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[54] METHOD FOR PRODUCING A HARD PAVING OR
SURFACING MATERIAL
6 Claims, No Drawings

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ABSTRACT: This invention relates to a paving material and method for manufacturing the same. Specifically, the paving material comprises soil in finely divided form in a matrix or dispersion of calcium carbonate. This material is produced by blending moist soil or other relatively fine inert ingredients such as crushed rock, sand, gravel etc. with finely divided calcium and/or magnesium oxides and/or hydroxides. The calcium- and/or magnesium-containing material of the compact is reacted with carbon dioxide in gaseous form to produce a matrix of calcium and/or magnesium carbonate throughout the compact. This calcium carbonate matrix binds, densifies and hardens the structure of the compact.

METHOD FOR PRODUCING A HARD PAVING OR SURFACING MATERIAL

In many paving applications, and particularly in repairing military airfield paving subjected to explosive damage by bombs or artillery, there is a need for a paving that may be easily and rapidly applied and yet will be long lasting and not subject to deterioration by use and weather conditions, such as rain and snow. Currently, temporary airfields are constructed in combat areas by merely leveling the existing terrain; however, the surface is subject to rapid deterioration under wet weather conditions. To offset this deficiency, metal matting or webbing is often placed on top of the leveled terrain. This solution to the problem is expensive and, in addition, requires the transport to and storage at the combat area of these required materials. Similarly, in the construction of temporary roadways, often the bare ground provides the road surface over which vehicles travel. These temporary roadways are also subject to rapid deterioration due to the weather; also, they are susceptible to rapid digging and thus in combat areas they may be easily mined with explosives by an enemy.

It is therefore a primary object of the present invention to provide a hard paving material, and a method for producing and applying the same, that may be rapidly applied with a minimum of materials and equipment and is ready for use almost immediately upon application.

This and other objects of the invention, as well as a complete understanding of the invention, will be apparent from the following description and specific examples:

In the practice of the invention, moist soil at the area to be paved is loosened to a suitable depth, which may depend upon the depth of the paving desired. This may be accomplished either manually or by the use of earth-working equipment, such as a mechanical tiller. In the case of airfield repair, holes in the runway to be repaired may be filled with soil or other soil-like materials from the immediate surroundings. An alkaline earth material, which is an alkaline earth oxide and/or hydroxide, such as finely powdered calcined lime or dolomitic lime hydrate, is blended with the soil. Under the surface of this blend carbon dioxide in solid or gaseous form is introduced. The solid carbon dioxide vaporizes because of the heat contained within the soil to produce gaseous carbon dioxide. The gaseous carbon dioxide subsequently reacts with the calcined lime or dolomitic lime hydrates to produce the calcium carbonate bonding matrix. In the case of airfield holes, carbon dioxide can be introduced into the fill in one of two ways. If solid carbon dioxide is used it is placed in the hole first and the blend of soil and lime is filled in on top of it to ground level. Alternately, gaseous carbon dioxide can be introduced into the fill by laying perforated pipes into the bottom of the hole and subsequently filling the hole with the blend of soil and lime. The perforated pipe is connected to an external burner that utilizes any carbonaceous fuel, such as gasoline, gas, oil, or coal as a source of fuel. The products of combustion from these carbonaceous fuels produce carbon dioxide which is subsequently pumped into the perforated pipe to react with the lime materials contained within the soil-lime blend. Typically, these combustion products will contain about 25 percent carbon dioxide. In the case of road construction, the carbon dioxide is similarly continuously introduced at the interface of the loosened surface soil and the solid untilled soil. The moist soil and lime blend is then compacted by manual or mechanical tamping. The solid carbon dioxide beneath the blend is converted to gaseous form by the latent heat of the surrounding soil. Alternatively, perforated pipe connected to an external source of carbon dioxide such as the carbonaceous fuel burners mentioned earlier, can be laid down on the untilled soil and then covered with a blend of soil and calcined lime or dolomitic lime hydrate to produce the desired result. The gaseous carbon dioxide permeates upwardly through the blended soil and lime whereupon it reacts with the lime to form calcium carbonate.

The calcium carbonate produced as described above, acts as a cementing matrix that binds the loose compact into a

dense, hard structure that is ready for use under load in about 30 minutes. In the practice of the invention compaction of the moist soil and lime blend at pressures of 50 pounds per square inch or greater have been found to be satisfactory and satisfactory results have been achieved even by the use of less pressure during compacting. The resulting paving material comprises a dense, hard compact of finely divided soil in a dispersion or matrix of calcium carbonate. The soil should be at a moisture level of about 2 to 10 percent.

It is not necessary to supply carbon dioxide in stoichiometric amounts to react with all the lime in the compact—it being understood that less than stoichiometric amounts of carbon dioxide will merely serve to correspondingly decrease the initial strength and hardness of the product. In addition, any excess lime in the compact will react with the carbon dioxide within the atmosphere, and thus the compact will continue to harden and densify with time.

EXAMPLE I

A moist clay soil along a selected area was plowed, tilled and blended with about 10 percent by weight of finely powdered calcined dolomitic lime hydrate to a depth of about four inches. Powdered solid carbon dioxide (dry ice) was injected beneath the surface of the loose blend at the interface with the unloosened soil. In this manner the loose blend of soil and lime rested directly on top of quantities of the carbon dioxide. The loose blend was tamped to form a compact atop the carbon dioxide. At this time, the carbon dioxide, because of the sensible heat contained in the soil, was converted to gaseous carbon dioxide. This gaseous carbon dioxide permeated upwardly through the interstices of the compacted blend and reacted with the dolomitic lime hydrate to form a matrix of calcium carbonate throughout the compacted blend. The calcium carbonate matrix thus produced provided a cementing action that bound the loosely compacted blend into a solid, dense, hard coherent structure. After approximately 30 minutes, it was found that the compact was hardened to a "stone-like" consistency.

EXAMPLE II

The same loosened soil as used in example I was mixed with about 10 percent by weight of the same lime hydrate at a moisture content of about 7 percent and compacted into cylinders of one square inch cross-sectional area and about one inch in height. These cylinders were subjected to gaseous carbon dioxide for about 30 minutes, after which time they were found to withstand compressive loads in excess of 2500 pounds per square inch.

Because solid or gaseous carbon dioxide can be employed as in examples I and II, the invention can be readily employed to produce paved areas, such as roads and aircraft runways, on a continuous basis. In this application, a tractor, bulldozer or the like can be used to level out an area to be paved for use as a road or runway. Once leveled, the same equipment is used to pull a plow or rotary tiller to break up and loosen the soil to the desired depth of the pavement. During this tilling operation, the tractor or bulldozer deposits continuously into the tilling device a quantity of an alkaline earth oxide and/or hydroxide, which is continuously and proportionately blended with the loosened soil. If the soil is not sufficiently moist, water may be added through the tilling device in a similar manner. Immediately behind the soil tilling device are positioned injection nozzles that are connected to a tank containing liquid or solid powdered carbon dioxide, which is injected by the nozzles at the interface of the solid, unworked soil, and the loosened soil and lime blend. If liquid carbon dioxide is employed, the nozzles are designed to provide a cooling effect, brought about by the change in pressure at the injection point, that converts the liquid carbon dioxide to solid form upon deposit at the interface. This, of course, would not be required if solid carbon dioxide is used. Immediately following the injection of the carbon dioxide, a weighted roller, which

preferably is attached to and follows directly after the plow or tiller, compacts the blend. Compaction under pressure in excess of 50 pounds per square inch is preferred. The compacted soil and lime blend is situated on top of the solid powdered carbon dioxide. At a time in excess of 30 minutes, but depending upon the depth of the blend, the blend will have solidified into a dense, hard pavement sufficient to withstand the compressive loads of vehicles traveling thereover.

Alternatively, those versed in the art will recognize that gaseous carbon dioxide either in pure or diluted form could be used to accomplish the same result. Economics and expediency will dictate which of the two methods should be employed for a given situation. The second method for the paving of a road or runway is as follows. The road or runway is leveled and superfluous soil is removed to the depth desired. The soil removed from the road or runway is then blended with the calcined lime or dolomitic lime hydrates. On the solid supporting surface resulting from the leveling operation, a network of perforated plastic or steel pipe is placed. The perforated pipe network is connected to an external carbonaceous fuel burner employing gas, oil, gasoline or coal as a source of fuel. The pipe network is then covered with the blend of soil and lime or dolomitic lime hydrate to the depth desired. The loose mixture is then compacted by means of a weighted roller to produce a smooth compacted surface. Compaction under pressure in excess of 50 pounds per square inch is preferred. Once the compaction has been accomplished the burner is turned on and the products of combustion are forced into the perforated pipe network. The products of combustion containing substantial quantities of carbon dioxide then permeate upward through the compacted blend of soil and lime or dolomitic lime hydrate. The reaction between the lime or dolomitic lime hydrate and the gaseous carbon dioxide contained in the products of combustion resulting from the burner produce a calcium carbonate matrix that forms a dense hard pavement sufficient to withstand compressive loads of vehicles traveling thereover.

It is to be understood that by varying the percentage of lime in the soil and lime blend, increased compressive strengths may be produced in the final compact on the order of 3,000 pounds per square inch, which approaches the compressive strength of many types of concrete. Also, faster reaction rates will be achieved by using essentially pure carbon dioxide rather than combustion products typically containing only about 25 percent carbon dioxide.

In the practice of the invention, magnesium oxides and/or hydroxides may be used in place of or in combination with the

calcium oxides and/or hydroxides to provide upon reaction with carbon dioxide a magnesium carbonate matrix.

As used herein, dolomitic lime hydrate is a mixture of calcium and magnesium hydrates obtained from the calcination and hydration of the naturally occurring mineral dolomite.

It will be obvious to those skilled in the art that various adaptations and modifications of the invention may be made without departing from the scope and spirit of the appended claims.

I claim:

1. A method for producing a hard paving or surfacing material comprising, blending moist soil with at least one alkaline earth material selected from the group consisting of calcium and magnesium oxides, hydroxides and mixtures thereof in finely divided form, compacting the blend under pressure to produce a compact of said soil and said alkaline earth material, reacting said alkaline earth material with carbon dioxide in gaseous form to produce a matrix of alkaline earth carbonate throughout said compact which binds, densifies and hardens the structure of said compact.

2. The method of claim 1 wherein said alkaline earth material is at least one material selected from the group consisting of finely powdered lime hydrate and dolomitic lime hydrate.

3. The method of claim 1 wherein said compacting is effected by a pressure in excess of 50 pounds per square inch.

4. The method of claim 1 wherein said carbon dioxide in gaseous form is produced by converting carbon dioxide in solid form to gas by the sensible heat of said compact.

5. A method for producing a hard paving or surfacing material along a selected soil area comprising, loosening the soil to a selected depth along said area, blending at least one alkaline earth material selected from the group consisting of calcium and magnesium oxides, hydroxides and mixtures thereof in finely divided form with said loosened soil, introducing solid carbon dioxide at the interface of said blend and unloosened soil, compacting said blend atop said carbon dioxide to gassify said carbon dioxide, which carbon dioxide in gaseous form permeates said compacted blend and reacts with said alkaline earth material to form an alkaline earth carbonate matrix throughout said compacted blend, which binds, densifies and hardens the structure of said compact.

6. The method of claim 5 wherein gaseous carbon dioxide is introduced at the interface of said blend and unloosened soil by introducing thereto combustion products from a carbonaceous fuel burner, said combustion products containing a quantity of said gaseous carbon dioxide.

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