of the wear layer may face the channel or the valley for resisting wear due to the material in the channel to be drained.

The arrangement may preferably have at least one element to be supported on the floor for providing the topography, and/or the channel or valley. Such an element may be composed of a construction material comprising any one or more of: geofom, polystyrene foam, such as expanded or extruded

5 polystyrene foam, foam glass, foam concrete, aerated material, biomass, earth materials such as bark, earth, gravel or sand, or waste materials such as tyres, etc. The element may be configured to restrict or prevent the carrier fluid permeating into an inside of the element. Preferably, the element may be constructed using concrete comprising lightweight elements therein, e.g.

10 embedded and/or distributed in a structure, for example a matrix, e.g. a cement matrix, of the concrete. The respective lightweight elements may be provided in the form of beads or balls, although in general may have any suitable geometric shape. The lightweight elements may comprise chemical foam or the like, or another lightweight material. Typically, the density of the

15 material of the respective lightweight elements is less than that of the material of the structure in which the elements are embedded. For example, the respective lightweight elements may comprise polystyrene, e.g. expanded polystyrene. The matrix may comprise Portland cement. The respective lightweight elements may be treated e.g. coated, e.g. to enhance their

20 strength properties and/or maintain their shape against compressive forces and/or to ensure that the elements distributes homogenously in the concrete. The lightweight elements may comprise expanded polystyrene beads such as those of the aggregates marketed under the product name Polyterm Blu™ by

Editeco S.P.A. The lightweight elements may typically contain air or gas, e.g. may be aerated elements, being aerated with air or gas. The lightweight elements in the concrete may have an average diameter in the range of around 1 to 6 mm.

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The element to be supported on the floor may comprise the construction material or at least one block of the construction material which may be provided with at least one layer, e.g. a wear layer. The layer may be a layer as otherwise described above. When the construction material or block

10 thereof is provided with the layer, high load-bearing and durability properties may be obtained. Although suitable load bearing properties may be obtained using other construction material or blocks thereof without a layer, e.g. using concrete, a layer applied to the material or block thereof can improve such performance.

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The channel or valley may be coated with wear coating or layer against which material being carried on the drainage course or stored in the storage space can bear against in use. The wear coating or layer may comprise a surface against which material being carried on the drainage course or stored in the

20 storage space can bear against in use

The arrangement may include at least one leak outlet for removal of leak fluid.

The leak outlet may provide for removing leak fluid which may permeate or

leak into the element, e.g. if the element is not entirely impermeable. The leak outlet may also provide for removing or draining off leak fluid that may have penetrated in the region around the element, e.g. between the floor and the element, e.g. on an underside of the element. The leak fluid may

5 comprise an amount of carrier fluid which may have escaped from and/or may not be contained in the drainage course. Typically, the leak outlet may have an opening for letting through the leak fluid, and the opening may typically be positioned within an inside of the element. This may be a position inside a ridge structure or embankment of a channel or valley, or underneath the
10 bottom of the valley or channel. This may thus be a position between the valley or channel and the floor.

The arrangement may include the outlet to which the material is carried in the mixture with the carrier. Where the mixture is a slurry, this may be a slurry
15 outlet. The outlet may be an outlet of the drainage course. This outlet may be coupled to a suction device, such a pump. Thus, the outlet may be a suction outlet. The outlet may be provided by a section of pipe with a pump connected thereto, and/or may comprise an opening into such a pipe. The outlet may be aligned with the drainage course. The topography may
20 comprise at least one ridge or crest between adjacent valleys.

The outlet may be an opening in a wall, through which the material or mixture may be drained or dumped into the sea, or through which the material or mixture may be led toward shore via a pipeline.

- 5 The injector may be arranged on or adjacent to the ridge or the crest.

The ridge or crest may be formed using a construction material, which may comprise any one or more of: geofoam, polystyrene foam, such as expanded or extruded polystyrene foam, foam glass, foam concrete, aerated material, biomass, earth materials such as bark, earth, gravel or sand, or waste materials such as tyres, etc. It may be formed by the element arranged to be supported on the floor. The construction material may preferably comprise concrete comprising lightweight elements therein, e.g. embedded and/or distributed in a structure, for example a matrix, e.g. a cement matrix, of the concrete. The respective lightweight elements may be provided in the form of beads or balls, although in general may have any suitable geometric shape. The lightweight elements may comprise chemical foam or the like, or another lightweight material. Typically, the density of the material of the respective lightweight elements is less than that of the material of the structure in which the elements are embedded. For example, the respective lightweight elements may comprise polystyrene, e.g. expanded polystyrene. The matrix may comprise Portland cement. The respective lightweight elements may be treated e.g. coated, e.g. to enhance their strength properties and/or maintain

their shape against compressive forces and/or to ensure that the elements distributes homogenously in the concrete. The lightweight elements may comprise expanded polystyrene beads such as those of the aggregates marketed under the product name Polyterm Blu™ by Editeco S.P.A. The
 5 lightweight elements may typically contain air or gas, e.g. may be aerated elements, being aerated with air or gas. The lightweight elements in the concrete may have an average diameter in the range of around 1 to 6 mm.

The construction material or at least one block of the construction material
 10 used for the ridge or crest may be provided with at least one layer, e.g. a wear layer. The layer may be a layer as otherwise described above in this aspect.

According to a second aspect of the invention there is provided an element for providing a topography at a base of a storage space on a vessel for providing
 15 a drainage course to drain material from the storage space using a carrier fluid.

The element may preferably comprise at least one construction material, which may be selected from any one or more of: geofoam, polystyrene foam,
 20 such as expanded or extruded polystyrene foam, foam glass, foam concrete, aerated material, biomass, earth materials such as bark, earth, gravel or sand, or waste materials such as tyres, etc. The construction material may preferably comprise concrete comprising lightweight elements therein, e.g.

- embedded and/or distributed in a structure, for example a matrix, e.g. a cement matrix, of the concrete. The respective lightweight elements may be provided in the form of beads or balls, although in general may have any suitable geometric shape. The lightweight elements may comprise chemical
- 5 foam or the like, or another lightweight material. Typically, the density of the material of the respective lightweight elements is less than that of the material of the structure in which the elements are embedded. For example, the respective lightweight elements may comprise polystyrene, e.g. expanded polystyrene. The matrix may comprise Portland cement. The respective
- 10 lightweight elements may be treated e.g. coated, e.g. to enhance their strength properties and/or maintain their shape against compressive forces and/or to ensure that the elements distributes homogenously in the concrete. The lightweight elements may comprise expanded polystyrene beads such as those of the aggregates marketed under the product name Polyterm Blu™ by
- 15 Editeco S.P.A. The lightweight elements may typically contain air or gas, e.g. may be aerated elements, being aerated with air or gas. The lightweight elements in the concrete may have an average diameter in the range of around 1 to 6 mm.
- 20 The construction material or at least one block of the construction material may be provided with at least one layer, e.g. a wear layer, thereupon. The layer may be a as otherwise described anywhere above in relation to the first aspect.

According to a third aspect of the invention there is provided a method of draining material from a storage space of a vessel using the arrangement of the first or eighth aspect.

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According to a fourth aspect of the invention there is provided an arrangement for draining surplus fluid from a storage space on a vessel for removing the surplus fluid from (e.g. dewatering) stored material in the storage space, the arrangement comprising:

10 a topography arranged to define at least one drainage course at a base of the storage space, the topography being configured to concentrate the surplus fluid in the drainage course for carrying the surplus fluid on the drainage course to at least one outlet.

15 According to a fifth aspect of the invention there is provided a method of draining surplus fluid from a storage space on a vessel for removing fluid from (e.g. dewatering) stored material in the storage space using the arrangement of the fourth or the eighth aspect.

20 According to a sixth aspect of the invention there is provided a vessel provided with the arrangement of the first, fourth, or eighth aspect.

According to a seventh aspect of the invention, there is provided a method of providing a vessel with the arrangement of the first, fourth or eighth aspect.

In an eighth aspect, there is provided is provided an arrangement or
 5 apparatus for draining material from a storage space of a vessel, the arrangement or apparatus comprising:

at least one drainage course at a base of the storage space, for carrying at least part of the material using a carrier fluid on the drainage course to drain the material.

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In a ninth aspect of the invention, there is provided an element for providing a drainage course for draining material from a storage space using a carrier fluid. The element may comprise any one or more of: geof foam, polystyrene foam such as expanded or extruded polystyrene foam, foam glass, foam
 15 concrete, aerated material, biomass, earth materials such as bark, earth, gravel or sand, or waste materials such as tyres, etc. The element for providing the drainage course may preferably comprise concrete comprising lightweight elements therein, e.g. embedded and/or distributed in a structure, for example a matrix, e.g. a cement matrix, of the concrete. The respective
 20 lightweight elements may be provided in the form of beads or balls, although in general may have any suitable geometric shape. The lightweight elements may comprise chemical foam or the like, or another lightweight material. Typically, the density of the material of the respective lightweight elements is

less than that of the material of the structure in which the elements are embedded. For example, the respective lightweight elements may comprise polystyrene, e.g. expanded polystyrene. The matrix may comprise Portland cement. The respective lightweight elements may be treated e.g. coated, e.g. to enhance their strength properties and/or maintain their shape against compressive forces and/or to ensure that the elements distributes homogenously in the concrete. The lightweight elements may comprise expanded polystyrene beads such as those of the aggregates marketed under the product name Polyterm Blu™ by Editeco S.P.A. The lightweight elements may typically contain air or gas, e.g. may be aerated elements, being aerated with air or gas. The lightweight elements in the concrete may have an average diameter in the range of around 1 to 6 mm.

The element may comprise the construction material or at least one block of the construction material which may be provided with at least one layer, e.g. a wear layer. The layer may be a layer as otherwise described anywhere above in relation to abovementioned aspects.

Any of the aspects of the invention may include the further features as described in relation to any other aspect, wherever described herein including the claims. Features described in one embodiment may be combined in other embodiments. For example, a selected feature from a first embodiment that is compatible with the arrangement in a second embodiment may be employed,

e.g. as an additional, alternative or optional feature, e.g. inserted or exchanged for a similar or like feature, in the second embodiment to perform (in the second embodiment) in the same or corresponding manner as it does in the first embodiment.

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Embodiments of the invention are advantageous in various ways as will be apparent from the specification throughout.

Description and drawings

10 There will now be described, by way of example only, embodiments of the invention with reference to the accompanying drawings, in which:

Figure 1 is an end-on schematic representation of a barge according to an embodiment of the invention being loaded with granular cargo material;

15 Figure 2 is a top view schematic representation along the line I-I' of the vessel of Figure 1 without showing the loaded material;

Figure 3 is a side view schematic representation of the vessel of the vessel along the line II-II' of Figure 2;

Figure 4 is a sectional representation in larger scale of an arrangement
20 according to another embodiment of the invention;

Figure 5 is a sectional representation of an arrangement according to yet another embodiment of the invention;

- Figure 6 is a sectional representation of an arrangement according to an embodiment of the invention;
- Figure 7 is a perspective representation of an arrangement according to another embodiment;
- 5 Figure 8 is a close-up perspective of part of the guide arrangement of Figure 7 showing additional detail;
- Figure 9 is an end-on sectional schematic representation of an arrangement on a cargo floor according to another embodiment, in smaller scale;
- 10 Figure 10 is an end-on sectional schematic representation of a guide arrangement on a cargo floor according to another embodiment, utilising components from pipes;
- Figure 11 is an end-on sectional schematic representation in smaller scale of a bulk carrier according to an embodiment of the invention
- 15 being loaded with granular cargo material;
- Figure 12 is a top-view of a geometry of components of an arrangement according to another embodiment; and
- Figure 13 is an end-on sectional representation of various possible ridge/valley configurations in other embodiments of the
- 20 invention.

With reference to Figure 1, a barge 1 is shown during loading of material comprising sand 2 from an adjacent dredging vessel 3. The barge 1 and the

dredging vessel 3 are illustrated as floating on the surface 4 of the water. The sand is dredged from the waterbed and supplied from the dredging vessel 3 through sections of tubing before being delivered into a storage space 5 on the barge 1.

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With further reference to Figures 2 and 3, the barge 1 is provided with self-offloading equipment near the base 6 of the storage space 5. The equipment includes injectors 7 for injecting water into the storage space 5 in order to “fluidise” the sand 2 at the base 6 of the storage space 5. The water is

10 pumped through the injectors 7 using a water pump 8 connected thereto. The unloading equipment further includes suction outlets 9a and 9b connected to a suction pump 10, which operates to generate suction in the storage space 5 near the suction outlets 9a and 9b. By fluidising the sand 2, particles of sand are suspended in the injected water to form a fluidic mixture of sand and
15 water on the base 6 that can be drained away.

A topography is provided which in this example defines two catchment valleys 16a, 16b at the base 6. The catchment valleys 16a, 16b each have sloping side surfaces 17, which slope in opposition to one another, toward the valley
20 bottom 18a, 18b. The two suction outlets 9a, 9b are aligned with the respective catchment valleys 16a, 16b. The suction pump 10 is operated such that fluidic mixtures of sand and water in the respective catchment

valleys travel along the valley on the valley bottoms 18a, 18b toward the relevant suction outlet 9a, 9b.

The injectors 7 in this example are arranged near upper side portions of each valley 16a, 16b. The middle injector 7 is arranged on a ridge 19 between the two catchment valleys 16a, 16b.

Injected water collects in the catchment valleys 16a, 16b, on the valley bottoms 18a, 18b. The injected water tends to propagate on the sloping side surfaces 17 toward the valley bottom 18a, 18b, under the influence of gravity, due to the slope of the side surfaces 17.

The injected fluid tends thus to collect in the valley bottom 18a, 18b where it is utilised to fluidise the sand, producing a fluidic mixture of sand and the injected water. The mixture of sand and water produced by the injection of water is guided by the valley 16a, 16b, along the valley 16a, 16b, toward the suction outlet 9a, 9b to drain the sand from the storage region 5. The valleys 16a, 16b provide in this way drainage courses on which the mixture of sand and water can be drained away in a fluid flow along the valleys 16a, 16b.

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The arrows are indicative of the flow of injected water and/or water and sand mixture in the catchment valleys 16a, 16b during draining or offloading.

The catchment valleys 16a, 16b are constructed using lightweight and low-cost construction materials.

Turning now to Figure 4, an arrangement having a ridge structure 119
5 between adjacent catchment valleys 116a, 116b is depicted. The ridge structure 119 provides planar valley side surfaces 117, similar to those described above, although exemplifying a steeper slope. The ridge 119 is constructed using geofoam shaped into an element 120 with desired shape, in this case the element having a triangular section. The element 120 is
10 supported on a floor 142 of the vessel. Geofoam is beneficially of very low density and weight. It also has low water permeability characteristics. Other construction materials such as those described hereinabove may be utilised in the same manner.

15 The geofoam element has outer layers of material 121 which defines the sloping side surfaces 117 for the valleys 116a, 116b. The material of the outer layer may comprise or consist essentially of metal, such as metal plating, although a plastic or composite layers or plating may be utilised similarly. Provision of the outer layers 121 may facilitate strength for
20 supporting the load of sand and/or injected water upon the surfaces 117 of the valley sides and bottoms 117, 118a, 118b, and may protect the geofoam element 120 from damaging exposure to the sand and/or water in the storage space.

Although this illustrates particularly a ridge 119, other formations such as embankments, sloped surfaces, or supporting members for constructing a suitable topography at the base 6 may similarly be built using geofoam.

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In the arrangement of Figure 4, an injector 107 with jet nozzles 122a, 122b is provided at the top of the ridge 119. The injector 107 is arranged to inject water on both sides of the ridge 119, i.e. to supply water to both of the adjacent valleys 116a, 116b, the water being directed toward the valley bottoms 118a, 118b by the sloping surfaces 117.

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A leak outlet 141 arranged near the bottom of the element 120 has an opening to drain off water which may escape the drainage course and leak and permeate somewhat into the element 120 when the jetted water is being applied in the storage space. The opening to the outlet 141 is positioned inside the element 120 to allow such leaked fluid to be removed. Water may also leak and penetrate into a region between the floor 142 and the bottom of the element 120, and the leak outlet 141 may be configured also to allow this water to be drained

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In Figure 5, an arrangement 106' includes a ridge 119' identical to that of Figure 4 except that instead of providing a single injector 107 at the top of the ridge, the arrangement 106' has injectors 107a', 107b' in each of the adjacent

valleys 116a', 116b', at the valley bottoms 118a', 118b'. The valleys 116a', 116b' are V-shaped.

Turning to Figure 6, an arrangement 106'' with a U-shaped catchment valley 116'' at a base of the storage space is depicted. The valley 116'' is constructed by a shaped block of geofoam in which the desired valley shape is cut out. A coating 121'' of material is applied to the cut-out to provide side and floor surfaces 117'', 118'' of the valley. The coating 121'' may add strength and protect the geofoam from exposure. The coating material may be metal or plastics or other material, e.g. as plating. A single injector 107'' is positioned along the valley 107'' on the valley bottom 118''.

In the embodiments above, geofoam is an example of a particular construction material. More generally other construction materials may be used, e.g. to form one or more blocks for forming the channel and ridges of the topography. Such a construction material may be one of those as hereinbefore described. In certain embodiments, a block of any such construction material may be used instead of the block of geofoam for providing the channel and ridge topography. The block may comprise a layer, e.g. a wear layer, applied to the construction material for the material in the storage space to bear against. The layer may thus comprise a surface of the channel or valley, may protect the construction material and/or may provide a surface that is resistant to wear upon contact with and friction being

imparted to the surface by the material in the drainage course. The Figure 4 example provides an example of such an arrangement using a wear layer in the form of the plate 121 and Figure 6 in the form of the coating 121" applied to geofoam. The wear layer may thus be in the form of plating or a coating

5 such as the coating 121" described above. In one particular embodiment, the wear layer may comprise a coating, e.g. a coating of polyurea or a hybrid of polyurea. Where the construction material is concrete, the coating of polyurea or the hybrid of polyurea may enhance the properties and strength or resilience of the block. The polyurea or hybrid of polyurea may be applied,

10 e.g. sprayed onto the sloped surfaces of the concrete block to provide the coating. Spray application can be time-saving in speed of coverage and dry time. Alternatively, a coating of polyurethane or epoxy may be applied onto a block of the concrete for providing the coating. Typically, the concrete comprises expanded polystyrene beads homogeneously distributed in

15 Portland cement matrix of the concrete.

Referring to Figures 7 and 8, a further example arrangement 206 at a base of the storage space is illustrated. Multiple valleys 216a-216f are arranged in parallel with their valley bottoms inclined by the angle α . First and second

20 sets of valleys have bottoms inclined on opposite sides toward a collecting trench 223. Each valley 216a-216f is configured such as the valley 216b as shown in Figure 8, which has an injector pipe 207a running along a valley floor 218b with jet nozzles 222b. Nozzle outlets, such as nozzles 222b, are

provided along the injector pipes in each valley 216a-216f for injecting the water into the storage space in the region adjacent to the valleys 216a-216f. Injected water and/or mixed water and sand may be guided into the valley bottoms and then into the collecting trench 223 from which slurry from the

5 different valleys 216a-216f can be combined and drained as a combined slurry by suction applied from the suction extraction device through a suction outlet pipe 209.

In this example, the valleys 216a-216f may be constructed from folded sheet

10 material, with a filling element 224 for inclining and supporting the valley bottoms being composed of geofoam, or another construction material, such as concrete with lightweight elements in a matrix of the concrete.

Figure 9 illustrates an example arrangement 306 on a floor 342 of a cargo

15 hold, where the base has multiple V-valleys 316 that each have an injector pipe 307 along the valley bottom 318 (into the page).

Figure 10 is another example arrangement 406 on a flat floor 442 of a cargo hold, where the topography at the base of the storage space has multiple U-

20 channels 416a-416d providing drainage courses. The topography is constructed by adapted off-the-shelf tubing such as culvert pipes or the like. As can be seen in Figure 10, four U-channels 416a-416d have been constructed by halving two pipes of different diameter. A further pipe, of a yet

another different diameter, is used to form a ridge 419 between two of the channels 416a, 416b. Geofoam elements 424 are used to fill the intervening spaces for adding support to the arrangement.

5 Figure 11 illustrates a bulk cargo vessel 501 during loading of dredged particulate material 502 from an adjacent dredging vessel 503. The particulate material 502 is directed into a cargo hold of the cargo vessel through tubing 530. The topography at the base 506 of the cargo space 505 has valley 516 wherein sloped valley sides are provided by wedged geofoam
10 elements 524 layered with fronting material supported on a tank top deck, for supporting the load of the stored particulate 502 on the deck. Injectors 507 are arranged close to the base 506 on the valley sides. A suction outlet 509 is provided centrally aligned with the bottom of the valley 516 for drawing in fluidised particulate.

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Figure 12 illustrates a geometry 600 for use at the base of the storage region, wherein a topography has four parallel catchment valleys 616a-616d which are each provided with an injector pipe 607 along the valley 616a-616d. A suction pipe 609 is provided at right angles to the injector pipes 607 crossing
20 the valley axes, with suction outlets 609 aligned with each catchment valley 616a-616d to receive fluidised sand. Nozzles 622 along the injector pipe 607 for jetting the water into the storage space in the valleys 616a-616d are

spaced 2 m apart along the pipes 607, whilst the spacing between injector pipes 607 is 5 m.

It will be appreciated that the invention includes further embodiments which
 5 are otherwise the same as those described above with reference to the various figures, but in which the geofoam is replaced instead by another construction material such as concrete which comprises lightweight elements in a structure, e.g. a matrix, of the concrete. The lightweight elements and matrix may be as described anywhere hereinabove. Accordingly, reference
 10 made in the above embodiments to a block or element of geofoam or a geofoam element, can be regarded as referring respectively to a block or element of the construction material, e.g. to a block or element of concrete or a concrete element, as the case may be.

15 In such embodiments, a valley, a channel floor, or channel side in the drainage course may comprise a wear layer on a block of the construction material e.g. concrete. The wear layer may be obtained by applying a coating onto a block of the concrete, for instance by spraying polyurea onto a sloping surface of the block of the concrete. Alternatively, polyurethane or epoxy may
 20 be applied, for example painted, onto a block of the concrete to provide the coating. In other variants, plating such as a steel plate or the like may be applied onto the block of the construction material to act as the wear layer. In

yet further variants, the wear layer may comprise a sprayed layer of cement, e.g. cement with fibre

By way of the wear layer, an interface is provided between the material in the storage space and the construction material (e.g. concrete) for resisting wear and tear. In this way, the construction material may be protected from damage from the stored material in the hold and for facilitating long-term use of the topography. The use of the concrete with lightweight foam elements in the structure or cement matrix of the concrete, provides for a strong and stable homogeneous concrete material which can tolerate repeat exposure to high compressional forces to which it can be subjected by storing material in the cargo space. By incorporation of foam elements, the resulting concrete can also be made relatively light in weight and overall of low density. Cut-outs may be formed in such blocks of concrete to reduce weight further whilst retaining sufficient strength against compression or deformation under pressure for typical cargo loads. Such embodiments can therefore be particularly beneficial in terms of pressure, compression, density, and/or insulation behaviour.

In embodiments with a wear layer, the block of the construction material may be provided with a formation or other structure for facilitating connection or adherence of the wear layer to the construction material (e.g. concrete) of the block. This may help to prevent delamination of the wear layer from the block

when exerted to the loads imparted onto the layer from the material in the storage space. Shear forces which may arise due to the load of the material above may thus be transferred via the layer to the construction material to which the layer is applied. The formation may for instance comprise steel reinforcement or other structure which penetrates into in the construction material (e.g. concrete) at the interface with the wear layer. In general, the structure may be provide means onto which the wear layer can attach securely, for resisting the significant forces which may be imparted from the load of the dredged material in the storage space.

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Although the embodiments here are described with reference to offloading material from a storage space by injecting water, it will be appreciated that the topographic base can be utilised prior to transporting the sand, for example to facilitate draining surplus water from the cargo space.

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The provision of catchment valleys and topography for providing one or more drainage courses can be beneficial for concentrating the injected water and slurry to defined regions of the base and/or floor. This can facilitate extraction using the suction outlets and injectors. Since the topography is predefined, suction and injection components of the offloading equipment can be placed optimally. The valleys can define drainage courses with efficient routes for the particles to the outlets. This can reduce energy requirements and water consumption. The topography can be retro-fitted and placed on a floor at the

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base of existing storage spaces cost effectively, using off-the-shelf components, and the topography can be built without adding significant weight, so that the load capacity of the vessel is not significantly compromised. The floor can be a tank top deck of a barge or bulk carrier.

- 5 Accordingly, the topography and drainage course may be provided on a floor or region thereof that is a substantially flat to facilitate drainage across floor.

The embodiments described may be usefully applied to drain a wide range of different materials, and in general a material that can be fluidised and handled
10 as a slurry.

Figure 13 provides examples of how the topography may be arranged in other variants, wherein different ridge/valley geometries A-E are indicated. The respective geometries have valleys which are denoted 716-716'''' and ridges
15 which are denoted 719-719'', on floor 742-742'''. The ridges and valleys may be provided with wear-layers on the sides and bottoms of the valleys in the manner as indicated above. Elements in the form of blocks of concrete may be shaped into the geometries as illustrated and provided on the floor to form the ridges and valleys. Other geometries are also possible for material to
20 collect in channels or valleys. The concrete may comprise foam or other lightweight elements embedded in a cement matrix of the concrete. The slurrified material which collects in the valleys 716-716'''' can be drained away along the respective valley on a drainage course toward an outlet. Typically,

fluidising nozzles (not shown) are arranged near the ridges 719-719'' for fluidising the material stored in the storage space and to be drained away in fluidised form.

- 5 Various modifications and improvements may be made without departing from the scope of the invention herein described.

CLAIMS

1. An arrangement for draining material from a storage space of a vessel,
the arrangement comprising:

at least one injector for injecting a carrier fluid into the storage space;

5 and

a topography arranged to define at least one drainage course at a base
of the storage space, the topography being configured to concentrate the
injected carrier fluid in the drainage course for carrying the material on the
drainage course to an outlet.

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2. An arrangement as claimed in claim 1, wherein the topography
comprises surfaces sloping in opposition to one another toward a bottom of
the drainage course.

15 3. An arrangement as claimed in claim 1, wherein the topography
comprises a catchment region for collecting injected carrier fluid, or a fluidic
mixture of the injected carrier fluid and an amount of the material to be
drained.

20 4. An arrangement as claimed in any preceding claim, wherein the
topography comprises at least one valley or channel defining the drainage
course in a bottom of the valley or channel.

5. An arrangement as claimed in claim 4, wherein the valley or channel has a V or U shaped section.

6. An arrangement as claimed in claim 4 or 5, wherein the channel or valley is constructed using adapted tubing.

7. An arrangement as claimed in any of claims 4 to 6, wherein the channel or valley is coated with wear coating comprising a surface against which material being carried on the drainage course or stored in the storage space can bear against in use.

8. An arrangement as claimed in any of claims 4 to 7, wherein the channel or valley is coated with a polyurea material or a hybrid of polyurea material.

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9. An arrangement as claimed in any of claims 4 to 8, wherein the channel or valley is constructed from at least one block of construction material with at least one wear layer applied thereto, for material in the drainage course and/or stored in the storage space to bear against in use.

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10. An arrangement as claimed in any of claims 4 to 9, wherein the channel or valley is constructed using concrete comprising lightweight elements therein.

11. An arrangement as claimed in claim 10, wherein the concrete is coated with at least one layer comprising polyurea material or a hybrid of polyurea material.

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12. An arrangement as claimed in any preceding claim, wherein the outlet is aligned with the drainage course.

13. An arrangement as claimed in any preceding claim, wherein the
10 topography comprises at least one ridge between adjacent valleys or channels.

14. An arrangement as claimed in claim 13, wherein the injector is arranged on or adjacent to the ridge.

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15. An arrangement as claimed in claim 14, wherein the ridge is formed using a block of concrete which comprises lightweight elements therein.

16. An arrangement as claimed in any preceding claim, further comprising
20 an outlet for removing leak fluid.

17. An arrangement as claimed in any preceding claim, wherein the topography is configured to be provided on a floor.

18. An arrangement as claimed in any preceding claim, wherein the topography is configured to be provided on a tank top deck of the vessel.

5 19. An element for providing a topography at a base of a storage space on a vessel, for providing a drainage course to drain material from the storage space using a carrier fluid.

20. An element as claimed in claim 19, comprising concrete which
10 comprises lightweight elements therein.

21. A method of draining material from a storage space of a vessel using the arrangement of any of claims 1 to 18.

15 22. A vessel provided with the arrangement of any of claims 1 to 18.

23. A method of providing a vessel with the arrangement of any of claims 1 to 18.

20 24. An arrangement for draining surplus fluid from a storage space on a vessel for removing the surplus fluid from stored material in the storage space, the arrangement comprising:

a topography arranged to define at least one drainage course at a base of the storage space, the topography being configured to concentrate the surplus fluid in the drainage course for carrying the surplus fluid on the drainage course to at least one outlet.

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25. A method of draining surplus fluid from a storage space on a vessel for removing the surplus fluid from stored material in the storage space, using the arrangement of claim 24.