SLIP FORM PAVER

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A slip-form paver for applying a formable paving material onto a surface is described. The paver comprises a feed hopper having a bottom outlet, said hopper being adapted for directing the formable paving material through the bottom outlet. A slip-form mould is mounted below the bottom outlet for receiving said formable paving material and applying said material onto said surface. The hopper converges inwardly towards the bottom outlet such that the formable paving material passing through said hopper is directed towards said bottom outlet, and the weight of the formable paving material is concentrated at said bottom outlet so as to compress, compact and/or consolidate said material into the slip-form mould.

ABSTRACT

A slip-form paver for applying a formable paving material onto a surface is described. The paver comprises a feed hopper having a bottom outlet, said hopper being adapted for directing the formable paving material through the bottom outlet. A slip-form mould is mounted below the bottom outlet for receiving said formable paving material and applying said material onto said surface. The hopper converges inwardly towards the bottom outlet such that the formable paving material passing through said hopper is directed towards said bottom outlet, and the weight of the formable paving material is concentrated at said bottom outlet so as to compress, compact and/or consolidate said material into the slip-form mould.
FIG. 7
SLIP FORM PAVER

TECHNICAL FIELD

[0001] The present invention relates to paving equipment.

BACKGROUND OF THE INVENTION

[0002] In conventional methods for paving a surface, e.g. a roadway, concrete is initially dumped on the surface. A first pass is required by a machine for rough placement and consolidation the concrete. A further pass is required by a separate machine, for final placement and finishing of the concrete. Low slump concretes commonly require augers, rammers and/or paddles in order to consolidate the concrete as it is extruded onto the surface (some machines actually using the ramming action to propel themselves), however this is typically restricted to concretes having a slump value of about 20 to 40 mm (slump may be measured using the ASTM C143 Slump Test).

[0003] Existing slip-form pavers typically comprise a rectilinear frame propelled and supported on each side by crawler tracks which in use straddle the longitudinal surface being paved. A slip-form is mounted below the moving frame which moulds concrete from a mass of concrete laid on the ground or a receiving bin for subsequent laying, consolidating and finishing into a roadway or other paved surface. Disadvantages with existing machines include the requirement for mechanical rams, paddles, augers or screws to compress and compact the concrete into the mould. Some existing pavers also require additional devices or machines for spreading, levelling and finishing the concrete surface, or multiple machines for the above process.

OBJECT OF THE INVENTION

[0004] It is the object of the present invention to substantially overcome or at least ameliorate one or more of the above disadvantages.

SUMMARY OF THE INVENTION

[0005] In a first aspect of the invention there is provided a slip-form paver for applying a formable paving material onto a surface, said paver comprising:

[0006] a feed hopper having a bottom outlet, said hopper being adapted for directing the formable paving material through the bottom outlet, and

[0007] a slip-form mould mounted below said bottom outlet for receiving said formable paving material and applying said material onto said surface, wherein said hopper converges inwardly towards the bottom outlet such that the formable paving material passing through said hopper is directed towards said bottom outlet, and the weight of the formable paving material is concentrated at said bottom outlet so as to compress, compact and/or consolidate said material.

[0008] The compression, compaction and/or consolidation may be effected using the slip-form paver without the need for mechanical intervention. It may be effected without the need for a separate device or discrete method step to effect said compression, compaction and/or consolidation. It may be effected without the need for internal mechanical intervention. The slip form mould has a rear opening to allow the formable paving material to exit the slip form paver.

[0009] In one form of the first aspect there is provided a slip-form paver for applying a flowable paving material onto a surface, said paver comprising:

[0010] a feed hopper having a bottom outlet, said hopper being adapted for directing the flowable paving material through the bottom outlet, and

[0011] a slip-form mould mounted below said bottom outlet for receiving said flowable paving material and applying said material onto said surface, wherein the walls of said hopper converges inwardly towards the bottom outlet such that the flowable paving material passing through said hopper is directed towards said bottom outlet, and concentrated at said bottom outlet and the weight of the flowable paving material is concentrated at the bottom outlet so as to compress, compact and/or consolidate said flowable material.

[0012] The bottom outlet may comprise a reverse taper extending outwardly from the converging walls of the hopper. The bottom outlet may be disposed so as to convey the compressed, compacted and/or consolidated material into the slip form mould. The bottom outlet may be coupled to or integral with at least a portion of the slip form mould. The slip form mould may comprise a screed plate. The bottom outlet may be coupled to or integral with the screed plate.

[0013] The following options may be used with the first aspect, either individually or in any suitable combination.

[0014] The slip-form paver may be self-propelled. It may have steerable crawler tracks or skids on each side thereof for propelling said paver. The steerable crawler tracks may have separate speed adjustments, so as to enable steering of the slip-form paver. The slip-form paver may comprise a propulsion module. The propulsion module may comprise a chassis. It may also comprise the steerable crawler tracks, said tracks being then coupled to the chassis. It may also comprise the speed adjustments, if present. The propulsion module may comprise suitable controls, as described herein, for controlling operation of the slip-form paver.

[0015] The bottom outlet may be closable so as to substantially (or totally) prevent formable paving material in the hopper from passing through the bottom outlet. It may be openable so as to allow formable paving material in the hopper to pass through the bottom outlet. The bottom outlet may be closable and openable by means of a closure panel which is locatable across said bottom outlet so as to close the bottom outlet.

[0016] The slip-form paver may comprise a source of said formable material for supplying the formable material to the hopper. The source may comprise a reservoir for storing the formable paving material. It may comprise a mixer for forming (i.e. for batching or mixing) the formable paving material. In some embodiments of the invention the source of the formable material is provided separately from the paver so that, in use, the source travels with or alongside the paver so as to provide the formable paving material to the paver, in particular to the hopper thereof.

[0017] The slip-form paver may comprise a level control mechanism for maintaining a substantially constant level of the formable paving material in the hopper. The level control mechanism may comprise a detector for detecting the level of the formable paving material in the hopper. It may comprise a feedback mechanism for adjusting supply of the formable paving material to the hopper in response to a signal from the detector, so as to maintain the substantially constant level of the formable paving material in the hopper.
[0018] The bottom outlet may include a reverse taper to provide further compression of the formable paving material on entering the slip-form mould. The slip-form paver may comprise a slip-form upper screed plate extending back from the bottom outlet and sloped downward toward the rear of said paver so as to provide further compression of the formable paving material during placement on the surface. The slip-form paver may comprise side forming panels which are angled inwardly towards the rear of the paver so as to provide further compression to the formable paving material during placement on the surface. The side forming panels may be adjustable so as to be capable of changing the width of paving, optionally controlling said width without stopping. The slip-form paver may therefore comprise a side forming panel adjustor for effecting the adjustment. Adjustment of the side forming panels may be remotely controllable. The slip form mould may comprise, or consist of, the side forming panels and the slip-from upper screed plate.

[0019] The feed hopper may be integral with the upper screed plate, thereby forming a hopper assembly. Accordingly, the hopper assembly may comprise the hopper, the bottom outlet (including the reverse taper) and the upper screed plate as an integral item. The screed plate, optionally the hopper assembly, may be height adjustable so as to adjust the thickness of the paving material on the surface. The paver may comprise a height adjustor for adjusting the height of the screed plate or hopper assembly so as to adjust the thickness of the paving material on the surface.

[0020] The hopper assembly described above may be detachable from the propulsion unit (also described above). Thus a single propulsion unit may be used with different hopper assemblies. This enables use of different hopper assemblies so as to pave to different widths. In this case, the paver may comprise a locking mechanism for locking the hopper assembly to the propulsion unit so as to prevent movement of the hopper assembly relative to the propulsion unit during operation of the paver. Thus the slip-form paver may comprise a propulsion module and a hopper assembly, said hopper assembly comprising the hopper and, if present, the slip-form upper screed plate, wherein the hopper assembly is detachable from the propulsion module.

[0021] The slip-form paver may additionally comprise a dispenser for dispensing a liquid onto the surface of the formable paving material and/or after said material is applied to the surface. The liquid may be an aqueous liquid, e.g., an aqueous solution. It may be water.

[0022] The slip-form paver may additionally comprise a vibrator or vibrators for vibrating the formable paving material as and/or after said material is applied to the surface. The vibrators may be electrically operated vibrators. They may be located on, or so as to vibrate, one or more of the reverse taper, the screed and the side forming panels.

[0023] The slip-form paver may additionally comprise one or more surface finishing devices. Suitable such devices include a coving device and/or a brooming device.

[0024] One such device may comprise (1) a cylinder disposed transversely across the paver at a height so as to contact the surface of the formable paving material as or after said material is applied to the surface and (2) a rotation mechanism for rotating the cylinder in a clockwise direction when viewed from the left side of the paver. A secondary cylinder, disposed transversely across the paver, may additionally be present so as to mechanically imprint the surface of the paving material in use, so as to give a predetermined impression onto the surface of the material. The slip-form paver may additionally comprise a height adjustment device for adjusting the vertical location of the cylinder(s). The height adjustment device may comprise a detector for detecting the location of the surface of the formable paving material. In this event the detected location may be used during operation of the paver for determining a desired height for the cylinder(s).

[0025] The slip-form paver may additionally comprise one or more reinforcement dispensers for dispensing one or more continuous tensile elements in the formable paving material as said paving material is located on the surface. The continuous tensile element material may be synthetic or may be metallic. The dispensers may comprise one or more dispensing tubes which extend from a reinforcement storage location to a region below the reverse taper, optionally to a region below the screed. This enables the reinforcement to be dispensed into the formable material as it is being laid on the surface. The dispensing tubes may be non-round or may be round. They may be flatish so as to accommodate a flat reinforcement. Commonly the reinforcement storage location will be located forward of the hopper, for example under a forward sloped wall thereof. Thus the reinforcement may be supplied in a roll located in the reinforcement location, and may be fed through the dispensers into the formable material in use. The dispenser may comprise a dispensing motor to rotate the rolls of reinforcement so as to facilitate dispensing them into the formable material through the dispensing tubes.

[0026] In a second aspect of the invention there is provided a method for applying a formable paving material to a surface, said method comprising:

[0027] providing a slip-form paver according to the first aspect;

[0028] filling the hopper to a predetermined level with the formable paving material; and

[0029] propelling the paver across the surface while allowing the formable paving material to pass from the hopper and into the slip-form mould, thereby compressing said paving material and applying it to the surface and forming it on the surface.

[0030] In one form of the second aspect there is provided a method for applying a flowable paving material to a surface, said method comprising:

[0031] providing a slip-form paver according to the first aspect;

[0032] filling the hopper to a predetermined level with the flowable paving material; and

[0033] propelling the paver across the surface while allowing the flowable paving material to pass from the hopper and into the slip-form mould, thereby compressing said paving material and applying it to the surface and forming it on the surface.

[0034] In this method, the formable paving material towards the lower end of the hopper is consolidated by means of the weight of said material in the hopper, which provides compression to the material.

[0035] The following options may be used with the second aspect, either individually or in any suitable combination.

[0036] The step of applying the paving material to and forming the paving material on the surface may comprise depositing the paving material on the surface and forming it into a desired shape. The desired shape may have a substantially rectangular transverse cross-section. It may be in the shape of a path or of a roadway.
The method may additionally comprise applying vertical compression to the formable paving material by means of a slip-form upper screed plate. It may additionally comprise applying horizontal compression to the formable paving material by means of side forming panels which are angled inwardly towards the rear of the paver.

The method may comprise continuously supplying the formable paving material to the hopper so as to maintain a substantially constant level of the formable paving material in the hopper. This may be by means of a reservoir in which the formable paving material is stored, or it may be by means of a mixer for forming the formable paving material. The source of the formable material may be integral with the paver or it may be provided separately from the paver so that, in use, the source travels with or alongside the paver so as to provide the formable paving material to the paver, in particular to the hopper thereof.

The method may comprise adjusting (optionally continuously adjusting) the height of the screed plate, optionally of a hopper assembly comprising the screed plate, above the surface on which the paving material is laid. The adjusting may comprise detecting the height, generating a signal relating to said height and using said signal to provide feedback so as to control a height controller so as to adjust the height.

The method may additionally comprise dispensing liquids on the surface of the formable paving material as and/or after said material is applied to the surface. It may comprise vibrating the paving material, e.g. the surface thereof, as and/or after said material is applied to the surface.

In the event that the paver additionally comprises a surface finishing device, said device comprising: (1) one or more cylinders disposed transversely across the paver at a height so as to contact the surface of the formable paving material as or after it is applied to the surface, and (2) a rotation mechanism for rotating the cylinder(s), the method may comprise rotating said cylinder, or at least one of said cylinders, in a clockwise direction when viewed from the left side of the paver.

The method may comprise imprinting the surface of the formable material as or after it is applied to the surface.

The method may comprise controlling and/or adjusting one or more parameters of the operation of the paver, for example the height of the upper screed plate, the angle or pitch of the upper screed plate, the angle of the side forming panels, the separation distance of the side forming panels, the speed and direction of movement of the paver, the depth of material in the hopper etc. The controlling may be remote controlling. It may be local controlling. Each parameter may, independently, be remotely controlled or may be locally controlled or both. Each parameter may, independently, be mechanically controlled or electrically or electronically controlled or both.

The formable paving material may be a granular non-consolidating material or a granular self-hardening material. It may be a high slump paving material. It may be a low slump material. It may be a zero slump material. It may be a flowable material.

The method may be a single pass method.

The present invention also provides the use of a slip-form paver according to the first aspect for applying a formable, optionally flowable, paving material to a surface.

The invention also provides a single pass method for applying a paving material to a surface, said method comprising:

- consolidating the paving material;
- applying the paving material to the surface;
- forming the paving material on the surface; and
- optionally finishing a surface of the paving material wherein the step of consolidating is conducted prior to, and optionally also simultaneously with, the step of forming. The applying and forming steps may occur simultaneously. The options described above for the second aspect of the invention may be applied to this method. The paving material may be formable. It may be flowable.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention will now be described, by way of an example only, with reference to the accompanying drawings wherein:

FIG. 1 is a front perspective view of a slip-form paver according to said invention.

FIG. 2 is a rear perspective view of the slip-form paver of FIG. 1.

FIG. 3 is a side elevation view of the slip-form paver of FIG. 1.

FIG. 4 is a perspective view showing parts of the inside sloped walls of the feed hopper.

FIG. 5 is a front elevation view showing part of the slip-form mould mounted below the feed hopper.

FIG. 6 is a schematic side view of the paver.

FIG. 7 shows options for the hopper of the paver.

FIGS. 8 to 23 show drawings of various aspects of the paver.

FIGS. 24 to 32 show photographs of various aspects of the paver.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to paving equipment. More particularly, although not exclusively it discloses an improved form of slip-form paver or extrusion system for applying and forming self-consolidating and self-hardening materials, non self-hardening materials, cementitious flowable and non flowable materials into a continuous roadway surface or the like. Thus materials that may be laid or extruded by the present invention may be self-consolidating. They may be self-hardening. They may be non self-hardening. They may be cementitious flowable materials. They may be cementitious non flowable materials. They should be formable materials. They may be flowable under gravity (either low slump or high slump). They may be non flowable under gravity. They may be zero slump materials.

A slip-form paver for applying a formable paving material onto a surface is described. The paver comprises a feed hopper having a bottom outlet, said hopper being adapted for directing the formable paving material through the bottom outlet. A slip-form mould is mounted below the bottom outlet for receiving said formable paving material and depositing said material onto said surface. The hopper converges inwardly towards the bottom outlet such that the weight of the formable paving material passing through the hopper is directed towards, and concentrated at, said bottom outlet so as to compress, compact and/or consolidate said material into the slip-form mould without the need for internal mechanical intervention (e.g. mechanical rams).

The hopper is commonly open at the top, although it may be closed or restricted by means of a grate or mesh to prevent ingress of extraneous materials (e.g. wind-blown rub-
mish, leaves, branches etc.), in which case an inlet should be provided to allow ingress of the formable paving material. The closure or restriction may function as a safety mechanism by preventing ingress of parts of the body (arm, leg etc.) of an operator or other person. The hopper commonly has a rectangular or square cross-section. In some embodiments it may have a cross-section that varies in shape with height. The top may for example be square, rectangular, triangular, round, elliptical, trapezoid or some other suitable shape. The width of the top of the hopper may be about 1 to about 6 m or more, or about 1 to 5, 1 to 3, 2 to 6, 3 to 6, 2 to 5, 2 to 3, 3 to 4 or 2.5 to 3.5 m, e.g. about 1, 1.5, 2.2, 2.5, 3, 3.5, 4, 5, 4.5, 5.5 or 6 m. In some cases the width may be more than 6 m, e.g. 7, 8, 9 or 10 m. The depth (i.e. horizontal front to back dimension) of the hopper at the top may be about 1 to about 2 m, or about 1 to 5, 1.5 to 2 or 1.2 to 1.7 m, e.g. about 1, 1.25, 1.5, 1.75 or 2 m. The vertical height of the hopper may be about 1 to about 2 m, or about 1 to 1.5, 1.5 to 2 or 1.2 to 1.7 m, e.g. about 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 or 2 m. The volume of the hopper may be about 1 to about 4 m³, or about 1 to 3, 1 to 2, 2 to 4, 3 to 4 or 4 to 2 m³, e.g. about 1, 1.5, 2, 2.5, 3, 3.5 or 4 m³.

**[0065]** The hopper has a bottom outlet at its lower end. Commonly the bottom outlet extends the entire width of the hopper. It is commonly some width as the top of the hopper, as described above. The depth (i.e. horizontal front to back dimension) may be about 100 to about 500 mm, or about 200 to 500, 500 to 500, 100 to 500 or 500 to 400 mm, e.g. about 100, 150, 200, 250, 300, 350, 400, 450 or 500 mm. The area of the bottom outlet may be about 0.5 to about 2 m², or about 0.5 to 1, 1 to 2 or 0.8 to 1.5 m², e.g. a 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 or 2 m². The area ratio between the top of the hopper and the bottom outlet may be about 3:1 and about 6:1, or about 3:1 and 5:1, 4:1 and 6:1 or 4:1 and 5:1, e.g. about 3:1, 3.5:1, 4:1, 4.5:1, 5:1, 5.5:1 or 6:1.

**[0066]** In operation the formable paving material passes out of the bottom outlet and into the slip-form mould below. It may do so under the force of gravity. As the area of the bottom outlet is small relative to the cross-sectional area of upper portions of the hopper, the force on the paving material exiting through the bottom outlet will be relatively high, causing compression of the material and avoiding the use of separate compression devices. The pressure increase may be approximated using Bernoulli’s equation, which indicates that for a fluid in flow, the pressure in the fluid will increase as it passes through a constriction. It will be understood that in order to achieve this effect, it is not necessary for the entire height of the hopper to taper towards the bottom outlet, nor is it necessary for the taper to be constant. Thus in some embodiments only a portion of the hopper will be tapered. In some embodiments the tapering will vary in pitch at different heights in the hopper. The taper in the hopper may be variable. Thus a mechanism (e.g. an electrically powered screw mechanism or a hydraulically powered cylinder mechanism) may be provided for varying the taper of the hopper. The taper may be variable as the formable material is being laid on the surface. The compression applied to the formable material as it passes through the hopper is thought to vary with the taper of the hopper. It will also vary with the depth of the flowable material in the hopper. Thus it may be beneficial to vary the taper to compensate for the varying depth as the material is laid so as to maintain an approximately constant degree of compres-

sion and therefore a relatively constant set of properties of the material once set or cured. In some embodiments the taper is fixed.

**[0067]** It should be noted that in this specification, where the context suggests such, the term “cylinder” may encompass a combination of a cylinder and a piston which moves in that cylinder. These may be used in various places in the paver for operating components, for example (as in FIG. 19) for raising and lowering the hopper and (as in FIG. 14) for operating the closure panel. It should be recognised that the cylinders of the finishing devices, described earlier, are not cylinder/piston combinations, as they operate by rotation rather than by extension/retraction.

**[0068]** The slip-form paver may be self-propelled. It may have a motor for driving the paver. It may comprise a cabin area for accommodating a driver who drives the paver in use. The cabin area may comprise a control module for controlling the operation of the paver. These may conveniently be mounted behind the hopper. They may be attached to the hopper or to the hopper assembly. It may be detachable therefrom by means of easily separable links.

**[0069]** The hopper assembly may be mounted on, and attached to, a propulsion module. An example of a suitable attachment mechanism comprises one or more posts and one or more sleeves, wherein the posts are disposed to fit inside the sleeves. The posts may form part of the propulsion module and the sleeves may form part of the hopper assembly. Alternatively the posts may form part of the hopper assembly and the sleeves may form part of the propulsion module. Alternatively, one or more posts and one or more sleeves may form part of the hopper assembly and the sleeves corresponding to the one or more posts and the posts corresponding to the one or more sleeves may form part of the propulsion module. In one example, the hopper assembly comprises three sleeves on either side, and the propulsion module comprises three posts on either side, disposed so that all six posts can simultaneously be inserted into the six sleeves. The sleeves may be lubricated so as to reduce wear due to movement of the posts therein. The sleeves may be larger than required for accommodating the posts, so as to allow for tilting of the hopper relative to the propulsion module. This may be required in cases where the substrate on which the formable material is laid is uneven in a transverse direction and it is desired to lay the flowable material such that its surface is horizontal in the transverse direction.

**[0070]** As noted above, the propulsion unit may be used with different hopper assemblies, in particular with hopper assemblies of different widths, so as to allow laying of different widths of formable material. The propulsion unit may have adjustable width. It may comprise a width adjustor. Thus it may comprise transverse beams and locking mechanisms (e.g. locking pins) so that the transverse distance between the tracks and/or wheels may be varied. This enables hopper assemblies of different widths to be mounted on the same propulsion unit.

**[0071]** The paver may have steerable crawler tracks on each side thereof for propelling the paver. Alternatively or additionally it may have wheels for propelling the paver. The wheels or tracks may comprise a rubber surface for contacting the surface on which the paver moves. The wheels and/or tracks may be coupled to the motor so as to propel the paver. The crawler tracks may be independently height adjustable so as to adjust the height of the paver (in particular of the slip-
form mould above the ground. This may be used to adjust the thickness of the layer or cross fall of paving material laid on the surface.

In some embodiments the slip-form paver is not self-propelled. In this case, it may be fitted with skids or slides for moving along a surface. It may be adapted to be dragged or drawn, e.g., by a motorised vehicle, so as to move along the surface in use.

The bottom outlet may be closable so as to substantially prevent formable paving material in the hopper from passing through the bottom outlet. This enables the hopper to be filled to a desired level with the paving material prior to commencing applying it to the surface. The bottom outlet may be openable so as to allow formable paving material in the hopper to pass through the bottom outlet. Thus, when starting to lay the formable paving material on the surface, the bottom outlet would commonly be initially in a closed position, allowing the hopper to be filled. The bottom outlet would then be opened and the paver propelled across the surface so as to allow the paving material to exit the hopper and be applied to the surface. The bottom outlet may be closable and openable by means of a closure panel which is locatable across said bottom outlet so as to close or open the bottom outlet. The closure panel may for example slide horizontally so as to close or open the bottom outlet. It may alternatively rotate about an axis along the width of the bottom outlet so as to close or open the bottom outlet. It may be remotely operable or may be locally operable. It may be motorised so as to be operable by an operator driving or operating the paver. The closure panel may be remotely operable. It may be remotely controllable. It may be electrically controllable. It may be operable by means of a cylinder or ram. The cylinder or ram may pass across the bottom outlet, optionally within a sleeve, so as to enable movement of the closure panel. The cylinder or ram may be disposed so that when the bottom outlet is open, the closure panel is located forward of the bottom outlet, and when closing the bottom outlet, the closure panel is withdrawn in a rearward direction so as to close the bottom outlet. The sleeve may have a substantially circular cross-section. It may have a cross-section that is an ellipse having a substantially vertical major axis. It may have a cross section approximating an ellipse having a substantially vertical major axis but having a pointed upper end (and optionally also a pointed lower end). It may have an invertd teardrop type cross section. It may have a streamlined cross section. Such cross sections may facilitate flow of the formable material around the sleeve when the paver is laying the formable material.

As the pressure at the bottom outlet of the hopper is at least in part due to the paving material in the hopper and the quality of the paving material applied to the surface is dependent on the compression applied to the paving material, it is important that during the application of the paving material to the surface, the depth of the paving material in the hopper is kept substantially constant. In order to achieve this, it is necessary to continuously supply the paving material to the hopper during use, at substantially the same rate as the paving material is applied to the surface.

The slip-form paver may comprise a source of said formable material for supplying the formable material to the hopper, so that the hopper is continuously topped up from a source integral with the paver. The source may comprise a reservoir for storing the formable paving material or a mixer for forming, e.g., mixing or batching, the formable paving material. Thus in one embodiment a cement mixer is integral with the paver, and the mixed cement from the mixer is continuously supplied to the hopper. In some embodiments of the invention the source of the formable material is provided separately from the paver so that, in use, the source (either reservoir or mixer) travels with or alongside the paver so as to provide the formable paving material to the paver, in particular to the hopper.

In order to ensure that the level of the paving material in the hopper remains substantially constant during use of the paver, there may be a level control mechanism. This may comprise a detector for detecting the level of the formable paving material in the hopper. The detector may be a mechanical detector, e.g., a float, or may be an optical detector, e.g., a laser detector, or may be some other type of detector. The detector may be coupled to the formable paving material so as to provide a level signal thereto. The level signal may then be used, e.g., by a data processor, to control the source so as to ensure the correct delivery rate of paving material to maintain a substantially constant level in the hopper.

The bottom outlet may include a reverse taper to provide further compression of the formable paving material on entering the slip-form mould. The term "slip-form" refers to a form that slips over the material at different speeds. The slip forming may be constant slip forming or may be time delayed slip forming. The reverse taper may be at an angle of about 45° to the horizontal, or about 30 to about 60° to the horizontal, or about 30 to 45, 45 to 60 or 40 top 50°, e.g., about 30, 35, 40, 450, 50, 55 or 60°. The slip-form paver may comprise a slip-form upper screed plate extending back from the bottom outlet and sloped downward toward the rear of said paver so as to provide further compression of the formable paving material during placement on the surface. In the present specification, the terms "front", "rear" and related terms refer to a direction or location relative to the motion of the paver during normal operation. Similarly the terms such as "front", "forward" and the like also refer to a direction or location relative to the motion of the paver during normal operation. Also, the term "transverse" refers to a direction across or approximately at right angles (in a substantially horizontal plane) to the motion of the paver during normal operation, and "longitudinal" refers to a direction substantially parallel to the direction of motion of the paver during normal operation. The upper screed plate commonly extends at least the full width of the slip-form mould, and may extend beyond the outer boundaries thereof. The screed plate is preferably located rearwards from the bottom outlet, and from the reverse taper thereof if present. The rear edge of the upper screed plate may be at a height which defines the thickness of the paving material that is laid on the surface. It may for example be at a height of about 50 to about 500 mm above the surface, or about 50 to 250, 50 to 100, 100 to 500, 200 to 500, 100 to 300 or 100 to 200 mm, e.g., about 50, 100, 150, 200, 250, 300, 350, 400, 450 or 500 mm. In some cases it may be less than about 50 mm, e.g., 45, 40, 35, 30, 25, 20, 15 or 10 mm. The height of the edge above the surface may approximately define the thickness of the paving material, however due to viscoelastic effects in the paving material, the paving material may expand somewhat, leading to a greater thickness, or it may flow somewhat, leading to a smaller thickness. These effects will be characteristic of the particular paving material and its viscoelastic properties. The pitch of the upper screed plate (i.e., its angle relative to the surface) affects the degree of compression afforded thereby. Thus a steeper pitch
will generally provide a greater degree of compression and a flatter pitch will provide a lesser degree of compression. The pitch may be between about 5 and about 30° or it may be about 5 to 20, 5 to 10, 10 to 30, 20 to 30 or 10 to 20°, e.g., about 5, 10, 15, 20, 25 or 30°. The height and pitch of the screed plate may be fixed or they may be variable. They may be variable so as to vary the degree of compression and the thickness of the paving material laid on the surface. They may be manually variable, or they may be variable by means of a motor controllable, for example, by an operator of the paver from a control panel. The paver may comprise side forming panels which are angled inwardly towards the rear of the paver so as to provide further compression and/or width control to the formable paving material during placement on the surface. The inward angle may control the degree of additional compression provided by the side forming panels. The inward angle is defined as the angle of the side forming panels to the direction of movement of the paver in operation. A larger angle will provide a higher degree of compression and a smaller angle will provide a lower degree of compression. The width between the rear edges of the side forming panels on either side may control the ultimate width of the paving material laid on the surface. Similarly to the description above in connection with the upper screed plate, the width between the rear edges may be greater or less than the actual width of the paving material laid, due to viscoelastic effects in the paving material. The angle of the side forming panels may, independently, be between about 5 and about 30° or it may be about 5 to 20, 5 to 10, 10 to 30, 20 to 30 or 10 to 20°, e.g., about 5, 10, 15, 20, 25 or 30°. The width between the rear edges of the side forming panels is commonly about 1 to about 10 m, and may be about 1 and 5, 1 and 2, 2 and 10, 5 and 10, 3 and 8 or 5 and 7 m, e.g., about 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 m, depending largely on the desired width of paving. The side forming panels may be located rearwards of the screed plate. They may be located in approximately the same longitudinal location as the screed plate (i.e., at about the same distance from the bottom outlet of the hopper). In some cases they may be located forward of the screed plate. The locations in this case may refer in particular to the rear edges of the side forming panels and the screed plate.

[0078] Either the side forming panels or the screed plate or both may be adjustable (either in pitch, angle or position or any two or all of these) during operation of the paver, i.e., during laying of the paving material of the surface. This may be used in order to vary the compression on the paving material and/or to vary the thickness and/or width of the paving material on the surface. The control of these parameters may be controllable remotely by an operator operating the paver.

[0079] The slip-form paver may additionally comprise a liquid dispenser for dispensing a liquid (e.g., water) onto the surface of the formable paving material as and/or after said material is applied to the surface. This may serve to provide a seal and/or may serve to provide a smooth and/or even surface to the paving material. Provision of a small amount of liquid on the surface of the paving material before setting may serve to assist in finishing to a smooth surface. The liquid may be provided as a spray, whereby dispenser would comprise a spray head. The liquid may be provided from a plurality of apertures along the dispenser. The dispenser may be designed to provide liquid to substantially the entire width of the paving material.

[0080] The slip-form paver may additionally comprise a vibrator for vibrating the formable paving material as and/or after said material is applied to the surface. The vibrator may assist in compressing and/or settling the paving material. It may assist in bringing up a paste or cream to the surface to assist in finishing. The vibrator may be located so as to vibrate the paving material prior to its compression by the screed plate and/or prior to its compression by the side forming panels, or it may be located so as to vibrate the paving material after either one or both of these.

[0081] The slip-form paver may additionally comprise one or more surface finishing devices. One suitable such surface finishing device comprises (1) a cylinder disposed transversely across the paver at a height so as to contact the surface of the formable paving material as and/or after said material is applied to the surface and (2) a rotation mechanism for rotating the cylinder in a clockwise direction when viewed from the left side of the paver. The surface finishing device(s) may be located behind the side forming panels or behind the screed plate or both. It (they) may be located in front of the liquid dispenser or may be located behind the liquid dispenser. The cylinder(s) may extend at least the full width of the slip-form mould so as to finish the surface of the entire paving material applied to the surface. As the paving material is applied to the surface (optionally at least in part due to vibration from the vibrator), a layer of relatively thin slurry or cream may form on the surface of the paving material. The cylinder is preferably located so as to just touching the surface of the paving material as laid or slightly lower (e.g. 1-2 mm lower). This causes the cylinder to push into the surface of the paving material, thereby closing pinholes that may have formed therein, in order to improve the quality (smoothness, integrity) of the surface of the paving material. As noted above, in operation the cylinder rotates in a clockwise direction when viewed from the left of the paver, so as to push into the surface of the paving material. Thus the lower portion of the cylinder will move forward relative to the paver and to the surface of the paving material. This gives rise to active closing of the pinholes. The slip-form paver may additionally comprise a height adjustment device for adjusting the vertical location of the cylinder, in order to ensure that the cylinder is in the correct position relative to the surface of the paving material. The height adjustment device may comprise a detector for detecting the location of the surface of the formable paving material. Thus in one embodiment the detector determines the location of the surface of the paving material, sends a signal relating to that location to a controller, which adjusts the height of the cylinder to approximately 1 mm lower (or as desired) than the surface. In some embodiments the rotation device is absent, and the cylinder is unable to rotate about its axis. The diameter of the cylinder may be about 100 to about 150 mm, or about 100 to 130, 120 to 150 or 110 to 130 mm, e.g., about 100, 110, 120, 130, 140 or 150 mm. If the cylinder is rotatable, the rotation in operation may be between about 200 and about 200 rpm, or about 200 to 400, 200 to 300, 300 to 500 or 250 to 350 rpm, e.g., about 200, 250, 300, 350, 400, 450 or 500 rpm.

[0082] Another suitable such surface finishing device comprises an imprint device as to give the surface a desired effect. This may be in the form of a second cylinder having the desired imprint on the surface thereof. This may also be rotatable. In the event that both of the above finishing devices are used, the imprint device may be located rearwards of the other finishing device.
The slip-form paver may additionally comprise one or more reinforcement dispensers for dispensing a reinforcing material in the formable paving material as said paving material is located on the surface. The reinforcing material may comprise any suitable tensile element, e.g., strapping. The reinforcing material may be metallic reinforcement and/or synthetic reinforcement. The reinforcing material may be laid in the paving material as the paving material is being laid on the surface. The reinforcing material may be laid in a single strip, or it may be laid in more than one strip. Each strip may, once laid, be oriented longitudinally relative to the direction of application of the formable paving material to the substrate. In the event that more than one strip is laid, each may comprise the same material, or they may comprise different materials. Thus for example, they may be composed of a synthetic polymeric reinforcing strip, or one or more may comprise a synthetic polymeric reinforcing strip and another one or more may comprise a metallic reinforcing strip. If more than one strip is laid they may be laid in parallel. They may be laid side by side. They may be laid at intervals of about 50 to about 500 mm, or about 100 to 500, 200 to 500, 50 to 250, 50 to 100, 100 to 300 or 150 to 250 mm, e.g., about 50, 100, 150, 200, 250, 300, 350, 400, 450 or 500 mm, depending in part on the width of each strip and on the degree of reinforcement required. For example, the paver may be set up to dispense the strip at horizontal intervals of 200 mm. Thus side by side a 1.5 m form would have 7 rows of strip, a 3 m form would have 14 to 15 rows of strip and a 6 m form would have about 30 strips.

The formable paving material may be high slump. It may be low slump. It may be no slump. In the present context, the term “formable paving material” does not imply that the material flows under gravity, and merely indicates that under suitable pressure it is capable of flowing. The formable paving material may be capable of flowing under gravity with no additional pressure applied, although it is not necessary that this be the case. The formable paving material may be a granular non-consolidating material or a granular self-hardening material. It may be a high slump paving material. It may have a slump of up to about 150 mm, or up to about 120, 100, 80 or 50 mm, or about 50 to about 150 mm, or about 50 to 100, 100 to 150 or 80 to 120 mm, e.g., about 50, 60, 70, 80, 90, 100, 110, 120, 130, 140 or 150. The apparatus and method may be applicable to lower slump (e.g. 10, 20, 30 or 40 mm) materials, and in some cases to materials having slump greater than 150 mm. The formable paving material is preferably a hardenable or curable or settable material, so that once it has been applied to the surface as described herein, it hardens to a solid mass. It may set, cure or harden in between about 0.5 hours and about 1 week or even longer, depending on the nature of the material and the conditions (temperature, humidity etc.). Suitable materials include concrete, porous concretes, pervious concretes and other mineral based filled curable systems. Commonly concretes usable in the present invention have relatively high slump (e.g. greater than about 80 mm) however pervious concretes, such as those described in Australian provisional patent application no. 20089053992 (Curable dry blend) may also be used when they have low (e.g. less than about 50 mm) or zero slump. Thus the paver may be used in conjunction with a curable dry blend comprising a particulate filler having a void rate of about 20 to about 50% and a binder capable of binding particles of the particulate filler to form a solid mass. Suitable fillers include graded pulverised glass. An example of a formulation for such a material is:

| binder: Portland cement type 1 | 360 kg-white or offwhite cement or Portland types 2, 3, 4 or 5 may also be used. |
| Particulate filler: 2 mm graded fines | 1619.6 kg-sand at a calculated void rate of 40% |
| Retardant: tartaric acid | 0.4 kg |
| Pigment: iron oxide | 21.4 kg |

In a suitable process for making the dry blend, 50% of the filler and 50% of the binder was blended in to a homogeneous mix. The pigment and retardant were then added and batch rebled. The remainder of the filler and the binder were then added to and then final blend of total volume was then conducted. The dry blend may be combined with a suitable quantity of water, aqueous liquid or other curing agent to produce the formable material used in the present invention.

In some embodiments the paver of the invention is modular. In such embodiments, the paver comprises a propulsion module and a hopper assembly, wherein the hopper assembly is mounted on the propulsion module. The propulsion module commonly comprises any electronic components required for control of the paver and is adapted to accept hopper assemblies of different sizes so as to be capable of delivering different widths of paving material to the surface. The propulsion module may be fitted with a motor for propelling the paver as it delivers the paving material to the surface. The motor should be sufficiently strong to be capable of propelling the largest desired hopper assembly when full of paving material at a desired speed. The connection (mechanical, electrical, hydraulic, pneumatic etc.) between the propulsion module and the hopper assembly may be designed to connect and disconnect rapidly so as to allow rapid changeover of hopper assemblies. For example, a 2 m wide paver may be converted into a 3 m wide paver in about 30 minutes by disconnecting the hydraulics and electronics by means of quick disconnect couplings, lifting off the power plant, disconnecting the rams (if present), lifting off the 2 m hopper assembly and lowering the 3 m hopper assembly onto the propulsion module. The quick connect couplings for the electronics and hydraulics are then reconnected so as to prepare the paver for use. The hopper assembly may be coupled to the propulsion module by means of clamps or bolts or by means of complementary fittings or by some other means so as to secure the hopper assembly firmly to the propulsion module.

As described variously herein, certain parts of the slip-form paver are adjustable. For example the propulsion of the paver is controllable (start/stop, speed, direction), the bottom outlet may be closable, e.g. by means of an operable closure panel, the side forming panels may be adjustable in separation and angle, the upper screed plate may be adjustable in height and pitch etc. Each of the controllable and/or adjustable parts may, independently, be locally adjustable or may be remotely adjustable. They may be adjustable by means of a control panel. The control panel may be mounted on the slip-form paver, optionally on a propulsion module thereof (e.g. in an operator's console), or it may be separate from the slip-form paver. For example a control panel may be part of a control module that enables the slip-form paver to be operated by an operator remote from the paver, e.g. located on the ground near the paver. If the control panel is remote from the slip-form paver, it is preferable that the control be electrical or electronic. In the event that it is not remote from the
paver (either locally adjustable or adjustable by means of a control module on the paver) the control may be mechanical or it may be electrical or electronic. In particular, local control of parts may be mechanical, for example, the bottom outlet may be closable by means of a manually operated closure panel, or by means of an electrically operated closure panel. In the latter case, the control may be remote or it may be local. In the present context, “mechanical” control may also incorporate hydraulic and pneumatic controls.

The paver may comprise a height adjustor for adjusting the height of the screed hopper assembly so as to adjust the thickness of the paving material on the surface. The height adjustor may be a hydraulic cylinder, e.g. a hydraulic ram. Alternatively it may be a continuous screw threaded adjustor powered by an electric motor. It may be located on the propulsion unit or chassis, and may be coupled to the hopper assembly so as to be capable of raising the hopper assembly (when a piston in the cylinder, or the screw threaded adjustor, extends) or lowering the hopper assembly (when the piston, or the screw threaded adjustor, retracts). Commonly the height adjustor is located at or near the centre of gravity of the hopper, or of the hopper assembly, in a longitudinal direction (i.e. in the direction of movement of the paver). There may be more than one height adjustor. In this case they may be independently controllable. There may for example be a height adjustor, optionally an independently controllable height adjustor (e.g. hydraulic cylinder), on either side of the hopper.

The paver may comprise a height detector for detecting the height of the hopper above the surface. The height detector may be an optical detector, a laser detector, a mechanical detector or some other suitable detector. The detector may be coupled to a controller for controlling the height adjustor. This enables the detector to provide a feedback signal to the controller, which can provide a control signal to the height adjustor. In this manner, a predetermined profile of the formable material may be laid. For example a horizontal formable material surface may be provided even when the surface on which the formable material is laid is not horizontal, or is uneven (either longitudinally, transversely or both).

The method and apparatus described herein allows the formable paving material to be applied in a single pass, including any required compression and/or compaction, thereby saving time and cost relative to the multipass methods described in the background. The paver described herein is capable of applying the formable paving material to the surface at a rate of about 10 m/min, or at least about 12, 15 or 18 m/min, or about 1 to about 25 m/min, or about 1 to 20, 1 to 15, 1 to 10, 1 to 5, 5 to 15, 5 to 10, 10 to 8, 5 to 25, 10 to 25, 15 to 25, 10 to 20 or 15 to 20 m/min, e.g. about 1, 2, 3, 4, 5, 10, 15, 20 or 25 m/min. The paving material may be applied to the surface at a width of about 1 to 10 m, or between about 1 and 5, 1 and 2, 2 and 10, 5 and 10, 5 and 8 or 5 and 7 m, e.g. about 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 m. It may be applied in a thickness of about 50 to about 500 mm, or about 50 to 250, 50 to 100, 100 to 300, 200 to 300, 300 to 300, 100 to 300 or 100 to 200 mm, e.g. about 50, 100, 150, 200, 250, 300, 350, 400, 450 or 500 mm. The method and apparatus may allow laying of the formable paving material of up to about 5 km/day, or up to about 1, 2, 3 or 4 km/day, e.g. about 1, 2, 3, 4 or 5 km/day.

In operation the paver of the present invention may be used in conjunction with one or more other devices. In some cases, a single pass by several machines may enable a single pass preparation of ground and laying the formable material. In one example, a first machine, an excavator, excavates a path for laying the formable material. This may for example excavate so as to provide a smooth base for laying the formable material. A second machine may optionally lay an aggregate in the excavated path. In such cases, the aggregate should be laid with a percentage voids and depth such that the void volume of the aggregate is greater than that of the formable material. This is particularly valuable in cases where the formable material sets or cures to a porous solid. In such cases, water impacting on the porous solid can pass through to the aggregate, which can act as a reservoir to allow the water to drain into the underlying soil. In this way, the surface of the porous solid (e.g. a path, roadway etc.) can remain relatively dry when water impinges thereon, e.g. during rain periods. Following the second machine (if present) the slip-form paver may then lay the formable material on the aggregate (if present) or on the excavated path (if no aggregate is used). A source of the formable material, e.g. a mixer for blending or compounding the formable material, may either follow the paver or may move alongside it, so as to provide a continuous supply of the flowable material to the hopper of the paver. In this way, the virgin ground may be prepared and provided with a fully formed and compacted layer of flowable material, which may then cure or set to a hard, optionally pervious, solid path, roadway or other synthetic surface.

In some embodiments of the invention the paver is capable of laying more than one formable material simultaneously. For example, it may be capable of laying a first colour and a second colour side by side. An example of this is where a local authority wishes to have a shared cycleway where the cyclists’ portion of the path is green concrete and the pedestrian section is a regular grey concrete. Another example is where it is desired to lay a lower layer of unpigmented (and hence less expensive) material below, and an upper layer of pigmented material above, so as to provide a pigmented surface at reduced cost. The present invention enables such options to be formed in a single pass. This may be achieved by use of a divider in the hopper. The divider should be disposed substantially vertically in the hopper. The divider may separate the hopper into two or more hopper compartments, each of which may be loaded with a different formable material (or optionally with the same flowable material). The divider may extend as far as the bottom outlet. It may extend through the bottom outlet and at least part way along the upper screed plate. It may terminate at the bottom outlet so as to allow the closure panel to close the bottom outlet. In the event that the paver is to lay two different formable materials side by side (e.g. different colours), the divider should be oriented substantially longitudinally in the hopper. In the event that the paver is to lay two different formable materials with a first material above a second material, the divider should be oriented transversely in the hopper. In the latter case, the first material should be in the rear hopper compartment and the second material should be in the forward hopper compartment.

In some applications there may be a need to pour two or more distinct sections of formable material in one pass. These sections may for example form part of a driveway that has a grass section between the two parallel driving surfaces on which the tyres of a vehicle driving on the driveway are intended to run. To achieve this, a separator (or more than one separator) may be located in the hopper. In one example, the
A self propelled slip-form paver of the type referred to is disclosed herein, said paver including a feed hopper for directing a flowable paving material, granular non consolidating, or granular self hardening material through a bottom outlet and into a slip-form mould mounted below wherein the walls of said hopper converge inwardly towards the bottom in a manner such that the weight of the material passing through is directed towards and concentrated at said outlet to compress, compact and/or consolidate said material into the slip-forming mould (alternatively referred to as slip-form mould) without the need for any mechanical intervention in the said material.

Preferably said material is concrete, including pervious and porous types or natural granular materials. It is further preferred that the outlet includes a reverse taper to reduce or prevent ripping of low slump concretes and to provide a secondary compression of said concrete on entering the mould. It is further preferred that the slip-form upper screed plate extending back from the hopper outlet is sloped downward to provide a third stage compression of the said material against the side forms of the mould during placement. It is further preferred that said slip-form paver is propelled by steerable, optionally independently height adjustable crawler tracks on each side. The slip-form paver may have a height adjustment so as to be capable of varying the thickness of the paving material dispensed.

Referring first to FIGS. 1 to 3 the slip-form paver may comprise a rectilinear modular chassis 1 with side drive assemblies in the form of steerable crawler tracks 2. A mould 2A comprising sliding sideforms 3 and upper screed plate 4 is mounted below said chassis and is configured for slip-forming concrete into a predetermined shape and thickness for a paved road surface or the like. An upright hopper 5 is mounted directly above and on top of the mould to provide a continuous supply of concrete for the paving operation. With this embodiment the hopper is preferably formed as one piece with the mould. In use the hopper is continuously supplied with fresh ready mixed concrete, or other described materials. An operator's console 6 is located above the rear of the form at an elevated position from which the operation and progress of the paver can be monitored and controlled. In some embodiments of the invention the operator's console is not present. In that case it is preferable to provide the paver with a receiver so as to enable an operator to direct the machine from elsewhere by use of a remote controlled device. The paver may therefore also be adapted for fully remote operation through radio control where user input is capable or where said invention is capable of fully or partially autonomous function by means of additional technology. An internal combustion engine (in this embodiment a 4 cylinder diesel engine) in conjunction with hydraulic pump(s) (not shown) is mounted below the operator's console. This functions to provide motive power for the tracks through individual hydraulic motors on each crawler track and to otherwise operate the various systems of the paver as described hereunder.

The vertical height and angle of cross fall of the slip-form mould and hopper with respect to the ground engaging crawler tracks is adjustable by means of separate hydraulic cylinders 7 on each side. These act between the track frame and the outside of the hopper 5 as shown in FIG. 3. To maintain vertical alignment there are also three vertical guide sleeves 8 welded to each side of the hopper which slide over correspondingly placed vertical rods (or elements) 9 extending up from the track chassis. Although only one side of the paver is shown in FIG. 3 the arrangement on the opposite side is identical. With this embodiment the hydraulic cylinders 7 on each side may be operated independently whereby the orientation of the hopper and slip-form mould 2A can also be adjusted for variations in both grade and cross fall. It is also possible with the described arrangement for the paver to place materials below the grade of non excavated areas on both side of extrusion. It may be possible to pave with an indentation in the ground, e.g. in a ditch. The final surface of the paving material may be above the level of the surrounding ground, or may be level with the level of the surrounding ground, or may be below the level of the surrounding ground.

In accordance with the invention and as best shown in FIG. 4 opposite inside walls 10 and 11 of the hopper 5 are sloped to converge to a rectangular outlet 12. On wall 10 the slope down to the outlet 12 is substantially constant at about 45 degrees. The opposite wall 11 slopes in two stages. Initially near the upper edge 13 of the hopper it is steeply inclined at about 80 degrees to the horizontal. Near the bottom adjacent the outlet 12 the slope decreases to about 45 degrees from the horizontal. The effect of this wall configuration is to concentrate the weight of the granular material, semifluid or wet concrete in the hopper 2A that it is directed towards the outlet 12 and consolidated both before it enters the slip-form mould via said outlet and during the final extrusion stage 2A below.

The basic operation of the paver is to drive the crawler tracks 2 so that they straddle and travel along the length of the area to be paved. Materials from the hopper 5 are then progressively delivered under pressure of its own weight through the outlet 12 and into the slip-form mould 2A. The concrete or other described material is thereby placed onto a roadway or the like in a relatively even and level mass. The mould sideforms 3 and screed top plate 4 compress and shape the surfaces of the slab during this placement operation.

In FIG. 4 the hopper is shown empty and the outlet 12 is in its closed configuration with a horizontal sliding plate 14 across it. In operation when the hopper is supplied with material the plate is slid forwards and out from under the outlet 12 by a hydraulic cylinder 15 housed in a protective tube 16 as best shown in FIG. 5. This allows the material to flow under its own weight down into the mould 2A.

Although not shown an inside lip 12A of the hopper outlet 12 is preferably formed with a reverse taper. This provides an additional secondary downward compression of
the material as it enters the mould 2A and also prevents or reduces ripping of low slump mixes. A further third stage compaction/consolidation of the material is obtained by the downward slope of the screed top plate 4 as it passes over the preformed extrusion and compresses it out against the side-forms 3 while finishing the surface. With this embodiment of the invention the downward slope of the screed plate may be of the order of about 15 mm over the length of said plate. Other degrees of slope may however be used according to design requirements.

[0102] As best shown in FIG. 2 electrically powered vibrators 17 are also attached to the top of the screed plate 4. These further consolidate the material and assist in the surfacing of the extrusion by means of the finishing screed. They also assist the dissipation of entrapped air of the mix.

[0103] Any suitable form of coupling device may also be fitted to the rear of the screed or frame to enable attachment or towing of additional apparatus or machinery for further special surface finishing of the slab such as brooming, imprinting and or coving.

[0104] The features described in FIGS. 1 to 5 are shown in more detail in later figures.

[0105] It will thus be appreciated that this invention at least in the form of the embodiment disclosed provides a novel and improved form of slip-form paver. Clearly however the example described is only the currently preferred form of the invention and a wide variety of modifications may be made which would be apparent to a person skilled in the art. For example the configuration of the tractor chassis, hopper and control console may change following further testing and development by the inventors. The shape, orientation and dimensions of the slip-form mould may also be varied in accordance with specific paving applications.

[0106] Referring to FIG. 6 (which is not drawn to scale), paver 600 comprises feed hopper 602 which converges inwardly towards bottom outlet 604. Bottom outlet 604 is fitted with closure panel 606 which is driven by a pneumatic cylinder (not shown) inside tube 608. In FIG. 6 closure panel 606 is shown in the position where bottom outlet 604 is to open, however operation of the pneumatic cylinder is capable of retracting panel 606 as to close outlet 604 and prevent formable mixture in hopper 602 from passing through outlet 604. Thus when bottom outlet 604 is closed, paver 600 is capable of transporting formable mixture in hopper 602 without dispensing it, and when bottom outlet 604 is open, paver 600 is capable of laying the formable mixture on surface 610. Bottom outlet 604 is fitted with reverse taper 612, which inhibits “ripping” of the formable mixture as it is laid. Reverse taper 612 is integral with the walls of hopper 602. Slip-form upper screed plate 614 is located rearwards of taper 612, and is sloped downwards towards the rear, so as to provide additional compression to the formable material as it is being laid. Hopper 602, bottom outlet 604, closure panel 606, tube 606 having the hydraulic (or pneumatic) cylinder therein, reverse taper 612 and screed 614 all may form parts of a hopper assembly. The hopper assembly is height adjustable by means of one hydraulic cylinder on either side of hopper 602 (the cylinders are not shown in FIG. 6 for reasons of clarity). It is coupled to the propulsion module of the paver 600 by means of posts on the propulsion module and corresponding sleeves on the hopper assembly. These are also not shown in FIG. 6 for reasons of clarity, but are shown in detail in later figures. Side forming panel 616 is shown, and should be seen to be on the far side of paver 600 as viewed in FIG. 6 (i.e. on the far side of the formable material that is passing through paver 600 in operation). It is sloped slightly inwards towards the rear (i.e. the rear end is slightly closer to the viewer in FIG. 6 than the forward end), so as also to provide additional compression to the formable material as it is being laid. A corresponding side forming panel is also present on the close side of paver 600, but is not shown in FIG. 6 for reasons of clarity. Rearwards of screed panel 614 is finishing cylinder 620. Cylinder 620 is capable of being driven by a motor (not shown) so as to rotate in a clockwise direction as viewed in FIG. 6.

[0107] Control unit 618 is provided for controlling the operations of the paver. It may have allowance for an operator, or may be controllable remotely. The control unit comprises electric motors etc. for providing power and/or control to the various functions of the paver, including height adjustment for the hopper assembly, opening/closure of bottom outlet 604, operation of tracks 622 for propulsion of paver 600 etc. It is attached to (and detachable from) the hopper assembly, and is capable of being reattached to a different hopper assembly for control thereof. Tracks 622, showed partly in dashed lines in FIG. 6, form part of the propulsion module of paver 600, and are attached to a chassis (not shown).

[0108] Under the taper of hopper 602 is the reinforcement storage location, in which a roll 624 of reinforcement is located. Reinforcement dispenser 626 is a tube which passes to a region below screed plate 614 and through which the reinforcement is fed.

[0109] Vibrator 628 is located on reverse taper 612, so as to vibrate taper 612.

[0110] In operation of paver 600, hopper 602 is loaded with the formable paving material. When paver 600 is in a desired location, a hydraulic (or pneumatic) cylinder opens bottom outlet 604 by moving panel 606 forwards (i.e. to the left as viewed in FIG. 6). Tracks 622 drive paver 600 forwards (to the left as viewed in FIG. 6). The formable material 630 in hopper 602 then passes down through the taper of hopper 602, becoming increasingly compressed during that passage. It then passes out of bottom outlet 604 and around tube 608. As the formable material reaches the ground, the movement of paver 600 forwards causes the material to be compressed further, both between the two side forming panels 616 and between the screed panel 614 and surface 610. Reinforcement from roll 624 passes through tube 626 and is inserted into the formable material as it exits from tube 626. The reinforcement may be dragged from roll 624 by the formable material, or it may be propelled by a motor (not shown) attached to roll 624. As paver 600 progresses (in a leftward direction as shown in FIG. 6), cylinder 620 is maintained on the surface of the laid material, rotating in a clockwise direction. This causes a smooth surface to form on the laid material. Also, vibration of reverse taper 612 by means of vibrator 628 causes a less viscous portion of the material to accumulate on the surface of the laid material, thus facilitating the smoothing, and also reduction of pinholes, by cylinder 620.

[0111] In this manner, a smooth, even layer of reinforced paving material is formed on surface 610 in a single pass.

[0112] FIG. 7 shows options in regard to the hopper of the slip-form paver.

[0113] FIG. 7a shows a hopper having a separator so as to be capable of laying two strips of the formable material separated by a strip with no flowable material, for example for use in a driveway. Thus in FIG. 7a, hopper 705 is viewed from behind. Bottom outlet 710 extends for the full length of hop-
per 705. Separator 715, in the form of an inverted V is located in bottom outlet 710 such that it allows outlet 710 to be closed using a closure plate in 7a (not shown). It extends fully from front to back of the inside of hopper 705. Parallel directing plates 720 extend downwards to the surface or near the surface of the ground (610 of FIG. 6) from outlet 710 and extend rearwards (i.e. out of the page as shown) so as to extend to a region beneath the screw plate of the paver. Cylinder 725, used for operating the closure plate, may be conveniently located beneath separator 715. In this case, there may under certain circumstances be no requirement for a protective tube surrounding cylinder 725 as it is protected from the formable material by separator 715. In particular, if no closure plate is used then separator 715 and directing plates 720 may be connected by means of overlapping steel plates that would be bolted together, or they may be formed as one single plate steel assembly. Furthermore, reinforcing members may be present between both vertical members 720 so as to reinforce plates 720. Side forming panels 770 are shown, forming part of the slip form mould, to form and further consolidate the formable material.

[0114] In operation, formable material passes from hopper 705 and past separator 715, which causes the formable material to separate into two streams. These streams flow out of outlet 710 to either side of plates 720, which define an unpaved section between the two streams. Compression and finishing proceeds as described in relation to FIG. 6 so as to lay two parallel strips of the formable material separated by the unpaved section. Side forming panels 770 form and further consolidate the formable material.

[0115] FIG. 7b shows a hopper having a divider so as to be capable of laying two strips of different formable materials simultaneously side by side. In FIG. 7b, hopper 730 is viewed from behind. Bottom outlet 735 extends for the full length of hopper 730. Divider 740 is located in hopper 730, extending from near the top to bottom outlet 735 such that it allows outlet 735 to be closed using a closure plate (not shown). It extends fully from front to back of the inside of hopper 730 so as to divide hopper 730 into two hopper compartments 730a and 730b. Directing plate 745 extends downwards from outlet 735 and extends rearwards (i.e. out of the page as shown) so as to extend to a region beneath the screw plate of the paver. Side forming panels 770 are shown, forming part of the slip form mould, to form and further consolidate the formable material. In operation, formable material passes from hopper 730, i.e. from hopper compartments 730a and 730b past divider 740, which maintains the two streams of the formable material from the two hopper compartments separate. These streams flow to either side of plate 745. Compression and finishing proceeds as described in relation to FIG. 6 so as to lay two parallel strips of different formable materials separated by an unpaved section in a single pass. Side forming panels 770 form and further consolidate the formable material.

[0116] FIG. 7c shows a hopper having a divider so as to be capable of laying two layers of different formable materials simultaneously, one above the other. In FIG. 7c, hopper 750 is viewed from the left side, so that, in use, the paver moves from right to left of FIG. 7c. Bottom outlet 755 extends for the full width of hopper 750. Divider 753 is located in hopper 750, extending from near the top to bottom outlet 755 such that it allows outlet 750 to be closed using a closure plate (not shown). It extends fully from left to right of the inside of hopper 750 so as to divide hopper 750 into two hopper compartments 750a and 750b. Directing plate 760 extends downwards from outlet 755 and extends rearwards so as to extend to a region beneath reverse taper 612 and the screw plate 765 of the paver so as to prevent mixing and/or coalescence of the two streams of formable material. Directing plate should be located suitably to allow the two streams to contact and bond without substantial intermixing. This serves to maintain the different formable materials as distinct layers when formed and laid by the paver. In operation, formable material passes from hopper 750, i.e. from hopper compartments 750a and 750b past plate 760, which maintains the two streams of formable material, from the two hopper compartments, separate. The upper stream, from compartment 750a flows above plate 760, i.e. between plate 760 and screw 765. The lower stream, from compartment 750b flows below plate 760, i.e. between plate 760 and the ground. Compression and finishing proceeds as described in relation to FIG. 6 so as to lay two layers of the formable material one above the other. In a specific example, hopper compartment 750a contains a less expensive, unpigmented, formable material and hopper compartment 750b contains a more expensive, pigmented, formable material. The pigmented material is thus laid as the top layer. In order to vary the ratio of upper to lower layer, the positions of divider 753 and plate 760 may be altered forward or backward.

[0117] FIGS. 8 to 23 are line drawings showing different aspects of the paver. In these figures, the same numbering has been used as in FIG. 6 in cases where the feature is shown in FIG. 6. For other features, separate numbers have been used.

[0118] FIG. 8 shows track 622 which is used for locomotion of the paver. 800 is part of the main chassis of the paver (in particular of the track assembly which forms part of the propulsion module) and panel 805 is an outer stiffening plate of the track assembly onto which slide the side panels 806 of hopper 602 (these are as shown in 705 in FIG. 7a and 730 in FIG. 7b). A photograph of the track assembly, without the vertical post attached, is shown in FIG. 24. Panels 805A and 805B define a space 801 between them into which the posts may be secured. The posts are provided for attaching the hopper assembly to the propulsion module, as shown in subsequent figures. FIG. 25 is a photograph of the side of the hopper onto which are attached sleeves which fit onto the abovementioned posts for coupling the hopper to the propulsion module. FIGS. 26 and 27 are photographs which shows the posts fitted into the sleeves so as to attach the hopper to the propulsion module. Also shown in FIG. 26 is a cylinder for raising and lowering the hopper. The plates of the chassis (designated 805A and 805B in FIG. 8) can also be seen in FIGS. 26 and 27, with the posts secured between them in space 801 (of FIG. 8). In FIG. 27 a hole for hydraulic tensioning of the rubber track (622) may also be shown.

[0119] Referring again to FIG. 8, struts 803 are provided as support for the closure panel as it moves in order to open and close bottom outlet 604.

[0120] Referring to FIG. 9, bracket 810 is provided between side panel 806 of hopper 602 and support panel 815. The top ends of two adjacent sleeves 820a and 820b, to which support panel 815 is mounted, are also shown. These sleeves are for supporting the hopper assembly on the propulsion module (fitting over corresponding posts on the propulsion module), and are described in detail elsewhere. Bracket 810
has hole 825 passing therethrough. Bracket 810 forms the attachment point for attaching a height adjustor to the hopper assembly, which is used for adjusting the height of the hopper assembly above the ground in order to adjust the thickness of the formable material laid on the ground. The top end of the height adjustor has a Y-form, with holes corresponding to hole 825, so as to allow a locking pin to be inserted, thereby locking hopper 602 to the height adjustor, and hence to the propulsion module of which it forms a part.

[0121] FIG. 11 shows part of the mechanism for opening and closing bottom outlet 604. FIG. 11 is a view from the front of the paver. Hopper 602 slopes upwards towards the front of the paver. Closure panel 606 is capable of moving forward and backward along support struts 830 so as to open and close (respectively) bottom outlet 604 (not shown in FIG. 11). Hydraulic cylinder 835 is attached to panel 606, and passes through tube 608. Tube 608 passes through hopper 602, and protects cylinder 835 from the formable material in hopper 602 in use. Cylinder 835 is fixed at its far end (not shown), so that extension of the cylinder causes movement of panel 606 towards the front of the paver so as to open the bottom outlet. Side forming panels 616 are shown also in FIG. 11, extending downwards from the ends of the vertical plate that constitute the right and left sides of the hopper, so as to form and compress the sides of the formable material as it is laid on the ground.

[0122] FIG. 12 shows a rear view of the lower portion of hopper 602, including the outer portion of bottom outlet 604. Thus hopper 602 is shown tapering towards bottom outlet 604. Tube 608 is vertical plate which forms the left side of hopper 602 to which sleeves 820a and 820b are welded (as shown in FIG. 9). The lower portion of bottom outlet 604 comprises reverse taper 612, which is coupled to screw plate 614. FIG. 12 particularly shows vibrators 828, in this example located on reverse taper 612 and on screw plate 614, so as to assist in compressing and/or settling the paving material and assist in bringing up a paste or cream to the surface to assist in finishing. The vibrators may be electrically or pneumatically operated. FIG. 12 also shows hydraulic lines 840 leading to and from a hydraulically operated cylinder (not shown) which operates closure panel 606 (also known as a shutoff gate) to the bottom outlet 604. Couplings 845 are used to connect the cylinder hydraulics to the control unit. When the hopper assembly is disconnected from the control unit (for example when changing to a different hopper assembly) the couplings may be readily disconnected. They may comprise valves so as to prevent loss of hydraulic fluid from lines 840.

[0123] FIG. 13 shows left rear vertical plate 857 that attaches to the left side of hopper 602 and the final edge of upper screed plate 614 to which stiffening plate 846 is attached. Plate 857 serves to hold the rearward vibrator when needed. Plate 846 also acts as an attachment point for trailing items such as a finishing broom, coving tool and rotating pipe, shown as 620 in FIG. 6. Vertical 847d is one of the vertical supports of the power unit 618 (FIG. 6) and is also shown as the vertical member forming 860 in FIG. 14. Both items 860 have vertical members.

[0124] FIG. 14 shows a rear view of the hopper. This figure illustrates that the hopper need not be tapered over its full height. The absence of taper in the upper part of hopper 602 may serve to increase the volume of the formable material that can fit into hopper 602. Thus hopper has vertical rear panel 850 in its upper section and tapered rear panel 855 in its lower section. Reverse taper 616 and screed plate 614 have been described previously. Cylinder 835 (which operates the closure panel) is shown emerging from tube 608 as described previously. Support struts 860 are shown—these may be used to support the control unit 618 when the paver is fully assembled. Control unit 618 may be bolted onto struts 860, or fixed in some other suitable manner.

[0125] FIG. 15 shows a view from the inside of hopper 602. Hopper 602 comprises rear taper panel 855 and vertical rear panel 850, together with front taper panel 865 and side panel 870. In FIG. 15, the bottom outlet 604 is closed, with closure panel 606 located across outlet 604. FIG. 15 also shows the features shown in FIG. 9, although FIG. 16 shows the right hand side of hopper 602 whereas FIG. 9 showed the left hand side. Thus rearmost sleeve 820d and middle sleeve 820e have support panel 815 mounted thereon. Bracket 810 forms the attachment point for attaching a height adjustor to the hopper assembly, which is used for adjusting the height of the hopper assembly above the ground in order to adjust the thickness of the formable material laid on the ground. The top end of the height adjustor has a Y-form 875, the top of which may be seen in FIGS. 15 and 21, with holes corresponding to hole 825 (of FIG. 9). FIG. 15 shows locking pin 880 inserted so as to lock hopper 602 to the height adjustor, and hence to the propulsion module of which it forms a part.

[0126] FIG. 16 shows the lower region of the inside of hopper 602. This shows tapered rear panel 855 and closure panel 606. Tube 608 passes through the lower region of hopper 602 so as to protect cylinder 835 (which passes through the inside of tube 608) from the formable material in the hopper.

[0127] FIG. 17 shows another view of the vibrators shown in FIG. 12. FIG. 17 also views hopper 602 from the rear, showing rear taper panel 855, reverse taper 612 and screed plate 614. Vibrators 828 are shown attached to reverse taper 612 and screed plate 614 as described earlier. In FIG. 17, one vibrator is shown on either side of tube 608, which houses cylinder 835. Hydraulic lines 885 are shown connected to cylinder 835 for operating it, and electrical cable 890 is shown connected to one of the vibrators 828 for providing power for that. Similar electrical cables (not shown) are also attached to the other vibrators of FIG. 17.

[0128] FIG. 18 shows the inside left portion of hopper 602. Sleeves 820a and 820b, bracket 810, support panel 815 and side panel 805 have been described earlier in regard to FIG. 9. FIG. 18 also shows front sleeve 820c. Front taper panel 865 of hopper 602 is shown at a typical angle of about 45° to horizontal. This angle is sufficient to provide the desired degree of compression for most formable materials that would be used in the paver. Similarly rear taper panel 855 is shown at an angle of about 45° to horizontal in the opposite direction to panel 865, so that the angle between panels 855 and 865 is about 90°. The angles of the front and rear taper panels may be varied independently, commonly between about 30 and 60°. They may independently be, for example, 30, 35, 40, 45, 50, 55 or 60°. Rear vertical panel 850 is also shown. Panel 850 is commonly bent to a horizontal portion in order to provide additional mechanical stiffness. It is this horizontal portion of panel 850 that is indicated by the number 850 in FIG. 18. In many cases this panel will not be perfectly vertical, and may have a slight taper inwards towards bottom outlet 604, compression plate (as seen in FIG. 11 numbered 616 846) may be seen through outlet 604, which is shown as being open in FIG. 18.

[0129] FIG. 19 shows the lower section attachment of height adjustor 890. In FIG. 19, height adjustor 890 comprises cylinder 895 and piston 900, wherein piston 900 can move within cylinder 895 so as to raise or lower hopper 602. The bottom end of piston 900 is attached to Y-form 875a. Y-form 875a is locked onto bracket 810a by means of pin 880a. Bracket 810a is attached between outer chassis plate
right of picture are the three sleeves that receive the three posts. The 3 sleeves the hopper and the screed plate, as well as engine mounts form a single modular unit. The vertical plate marked with X, as well as the posts which fit into the sleeves are part of the track unit. The outer vertical plate with the X serves to prevent the track frame from falling over when doing a form change from one width to the other. From left to right can be seen the outer plate, vertical post and inner plate that are connected to the track frame. The round hole is provided in order to house the hydraulic hoses. Surrounding the smooth round disc and the notched one is the track. On the left hand side of the notched wheel is the final drive that turns the track in order to propel the paver. Ahead of the small round hole on the track frame is a tensioner for the rubber track.

[0135] FIG. 29 shows a rear view of the paver in operation. In particular, the formed and laid material in the shape of a pathway can be seen, having been laid in a single pass. The control units, hopper and tracks can be clearly seen on the paver.

[0136] FIG. 30 shows the rolls of reinforcement in the reinforcement storage location, beneath the front taper panel of the hopper. Attachments may be seen above the rolls which prevent the rolls from free spooling, and which control the dispensing of the reinforcement.

[0137] FIG. 31 shows a top down view of the inside of the hopper. The front of the hopper is towards the top of the photograph. In the centre of the photograph can be seen the housing for the cylinder which operates the closure panel, as well as the delivery tubes for the reinforcement and the supports for the closure panel.

[0138] FIG. 32 shows a view of the underside of the paver. To the far left of the photograph is the track on which the paver runs. The plate on left next to the track, with a squared corner, is the outer plate of the track assembly. Between this outer plate and the track is the vertical post which is used for coupling the hopper assembly to the propulsion module. The inner plate can not be seen as the track frame is not visible. The plate with the rounded edge (bearing an “SPM” stamp) is the front right panel of the hopper. Under this plate is where the side forming compression plate is located. The strap delivery tubes can be seen towards the right of the photograph, with the reinforcement strap from rolls in the upper right of the photograph passing through them. At the end of the visible tube is the corresponding vertical plate holding the delivery tubes for the reinforcement. This plate is positioned before the bottom right of 865 (of FIG. 15 and FIG. 18) or prior to the bottom of 862 (FIG. 11). Positioning of secondary vertical tube plate also assists in preventing concrete from rushing forward. On top of vertical plate through which the delivery tubes pass and below the rolls of synthetic reinforcement is the closure panel, viewed here from below.

1. A slip-form paver for applying a formable paving material onto a surface, said paver comprising:

- a feed hopper having a bottom outlet, said hopper being adapted for directing the formable paving material through the bottom outlet, and
- a slip-form mould mounted below said bottom outlet for receiving said formable paving material and depositing said material onto said surface, wherein said hopper converges inwardly towards the bottom outlet such that the weight of the formable paving material passing through said hopper is directed towards, and concentrated at, said bottom outlet so as to compress, compact and/or consolidate said material into the slip-form mould; and

said paver comprising a slip-form upper screed plate extending back from the bottom outlet and sloped down-
ward toward the rear of said paver so as to provide further compression of the formable paving material during placement on the surface.

2. The slip-form paver of claim 1, said paver being self-propelled.

3. The slip-form paver of claim 1, said slip-form paver having steerable crawler tracks on each side thereof for propelling said paver.

4. The slip-form paver of claim 1, said bottom outlet being closable so as to substantially prevent formable paving material in the hopper from passing through the bottom outlet and being openable so as to allow formable paving material in the hopper to pass through the bottom outlet.

5. (canceled)

6. The slip-form paver of claim 1, said paver comprising a source of said formable material for supplying the formable material to the hopper.

7. The slip-form paver of claim 6 comprising a level control mechanism for maintaining a substantially constant level of the formable paving material in the hopper.

8. The slip-form paver of claim 1 wherein the bottom outlet includes a reverse taper to provide further compression of the formable paving material on entering the slip-fom mould.

9. The slip-form paver of claim 1 wherein said paver comprises no internal mechanical intervention device.

10. The slip-form paver of claim 9 wherein the screed plate is height adjustable so as to adjust the thickness of the paving material on the surface.

11. The slip-form paver of claim 1, said slip-form paver comprising a propulsion module and a hopper assembly, said hopper assembly comprising the hopper and, if present, the slip-form upper screed plate, wherein the hopper assembly is detachable from the propulsion module.

12. The slip-form paver of claim 1 comprising side forming panels which are angled inwardly towards the rear of the paver so as to provide further compression to the formable paving material during placement on the surface.

13. The slip-form paver of claim 1 additionally comprising a liquid dispenser for dispensing liquid onto the surface of the formable paving material as and/or after said material is applied to the surface.

14. The slip-form paver of claim 1 additionally comprising a vibrator for vibrating the formable paving material as and/or after said material is applied to the surface.

15. The slip-form paver of claim 1 additionally comprising a surface finishing device, said device comprising: a cylinder disposed transversely across the paver at a height so as to contact the surface of the formable paving material as and/or after said material is applied to the surface; and a rotation mechanism for rotating the cylinder in a clockwise direction when viewed from the left side of the paver.

16. The slip-form paver of claim 15 additionally comprising a height adjustment device for adjusting the vertical location of the cylinder.

17. The slip-form paver of claim 16 wherein said height adjustment device comprises a detector for detecting the location of the surface of the formable paving material, said detected location being used during operation of the paver for determining a desired height for the cylinder.

18. (canceled)

19. The slip-form paver of claim 1 additionally comprising one or more reinforcement dispensers for dispensing a reinforcing material in the formable paving material as said paving material is deposited on the surface.

20. A method for applying a formable paving material to a surface, said method comprising: providing a slip-form paver according to claim 1; filling the hopper to a predetermined level with the formable paving material; and propelling the paver across the surface while allowing the formable paving material to pass from the hopper and into the slip-form mould, thereby compressing said paving material and locating it on the surface.

21. The method of claim 20 additionally comprising applying vertical compression to the formable paving material by means of a slip-form upper screed plate.

22. The method of claim 20 additionally comprising applying horizontal compression to the formable paving material by means of side forming panels which are angled inwardly towards the rear of the paver.

23. The method of claim 20 comprising continuously supplying the formable paving material to the hopper so as to maintain a substantially constant level of the formable paving material in the hopper.

24. The method of claim 20 additionally comprising dispensing liquid on the surface of the formable paving material as and/or after said material is applied to the surface.

25. The method of claim 20 additionally comprising vibrating the formable paving material as and/or after said material is applied to the surface.

26. The method of claim 20 wherein the paver additionally comprises a surface finishing device, said device comprising: (1) a cylinder disposed transversely across the paver at a height so as to contact the surface of the formable paving material as or after it is applied to the surface, and (2) a rotation mechanism for rotating the cylinder, said method comprising rotating said cylinder in a clockwise direction when viewed from the left side of the paver.

27. (canceled)

28. (canceled)

29. (canceled)

30. The method of claim 20, said method being a single pass method.

31. (canceled)

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