A method for incorporating binders during ground stabilisation, the method including continuously preparing ground in a mixing chamber (28) and adding binder in a substantially dry form directly to the mixing chamber. The binder may be supplied from a binder handling system which includes a continuously alternating, pressurised, multi-chamber binder-supply system having at least two supply chambers (36, 38) that are separately capable of being pressurised or placed under suction to continuously supply and maintain substantially full a binder reservoir (40). Also described is apparatus for incorporating binders during ground stabilisation, the apparatus being in the form of a machine capable of traversing the ground. The machine has a ground breaking assembly (20) with a mixing chamber (28), the ground breaking assembly being capable of co-operating with a binder handling system that is capable of continuously adding binder in a substantially dry form directly into the mixing chamber (28).
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METHODS AND APPARATUS FOR INCORPORATING
BINDERS DURING GROUND STABILISATION

Field of the Invention

The present invention relates to methods and apparatus for incorporating binders during ground stabilisation. Ground stabilisation is a part of the construction process for roads, paths, parking lots and runways and the like, and in particular is the process of preparing sub-grade, base and sub-base materials to provide a higher load bearing capacity such that they better withstand heavy traffic stresses.

Background of the Invention

Ground stabilisation generally involves thoroughly milling and pulverising the sub-grade, base and sub-base material (often in-situ), and subsequently mixing the pulverised material with suitable binders, such that after proper compaction and curing the material is more dense (stable) and provides the desired stronger base. Stabilisation techniques are used for new construction as well as for the recycling of older, deteriorated roads and the like.

The stability and load bearing capacity of a base material generally depends on two factors – the internal friction between particles and the cohesion of particles. In this respect, the higher the internal friction, the better the cohesion and the greater the load bearing capability of the base layer. It is recognised that the addition of a binder to the base material assists in allowing the particles to meet the desired requirements for friction and cohesion.

Binders are typically provided using one of two techniques. Firstly, binders may be slurried or foamed and provided in fluid form to the milled and pulverised base material during milling and pulverising. Secondly, and most commonly, binders in dry form may be laid in-situ over a base material to provide a coating
layer, such that a milling and pulverising machine may then pass over the coated base material to mill, pulverise and mix the binder into the base material in one action.

The existing wet techniques (namely, providing slurried or foamed binders such as bitumen foam or bitumen emulsions) present various difficulties, such as difficulties in cleaning the equipment after use and difficulties in disposing of unused slurry. Additionally, use in already wet areas generates unduly boggy conditions, and wet techniques are unable to process some popular binders (such as quicklime) due to problems caused by the hydration of the binder in the slurry mixer and pump.

Therefore, the dry techniques are often preferred, and have proven to be more popular. However, the existing dry techniques (such as laying binder before the ground stabilisation machines) generate significant amounts of dust that presents environmental and health problems. Whilst some attempts have been made to remove this problem by spraying water over the binder layer, this has merely served to again introduce similar problems to those mentioned above with the existing wet techniques, and has for instance caused hydration problems with certain binders.

It is thus an aim to provide a method and apparatus for incorporating binders during stabilisation which are not subject to the above difficulties.

Summary of the Invention

The present invention provides a method for incorporating binders during ground stabilisation, the method including continuously preparing ground in a mixing chamber and adding binder in a substantially dry form directly to the mixing chamber.
For ease of reference, the terms 'ground stabilisation' and 'ground' will herein be used. The term 'ground' is intended to include any type of base material that is used for the construction or recycling of roads, runways, parking lots and the like. The term specifically includes soil, dirt, rubble, gravel, sand, stones, concrete, pavement and the like, whether they be in particulate or agglomerated form.

The continuous preparation of the ground may be such as the milling and pulverising of the ground which, in this invention, occurs simultaneously with the addition of the binder. This milling and pulverising is usually in the form of digging down into the ground to a predetermined depth, crushing the particles and agglomerates to an acceptable size range, and re-laying the particles.

In a preferred form, the continuous preparation of the ground is achieved by a ground breaking assembly in the general form of a cylindrical drum having a plurality of outwardly projecting teeth configured over the external surface thereof, the assembly being located in a machine which may be driven over an area of ground to be stabilised. The drum is preferably configured such that its cylindrical axis lies substantially perpendicular to the direction of travel of the machine, such that rotation of the drum about its cylindrical axis increases the bite of the teeth into the ground to be stabilised.

The ground breaking assembly preferably includes a hood mounted over the drum to form a substantially enclosed chamber, referred to as a mixing chamber. In this respect, it is to be appreciated that the mixing chamber is 'substantially enclosed' in that the chamber is formed between the hood and the ground.

In the present invention, the binder is added in a substantially dry form directly to the mixing chamber. The term 'substantially dry form' is used herein to refer generally to binders in powdered form. Whilst such powdered binders may themselves have a moisture content, water is not to be added to form a binder
slurry nor foamed to produce a binder foam. Thus, the binder will be capable of being handled pneumatically, and will generally be considered in the art as 'dry'.

The type and amount of binder will usually be dictated by the composition of the ground being milled and pulverised, the size (gradation) of the particles, the moisture content of the particles, and the load bearing specifications for the base being prepared.

Particularly preferred types of binder are cement and lime. Cement generally results in the highest possible load bearing capacity when compared to other typical binders, and can be used to bind non-cohesive and poorly cohesive materials such as gravel, sand or reclaimed asphalt. On the other hand, lime is especially effective in clay-bearing soils and aggregates. It produces a hardening action in which the lime reacts chemically with the available silica to produce a permanent, strong, stabilised layer. Lime is also useful in wetter ground where it assists compaction by drying the ground.

However, when lime is used in non-plastic ground (ground which has a low PI), a second additive such as pozzolan is preferably used in order to assist in producing the necessary reaction to the lime. Fly ash is the most commonly specified pozzolan, although others such as blast furnace slag may be used. Fly ash in particular will interact chemically with lime to enhance the strength of the base.

In referring to the binder being added directly to the mixing chamber, this is rather than being laid out as a coating over the ground to be stabilised. In particular, the binder is preferably added to the mixing chamber so that it is virtually immediately blended with the particles resulting from the pulverising and milling.

The present invention thus also provides an apparatus for incorporating binders during ground stabilisation, the apparatus including a ground breaking assembly
substantially enclosed in a mixing chamber, and a binder handling system capable of adding binder in a substantially dry form directly into the mixing chamber.

5 It should be appreciated that the binder handling system of the present invention may be added to an existing ground stabilising machine to provide that machine with the advantages of the invention.

Thus, in one form, the apparatus of the present invention may be a machine capable of traversing the ground, the machine having a ground breaking assembly for milling and pulverising ground as the machine passes thereover, the ground breaking assembly including:

- a cylindrical drum supported with its cylindrical axis substantially horizontal and generally perpendicular to the direction of travel of the machine, and supported for rotation about its cylindrical axis;
- a plurality of outwardly projecting teeth configured over the external surface of the drum for digging into the ground during rotation of the drum to mill and pulverise the ground; and
- a hood mounted over the drum to substantially enclose the drum between the hood and the ground to form a mixing chamber;

wherein the ground breaking assembly cooperates with a binder handling system capable of continuously adding binder in a substantially dry form directly into the mixing chamber.

25 By incorporating the binder directly into the mixing chamber, the health and environmental concerns with laying binder ahead of a stabilising machine are removed. Additionally, by ensuring that the binder is added in a substantially dry form, the difficulties in using binders in a liquid form (slurry, foam or suspension) are also removed.

30 In a preferred form of the present invention, the binder handling system includes a continuously alternating, pressurised, multi-chamber binder-supply system.
Preferably, the multi-chamber system includes at least two binder supply chambers, there being at least a primary supply chamber and a secondary supply chamber, both being capable of being placed under pressure or under suction. In this form, binder can be delivered from the primary supply chamber to the mixing chamber, with excess binder returning to the secondary supply chamber, the binder supply alternating from the primary chamber to the secondary chamber when the first is empty. This allows for the provision of a constant supply of binder to the mixing chamber.

The binder handling system preferably also includes a binder reservoir in communication with the mixing chamber for the injection of binder directly to the mixing chamber, the binder reservoir being capable of receiving binder from either the primary chamber or the secondary chamber and, when full, being capable of allowing the return of binder to either the primary chamber or the secondary chamber as appropriate.

The binder reservoir is preferably continuously under a positive pressure to assist in urging movement of binder therethrough, either to the mixing chamber or returning to the primary or secondary chambers.

The binder handling system preferably also includes a binder delivery means that is controllable to adjust the rate of delivery of the binder from the reservoir to the mixing chamber. Preferred forms of binder delivery means will be further described below.

The binder handling system preferably operates to allow for the continuous supply of binder to the reservoir, such that binder may be delivered by the binder delivery means to the mixing chamber continuously and uninterrupted as necessary. In use, one supply chamber (say, the primary chamber) will be pressurised to urge binder therefrom into the binder reservoir. The primary chamber is preferably pneumatically pressurised such that the binder (in a
substantially dry form and thus generally a powder) is fluidised and travels along supply lines to fill the reservoir.

When the reservoir is full, the excess binder may return via a return line to the other supply chamber (say, the secondary chamber). The binder is preferably drawn into the secondary chamber by virtue of it (the secondary chamber) being placed under suction.

With the reservoir being maintained full, the binder delivery means is able to be operated at a desired rate to deliver a desired volume of binder to the mixing chamber. As binder is being delivered, and the level of binder in the binder reservoir is being maintained from the supply of binder in the primary chamber, the primary chamber is emptying. As the primary chamber empties, the pressurisation is reversed so that the secondary chamber is pressurised and now supplies binder to the binder reservoir, whilst the primary chamber is placed under suction to extract overflow from the binder reservoir.

As the binder delivery means will itself not continuously operate (for instance, where the stabilising machine turns around to process another section of road, or stops temporarily for other reasons), it is envisaged that there will be a reasonably regular transfer of binder between chambers, via the binder reservoir. Thus, it is envisaged that there may be a number of alternations of pressure before re-filling of the chambers becomes necessary.

Thus, the present invention additionally provides a method for incorporating binders during ground stabilisation, the method including continuously preparing ground in a mixing chamber and adding binder in a substantially dry form directly to the mixing chamber, the binder being supplied from at least two supply chambers which are separately and alternatively capable of being pressurised or placed under suction to continuously supply and maintain substantially full a binder reservoir, binder being added to the mixing chamber
via a binder delivery means capable of drawing binder continuously from the binder reservoir.

A preferred form of binder delivery means will now be described. In this respect, the present invention provides a binder delivery means for use with a ground stabilisation machine having a ground breaking assembly within a mixing chamber, and a binder reservoir under positive pressure, the binder delivery means including at least one delivery tube for delivering binder from the binder reservoir to the mixing chamber, each delivery tube having an inlet and an outlet, and each delivery tube being associated with an inlet regulating means and an outlet regulating means for controlling the entry and exit of binder to and from the delivery tube.

The present invention also provides a method for delivering binder from a binder reservoir to a mixing chamber of a ground stabilisation machine, the method including:

- continuously supplying binder to the binder reservoir under positive pressure; and
- operating a cycle of filling and then emptying at least one delivery tube with binder from the binder reservoir, the emptying acting to deliver binder to the mixing chamber.

The inlet and outlet regulating means of the binder delivery means are preferably some type of valve, adapted so as to open and/or close the inlet and outlet of the delivery tube as desired. In a preferred form, each delivery tube will have its own inlet regulating means and its own outlet regulating means.

Due to the binder reservoir being under a positive pressure, when the inlet regulating means is open, binder is urged into the delivery tube. Preferably, the outlet regulating means remains closed whilst the delivery tube fills with binder. Once full, the inlet regulating means will close, enclosing within the delivery tube an amount of binder. By knowing the volume of the delivery tube, the
amount of binder about to be delivered to the mixing chamber will thus be known.

The outlet regulating means may then be opened, allowing binder to exit the delivery tube and be delivered to the mixing chamber.

In a preferred form, the delivery tube is made of a flexible and resilient material, for example a soft but tough rubber such as a natural blend of white rubber having a hardness of in the range of 30 to 40 Duro. In this form, upon filling of the delivery tube in the manner described above, the positive pressure of the binder reservoir will force the tube to expand beyond its at-rest position. The binder in the tube when the inlet regulating means closes will then also be under positive pressure due to the natural resilience of the expanded tube.

Upon opening the outlet regulating means, the positive pressure on the binder in the delivery tube (caused by the natural resilience of the tube) will urge the binder out of the tube into the mixing chamber.

Preferably, the operation of the binder delivery means in the manner described above is such as to provide a cycle of filling and emptying each delivery tube. In this way, a known volume of binder can be delivered to the mixing chamber from each delivery tube. By altering the speed of the cycle, the volume delivered may be increased or decreased, thus increasing or decreasing the spread rate and amount of binder. Of course, such a change in cycle speed may be used merely to maintain a spread rate, in accordance with variations in the speed of travel of the ground stabilisation machine.

In a preferred form of binder delivery means, the inlet and outlet regulating means may be pinch-type valves comprising pneumatically operated pinch bars configured on opposed sides of a delivery tube. The pinch bars are thus actuated to move together and pinch the delivery tube therebetween, causing the tube to be closed and sealed at that point. It will be appreciated that such
pinch-type valves may alternatively comprise a fixed pinch bar and an opposed actuatetable pinch bar. Furthermore, more than two pinch-type valves may be arranged along the length of each delivery tube. For instance, three such valves may be used, one at each end and one in the middle. Further still, one pinch-type valve may be configured so as to pinch more than one delivery tube. In this form, one pinch-type valve may be configured to have an elongate pinch bar that is long enough to pinch two tubes.

Preferably, the binder reservoir is located above the mixing chamber, and delivery tubes are configured substantially vertically therebetween, with their inlet being the uppermost end in communication the binder reservoir, and their outlet being the lowermost end in communication with the mixing chamber.

In one form, the mixing chamber is an elongate chamber extending across the width of the ground stabilisation machine. In this form, the binder reservoir will also be elongate, similarly extending across the width of the ground stabilisation machine. A plurality of delivery tubes may then be provided, preferably configured closely adjacent to each other, extending across the width of the ground stabilisation machine. Thus, in operation, binder may be spread across the full width of the ground stabilisation machine.

Finally, the binder reservoir preferably includes an inlet for passage of binder from the binder handling system, and an outlet for return of excess binder to the binder handling system. The reservoir may also include internal baffle plates. The baffle plates assist in removing binder from suspension in the air stream from the binder handling system. They also assist in stabilising the binder to prevent surging within, or whilst exiting, the binder reservoir.

**Brief Description of the Drawings**

The present invention will now be described in relation to a preferred embodiment as illustrated in the accompanying drawings. However, it is to be
appreciated that the following description is not to limit the generality of the above description.

In the drawings:

5  Figure 1 is a schematic side view of a machine which may be adapted in accordance with the present invention;

Figure 2 is an exploded view of a part of the machine of Figure 1;

10  Figure 3 is a schematic flow-sheet of a preferred embodiment of the present invention;

Figures 4(a) and 4(b) are side schematic views (from opposite sides) of a vehicle adapted in accordance with the preferred embodiment of Figure 3;

15  Figure 5 is a perspective view of a preferred form of binder delivery means for use with the present invention;

20  Figure 6 is a section view through the binder delivery means of Figure 5; and

Figures 7(a) to 7(d) are an illustration of the sequence of operation of the binder delivery means of Figures 5 and 6.

25  **Detailed Description of the Drawings**

In the description of the preferred embodiment, the present invention will at least initially be illustrated in terms of being an adaptation of an existing ground stabilisation machine. This is described in the art as a 'retro-fit'. However, it is to be appreciated that the scope of the present invention extends to cover the manufacture of new machines which utilise the inventive principles. Indeed,
such new machines are illustrated and described in relation to the apparatus illustrated in Figures 4 to 7.

Thus, a conventional ground stabilisation machine 10 is illustrated in Figures 1 and 2. The machine 10 is as described in international patent application PCT/EP96/00556, and generally includes a working vehicle 12 having a ground breaking assembly 14 mounted between drive axles (16 and 18). The ground breaking assembly 14 is better illustrated in Figure 2, and generally includes a cylindrical drum 20 having a plurality of outwardly projecting teeth 22 configured over its external surface 24.

The ground breaking assembly 14 includes a hood 26 mounted over the drum 20 to form a substantially enclosed mixing chamber 28.

In operation, the ground 30 over which the machine 10 passes (in direction of travel A) is dug up by the action of the rotating drum 20 (and its teeth 22). The ground is thus milled and pulverised to a predetermined size range, and re-laid behind the machine 10 as a stabilised layer 32. Thus, a typical prior art operation would see binder laid over the ground 30 in advance of the machine 10, and the binder would interact and be blended with the milled and pulverised particles to form the stabilised layer 32.

However, the present invention introduces binder in a substantially dry form directly to a mixing chamber, such as the mixing chamber 28 shown in Figure 2. Indeed, further discussion of the embodiments of the present invention illustrated in Figures 3 to 7 will refer to features of the prior art apparatus illustrated in Figures 1 and 2 as being a part of the inventive embodiments. For instance, Figure 2 shows a nozzle or aperture 34 in the hood 26 that is shown to illustrate the manner in which binder, in substantially dry form (and thus in accordance with the present invention), may be added to a mixing chamber.
Figure 3 illustrates a preferred binder handling system for delivering the binder to the hood 26 in a continuous manner. This system is a continuously alternating, pressurised, multi-chamber system having a primary supply chamber 36 and a secondary supply chamber 38 for supplying binder to a binder delivery means 42. Both the primary and secondary supply chambers (36 and 38) are connected via lines to a binder reservoir 40, which in turn communicates with the binder delivery means 42 (the preferred operation of which will be described below). Binder passes from the binder delivery means 42 to the mixing chamber 28 via a delivery flap 44.

The preferred operation of the system of Figure 3 will now be described. The primary chamber 36 is filled with binder (ie cement powder etc) by loading through a filler hatch 46 or by pumping in through the return line 69 and valve 70. Valve 70 is automatically opened when the system is in fill mode.

During filling by (for example) a pressure tanker, the filter 71 in the secondary chamber 38 is operated and connected via the vent line 49 and a valve 50. The valve 50 is operated automatically when the system is in fill mode, and serves to allow air to be expelled by the system (after being filtered) as the primary chamber 36 is filling.

When the spreading operation commences, the primary chamber 36 is pressurised by a compressor 52. Valves 54 and 56 are opened to allow the pressurisation of the primary chamber 36 and the passage of binder therefrom to the binder reservoir 40 via the delivery line 59. The manner of fluidisation of the binder is described in more detail below.

Valves 58 and 60 are closed to prevent pressurisation of the secondary chamber 38 and to prevent binder being delivered from the secondary chamber 38. The secondary chamber 38 is put under suction by opening valve 55 and running the suction fan 57. Valve 48 is opened on the return line to allow
overflow of binder from the binder reservoir 40 to return to the secondary chamber 38 via the return line 69.

The binder is then aerated or fluidised and flows to the binder reservoir 40. To aerate the binder in the primary chamber 36, compressed air is supplied by the compressor 52 via a line 51 to the underside of an aeration bed 53 in the primary chamber 36. The aeration bed 53 is constructed of a perforated metal base, supporting a layer of course woven cloth. The cloth allows the compressed air to pass into the load of binder in the primary chamber 36, while preventing the binder from entering the aeration bed 53 and possibly blocking the compressed air line 51.

The compressed air passing into the binder causes the binder to become fluidised in the vicinity of the aeration bed 53, allowing it to move down the delivery line 59 as the pressure in the primary chamber 36 increases. Of course, it will be appreciated that a similar mechanism is provided for the secondary chamber 38, illustrated as the aeration bed 63.

In the embodiment illustrated and described, the flow of binder commences when the internal pressure reaches approximately 30kPa. The compressed air percolates through the binder and accumulates in the primary chamber 36, raising the internal pressure in the primary chamber 36 to approximately 120 kPa. The maintenance of this internal pressure continually pushes the binder down the delivery line 59 to the binder reservoir 40.

When the binder reservoir 40 is full, the overflow binder flows via the return line to the secondary chamber 38.

When the level of binder in the primary chamber 36 reaches the low level sensor 64, or the high level sensor 66 in the secondary chamber, the system changes over. To affect this, valves 48, 54 and 56 remain open, valve 55 is closed and valves 50 and 70 are opened. The pressure in the two chambers is
allowed to equalise, and then valves 48, 50, 54 and 56 are closed, valves 60, 58 and 68 are opened and chamber 36 is vented. This is done to minimise the change over time by reducing the time required to pressurise the secondary chamber 38 and re-establish the binder flow to the binder reservoir 40.

The process is repeated until both of the low level probes (64 and 72) are activated together, indicating both chambers are empty.

The filters 71 and 73 are cleaned continuously by a pulse of pressurised air generated by a control air compressor 74 and regulated by a valve system (76 and 78). Each filter is cleaned individually in a sequence so as to minimise the loss in filter efficiency.

A system such as that illustrated in Figure 3 is preferably built into a service tanker that would follow or precede a machine such as that illustrated in Figures 1 and 2. As can be seen, the binder handling system (illustrated in Figure 3) allows for the continuous supply of binder to the mixing chamber of the stabilisation machine.

Indeed, illustrated in Figures 4a and 4b is such a service tanker embodying the system illustrated schematically in Figure 3. The service tanker is in the form of a truck 80 having a cab 82 and a chassis 84. The chassis 84 carries a pressure vessel 86 partitioned so as to provide a primary chamber 36 and a secondary chamber 38. The service tanker is designed to move ahead of the machine of Figure 1 to provide a continuous supply of binder in the manner described above.

Various features of the service tanker are illustrated using the same reference numerals as used above in relation to the description of the flow diagram in Figure 3. Figure 4a generally illustrates the binder feed and flow system, and shows the return line 69, the delivery line 59, an aeration bed 53, the vent line 49, the main compressor 52, and the general location of the filters 71 and 73.
Figure 4b generally illustrates the filter system, showing the suction fans 57 and a control air compressor. The location of the aeration beds 53 and 63 is also well illustrated.

Figure 5 shows the general relationship of the parts of a binder delivery means 150, being a binder reservoir 152, delivery tubes 156, inlet and outlet regulating means (164, 166), and a mixing chamber 162, at least in the preferred embodiment illustrated.

The binder delivery means 150 is intended for use in conjunction with, for example, the ground breaking assembly 14 and the machine 10 illustrated in Figures 1 and 2. The binder delivery means 150 includes the binder reservoir 152 fed by a delivery line 154. The binder reservoir 152 is, in use, maintained under positive pressure by virtue of the pressurisation of the binder in the primary or secondary chambers (36,38) of the service tanker, to a level necessary to fluidise the binder with air.

It is envisaged that the binder reservoir 152 will operate under pressures in the order of 30 kPa to 80 kPa, with a pressure of about 50 kPa being preferred.

The binder delivery means 150 also includes at least one delivery tube. In this embodiment, there is a plurality of delivery tubes 156 extending across the full width of the binder reservoir 152, and thus the full width of the machine 10 carrying the ground breaking assembly 14 of Figures 1 and 2.

The delivery tubes 156 are configured substantially vertically between the binder reservoir 152 and the hood 158 surrounding the milling device 160 (shown in outline). The hood 158, together with the ground, defines the mixing chamber 162 therebetween.
Figure 5 also shows each delivery tube 156 having its own inlet regulating means 164 and outlet regulating means 166. The operation of the regulating means will be described below in relation to Figures 6 and 7.

Illustrated in Figure 6 is a more detailed view of a single delivery tube 56 and its relationship with the binder reservoir 152 and the mixing chamber 162, particularly by virtue of the inlet regulating means 164 and the outlet regulating means 166.

The inlet regulating means 164 and the outlet regulating means 166 are both shown as pinch-type valves, each having a pneumatic actuator 168 and a pinch bar 170. The pneumatic actuators are each rigidly fixed such that opposed pinch bars both move towards and against the delivery tube 156 to close and seal. The retraction of opposed pinch bars then unseals and opens the delivery tube.

In operation, and referring to Figures 7(a) to 7(d) where the inlet regulating means 164 is designated X and the outlet regulating means 166 is designated Y, both valves X and Y will be initially closed (Figure 7(a)). Valve X will open to allow binder to fill the delivery tube 156 while valve Y remains closed (Figure 7(b)). The tube 156 is flexible and resilient, and pressure of the binder reservoir 152 urges binder into the tube expanding it slightly against its inherent resilience (Figure 7(c)). Valve X is then closed, valve Y is opened and the resilience of the delivery tube 156, as it returns to its at-rest position, urges binder out into the mixing chamber 162 (Figure 7(d)).

The operation cycles continuously in this manner. In this respect, and in this preferred embodiment, all of the delivery tubes 156 cycle in the same sequence at the same time. However, it will be appreciated that this need not always be desirable. It may be preferred to have some tubes filling while others are emptying. It may also be preferred to only have some of the delivery tubes functioning, perhaps only every second or third tube depending on flow-rates
required. Alternatively, it may only be required to provide a thin internal band of binder within the mixing chamber, in which case perhaps only the central third of tubes would be used.

5 It will be appreciated that all such functions of the operations of all matters described herein may be controlled by suitable controllers and computers.

Figure 6 also illustrated baffles 172 provided within the binder reservoir 152, together with a manually of automatically operable flap 174 which may be configured to close off the outlet 176 of the delivery tubes 165.

In the particular embodiments illustrated in Figures 3 to 7, it will be understood that operating conditions may vary significantly depending on the use of the apparatus, and the desired results. However, in the embodiment illustrated and described herein, the following operating conditions have been found to be suitable. The primary and secondary chambers will preferably have an internal volume of about 20 m³ and 10 m³ respectively, while the binder reservoir will have an internal volume of about 300 litres. The compressor capacity is preferably about 320 cfm and the filter capacity is preferably about 500 cfm against 8' WG @ 20°C. The delivery and return lines for the binder are preferably of a diameter of about 100mm NB.

The internal diameter of the pinch-tubes is preferably about 50mm. With a typical depth of stabilised road base in the order of 100 to 500mm, a typical stabiliser speed of about 5 to 15 m/min, and a typical desired spread rate of 3 to 30 kg/m², the pinch-tube valves will typically cycle at rates in the order of 50 to 150 cycles/min.

Finally, it will be appreciated that there may be other modifications and alterations made to the configurations described herein that are also within the scope of the present invention.
Claims:

1. A method for incorporating binders during ground stabilisation, the method including continuously preparing ground in a mixing chamber and adding binder in a substantially dry form directly to the mixing chamber.

2. A method according to claim 1 wherein the continuous preparation of the ground is pulverising and milling, occurring simultaneously with the addition of binder.

3. A method according to claims 1 and 2 wherein the binder is supplied from a binder handling system which includes a continuously alternating, pressurised, multi-chamber binder-supply system having at least two supply chambers that are separately capable of being pressurised or placed under suction to continuously supply and maintain substantially full a binder reservoir.

4. A method according to claim 3 wherein binder is added to the mixing chamber via a binder delivery means capable of drawing binder continuously from the binder reservoir.

5. A method according to claim 3 or claim 4 wherein the multi-chamber system comprises a primary supply chamber and a secondary supply chamber such that binder can at least initially be delivered from the primary supply chamber to the mixing chamber, with excess binder returning to the secondary supply chamber, the binder supply alternating from the primary supply chamber to the secondary supply chamber when the primary supply chamber is empty.

6. A method according to claim 5 wherein, at least initially, the primary supply chamber is pressurised such that the binder is fluidised and travels along a supply line from the primary supply chamber to the binder reservoir, and the secondary supply chamber is placed under suction to draw excess binder from the binder reservoir when the binder reservoir is full.
7. A method according to claim 6 wherein when the primary supply chamber is emptied, the pressurisation and suction are reversed such that the secondary chamber is pressurised so that the binder travels along a supply line from the secondary supply chamber to the binder reservoir, and the primary supply chamber is placed under suction to draw excess binder form the binder reservoir when the binder reservoir is full.

8. Apparatus for incorporating binders during ground stabilisation, the apparatus being in the form of a machine capable of traversing the ground, the machine having a ground breaking assembly with a mixing chamber, the ground breaking assembly being capable of co-operating with a binder handling system that is capable of continuously adding binder in a substantially dry form directly into the mixing chamber.

9. Apparatus according to claim 8 wherein the ground breaking assembly is capable of milling and pulverising ground as the machine passes thereover, the ground breaking assembly including:
   - a cylindrical drum supported with its cylindrical axis substantially horizontal and generally perpendicular to the direction of travel of the machine, and supported for rotation about its cylindrical axis;
   - a plurality of outwardly projecting teeth configured over the external surface of the drum for digging into the ground during rotation of the drum to mill and pulverise the ground; and
   - a hood mounted over the drum to substantially enclose the drum between the hood and the ground to form a mixing chamber.

10. Apparatus according to claim 8 or claim 9 wherein the binder handling system includes a continuously alternating, pressurised, multi-chamber binder-supply system having at least two supply chambers that are separately capable of being pressurised or placed under suction to continuously supply and maintain substantially full a binder reservoir.
11. Apparatus according to claim 10 including a binder delivery means capable of drawing binder continuously from the binder reservoir for addition to the mixing chamber.

12. Apparatus according to claim 10 or claim 11 wherein the multi-chamber system comprises a primary supply chamber and a secondary supply chamber, directly or indirectly in communication with each other and the mixing chamber such that binder can at least initially be delivered from the primary supply chamber to the mixing chamber, with excess binder returning to the secondary supply chamber, the communication also being such that the binder supply can alternate from the primary supply chamber to the secondary supply chamber when the primary supply chamber is empty.

13. Apparatus according to claim 12 wherein, at least initially, the primary supply chamber is pressurised such that the binder is fluidised and travels along a supply line (from the primary supply chamber) to the binder reservoir, and the secondary supply chamber is placed under suction to draw excess binder from the binder reservoir when the binder reservoir is full.

14. A binder delivery means for use with a ground stabilisation machine having a ground breaking assembly, a mixing chamber and a binder reservoir under positive pressure, the binder delivery means including at least one delivery tube for delivering binder from the binder reservoir to the mixing chamber, each delivery tube having an inlet and an outlet, and each delivery tube being associated with an inlet regulating means and an outlet regulating means for controlling the entry and exit of binder to and from the delivery tube.

15. A binder delivery means according to claim 14 wherein each delivery tube is made of a flexible and resilient material.
16. A binder delivery means according to claim 14 or claim 15 wherein the binder reservoir is located above the mixing chamber and delivery tubes are configured substantially vertically therebetween.

17. A binder delivery means according to any one of claims 14 to 16 wherein the inlet and outlet regulating means are pinch-type valves comprising pinch bars configured on opposed sides of a delivery tube, the pinch bars being actuatable to move together to pinch the delivery tube therebetween, to close and seal the tube at that point.

18. A method for delivering binder from a binder reservoir to a mixing chamber of a ground stabilisation machine, the method including:
   - continuously supplying binder to the binder reservoir under positive pressure; and
   - operating a cycle of filling and then emptying at least one delivery tube with binder from the binder reservoir, the emptying acting to deliver binder to the mixing chamber.

19. A method according to claim 18 wherein the delivery tubes are each made of a flexible and resilient material.

20. A method according to claim 19 wherein each delivery tube has an inlet regulating means for controlling the entry of binder thereto, and an outlet regulating means for controlling the outlet of binder therefrom.

21. A method according to claim 19 or claim 20 wherein the cycle of filling and emptying operates as follows:
   (a) closing the outlet regulating means and opening the inlet regulating means of a delivery tube to allow the filling of the delivery tube with a predetermined volume whilst expanding the delivery tube against its natural resilience;
(b) closing the inlet regulating means and opening the outlet regulating means, allowing the delivery tube to return to its at-rest position and thus emptying the binder in the delivery tube into the mixing chamber; and

(c) re-commencing the cycle at (a).

22. A method according to claim 21 wherein the inlet regulating means and the outlet regulating means are pinch-type valves.
# INTERNATIONAL SEARCH REPORT

**PCT/AU 99/00092**

## A. CLASSIFICATION OF SUBJECT MATTER

<table>
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<th>Int Cl</th>
<th>E01C 21/00 G01F 11/02</th>
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According to International Patent Classification (IPC) or to both national classification and IPC.

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

WPAT: stabilis: and tube and dispenses:

- G01F 11/02 and tube
- G01F 11/1- and tube and stabilis:
- stabilis: and tube and (dispenses: or deliver: or meter: and (ground or soil)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>AU 47899/96 A (WIRTGEN GMBH) 15 August 1996 Figure 3</td>
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<td></td>
<td>US 2394017 A (SEAMAN) 5 February 1946 Figure 2</td>
<td>1-4, 8-11</td>
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<tr>
<td>X</td>
<td>GB 744602 A (NATIONAL RESEARCH DEVELOPMENT CORP.) 8 February 1956 Figures 3, 4</td>
<td>1-4, 8-11</td>
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</table>

* Further documents are listed in the continuation of Box C

**See patent family annex**

### Special categories of cited documents:

- **"A"** document defining the general state of the art which is not considered to be of particular relevance
- **"E"** earlier application or patent but published on or after the international filing date
- **"L"** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **"O"** document referring to an oral disclosure, use, exhibition or other means
- **"P"** document published prior to the international filing date but later than the priority date claimed

**"T"** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

**"X"** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family

**"Y"** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone

**"&"** document published prior to the international filing date but later than the priority date claimed

### Date of the actual completion of the international search

15 March 1999

### Date of mailing of the international search report

23 April 1999

### Name and mailing address of the ISA/AU

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### INTERNATIONAL SEARCH REPORT

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<tr>
<td>X</td>
<td>US 2482910 A (HETTELSATER) 27 September 1949 Figure 1 Column 10 line 14 - column 11 line 12</td>
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<td>X</td>
<td>US 2529656 A (HETTELSATER) 14 November 1950 Figure 1</td>
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<td>WO 8200349 A (ASKOV MEJERI A/S) 4 February 1982 Figure 2</td>
<td>14-22</td>
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<tr>
<td>X</td>
<td>US 3971494 A (ROSEN) 27 July 1976 Figure 1</td>
<td>14-22</td>
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<td>X</td>
<td>GB 1492033 A (UNITED KINGDOM ATOMIC ENERGY AUTHORITY) 16 November 1977 Figure</td>
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<td>X</td>
<td>FR 1519607 A (N. SCHLUMBERGER &amp; CIE) 5 April 1968 Figure 1</td>
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INTERNATIONAL SEARCH REPORT

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 1-13 are directed towards a method and apparatus for incorporating binders during ground stabilisation including preparing the ground in a mixing chamber and adding binder in a substantially dry form.

2. Claims 14-22 are directed towards a method and apparatus for delivering binder including a delivery tube which is filled and emptied during an operating cycle.

1. [X] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant’s protest.

[ ] No protest accompanied the payment of additional search fees.

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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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END OF ANNEX