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(54) MIXTURE FOR SUPPORTING SURFACING

(71) We, NICHOLSON REALTY LTD, a Limited Partnership in the State of Ohio, United States of America, of 5800 Monroe Street, Building F, Sylvania, State of Ohio 43560, United States of America, (assignee of JOHN PATRICK NICHOLSON), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to materials which are capable of supporting surfacing such as pavement bases.

In road paving, at one time it was thought that the base for the surfacing material should comprise a granular or gravel base. However, more recently, it has been concluded that there was a considerable difference in the performance between such bases and cement-aggregate or bituminous (asphalt)-aggregate bases. As reported in the Highway Research Board Special Report 61E, titled The AASHO Road Test, Report 5, Pavement Research, publication 954 of National Academy of Sciences - National Research Council, there is a clear superiority of such treated bases over untreated bases. In recent years, treated bases have become commonly known as stabilized bases.

In subsequent work, for example, use of asphalt mixtures in all courses of pavement above the subgrade has been proposed, The Asphalt Institute, Information Series No. 146, June 1968. Asphalt stabilized bases have become the most dominant stabilized base utilized to support a flexible surfacing such as asphalt concrete. In addition, asphalt concrete has found extensive use as a resurfacing material for concrete pavement.

It has also been proposed that a lime-fly ash-aggregate stabilized base be used in road paving. Such a base consists of a mixture of proper quantities of lime, fly ash, and graded aggregate at optimum mositure content, in which the stability is greatly enhanced by the cementing action which results from complex chemical reactions between the lime and the fly ash in the presence of water.

Stabilized bases are usually employed as base courses under wearing surfaces such as hot mixed, hot laid asphaltic concrete. A wearing surface is necessary to resist the high shearing stresses which are caused by traction, but the stabilized base provides the required stability to support wheel loads.

A serious obstacle to the expanded use of stabilized bases is the high energy costs for making the materials.

For example, it is well known that the production of portland cement which is used in stabilizing bases requires substantial quantities of coal in manufacture. In fact, the United States Department of Transportation has suggested that fly ash be substituted for a portion of the portland cement utilized in concrete or cement-aggregate bases, Federal Highway Administration Notice N5080.4, January 17, 1974.

The use of asphalt is asphalt-aggregate bases which is derived from petroleum processing not only utilizes petroleum which is in short supply but also requires high energy to produce them.

Similarly, the lime, fly ash and graded aggregate stabilized bases utilize lime which requires coal in production. Such bases have been used in limited geographical areas of the United States where they can compete economically because of availability of lime and fly ash.

Thus, the predominantly used stabilized bases utilize materials that are in short supply and require substantial quantities of energy to produce them. The materials may be termed energy intensive. There is a need to avoid or minimize the use of such energy intensive materials in road paving.

The object of this invention is to provide a mixture of materials for producing a stabilized base comprising a hard, strong, durable mass capable of supporting surfacing which avoids or minimizes the use of materials which are energy intensive and, moreover, utilizes materials that normally are waste materials that are readily available.

According to the present invention there is provided a mixture comprising about 88% by dry weight of pozzolan and about 12% by dry weight of cement kiln dust which, through pozzolanic reactions occurring on setting of the mixture with water, produces a hard, strong, durable mass capable of supporting surfacing.

According to the present invention there is also provided a mixture comprising 6 to 24% by dry weight of pozzolan, 4 to 16% by dry weight of cement kiln dust and 60 to 90% by dry weight of aggregate which, through pozzolanic reactionsn occurring on setting of the mixture with water, produces a hard, strong, durable mass capable of supporting surfacing.

According to the present invention there is further provided a method of making a stabilized load bearing material which comprises mixing about 88% by dry weight of pozzolan, about 12% by dry weight of cement kiln dust and water, compacting the mixture and permitting the mixture to react at ambient temperatures to produce a hard, strong, durable mass capable of supporting surfacing.

According to the present invention there is still further provided a method of making a stabilised load bearing material, which comprises mixing 6 to 24% by dry weight of pozzolan, 4 to 16% of dry weight of cement kiln dust, 60 to 90% by dry weight of aggregate and water, compacting the mixture and permitting the mixture to react at ambient temperatures to produce a hard, strong, durable mass capable of supporting surfacing.

In one embodiment of the present invention the pozzolan is fly ash.

This invention will now be further described with reference to the accompanying drawings in which:

Figures 1-3 are curves of compressive strength versus age at test for various compositions.

Figure 4 is curves of energy requirements for various pavement materials.

In accordance with the invention, the pozzolanic load supporting composition utilizes cement kiln dust.

The solid waste generated by cement manufacture is primarily kiln dust. This dust contains a mixture of raw kiln feed, partly calcined material, finely divided cement clinker and alkali metal sulfates (usually referred to as sulfates). There is economic value in returing the dust to the kiln, but when the alkali content of the returned dust is too high for the product clinker to meet specifications, the dust must be discarded. Up to about 15% of the raw materials processed may be collected as dust and of this about half may be low enough in alkalis to be returned to the kiln. The rest is usually stockpiled as a waste material which must be disposed and may be a nuisance and possibly a hazard.

Although the chemical reactions occurring in the resultant cement kiln dust are not well known, typical cement kiln dust has a chemical analysis as follows:

SiO_2
Al_2O_3
Fe_2O_3
CaO
MgO
SO_3
Na_2O
K_2O
Loss Ignition

More specifically, typical cement kiln dust may have the following analyses:

Ingredient	Source A*	Source B*	Source C	Source D	Source E	Source F	Source G	Source H	Source I	Mid-Range
SiO_2	28.5%	6.0%	22.4%	11.2%	13.0%	23.5%	14.8%	14.6%	14.7%	17.2%
Al_2O_3	9.6	3.4	4.71	3.2	4.0	3.77	3.4	3.4	3.7	6.4
Fe_2O_3	5.9	0.8	1.77	1.4	5.0	1.71	2.2	2.2	3.0	3.4
CaO	50.1	16.0	65.0	48.8	47.2	61.3	47.3	46.3	46.5	40.5
MgO	3.4	0.8	2.60	2.1	1.2	4.83	2.1	2.0	2.0	2.8
SO_3	26.3	0.7	1.12	2.4	13.6	1.48	4.8	5.0	8.2	13.5
Na_2O	3.18	0.08	0.24	0.2	0.45	0.24	0.9	0.9	0.8	1.6
K_2O	26.23	1.08	1.3	4.2	2.9	1.85	4.1	5.1	3.0	13.7
Loss on Ignition	32.0%	7.7%	2.50%	26;6%	12.9%	1.84%	21.1%	21.4%	18.2%	17.2%

*Sources A and B are upper and lower values respectively, from a group of 30 samples furnished by a single cement manufacturer.

	Range		
Ingredient	Low %	High %	Average %
SiO_2	6.0	28.5	16.5
Al_2O_3	3.2	9.6	4.35
Fe_2O_3	0.8	5.9	2.66
CaO	16.0	65.0	47.6
MgO	0.8	4.83	2.34
SO_3	0.7	26.3	7.07
Na_2O	0.08	3.18	0.78
K_2O	1.08	26.23	5.52
Loss on Ignition	2.50	32.0	16.0

When mixtures made in accordance with the invention and mixed with water to produce a pozzolanic reaction have been tested in accordance with the specifications given in ASTM C-593 for fly ash and other pozzolans for use with lime, it has been found that the compositions meet or exceed the specifications.

The term "fly ash" as used in connection with stabilized bases is well known and as used herein is intended to indicate the finely divided ash residue produced by the combustion of pulverized coal or lignite, which ash is carried off with the gases exhausted from the furnace in which the coal is burned and which is collected from these gases usually by means of suitable precipitation apparatus such as electrical precipitators. Those finely pulverized ashes resulting from combustion of oil and from combustion of waste materials in a large incinerator or natural pozzolans can also be utilized in the methods described herein providing their chemical compositions are reasonably similar to pulverized coal fly ashes. The fly ash so obtained is in a finely divided state such that usually at least 70% by weight passes through a 200-mesh sieve, although incinerator ashes may be considerably coarser. Fly ash may be considered an "artifical pozzolan", as distinguished from a "natural pozzolan".

The term "aggregate" as used in connection with load supporting compositions is also well known and refers to natural or artificial inorganic materials most of which are substantially chemically inert with respect to fly ash and lime, and substantially insoluble in water. Typically aggregate may comprise limestone, sand, blast furnace slag, gravel and synthetic aggregate.

Aggregates can comprise a wide range of types and gradations, including sands, gravels, crushed stones, and several types of slag. Aggregates should be of such gradation that, when mixed with cement kiln dust, fly ash and water, the resulting mixture is mechanically stable under compaction equipment and capable of being compacted in the field to high density. The aggregate should be free from deleterious organic or chemical substances which may interfere with the desired chemical reaction between the cement kiln dust, fly ash and water. Further, the aggregate should preferably consist of hard, durable particles, free from soft or disintegrated pieces.

It has been found that a preferable mixture comprises:

	Per Cent by Dry Weight
Cement Kiln Dust	8.0%
Pozzolan	12.0%
Aggregate	80.0%
Total	100.0%

However, the mixture for use in road stabilizer bases may vary as follows:

	Per Cent By Dry Weight
Cement Kiln Dust	4 - 16%
Pozzolan	6 - 24%
Aggregate	60 - 90%

As indicated above, tests were conducted in accordance with ASTM C-593. More specifically, the test specimens were molded using a mechanical compactor, having a 10 pound hammer with an 18 inch drop. The material was placed in the molds in three equal layers, and compacted by 25 blows per layer. The machine has a revolving turntable to evenly distribute the blows over the surface of the layer being compacted.

After molding, the samples were carefully removed from the molds, weighed, and sealed in plastic bag, labeled for identification, and placed in a constant temperature oven at 100°F to cure until tested. Two cylinders of each mix were marked for testing at 7, 14 and 28 days of curing. After removal from the oven, the samples are submerged in water for four hours, removed, and allowed to drain on a non-absorbant surface, capped and tested within one hour after removal from the water. The capping compound used is "Hydro-Stone" a lime based, quick-hardening compound. Plate glass was used to obtain even, parallel caps on the test specimens.

Examples of various tests and compositions are as follows:

EXAMPLE 1

	Percent	Weight of Batch
Cement Kiln Dust	8.0%	2.4#
Fly Ash	12.0%	3.6#
Limestone	80.0%	24.0#
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	10.8	4.73	141.9	128.1	12.57	10-16	13,140	1050
B	10.8	4.72	141.6	127.8	12.57	10-16	14,370	1140
C	10.8	4.73	141.9	128.1	12.57	10-23	15,780	1260
D	10.8	4.73	141.9	128.1	12.57	10-23	15,530	1240
E	10.8	4.73	141.9	128.1	12.57	11-06	17,800	1420
F	10.8	4.73	141.9	128.1	12.57	11-06	17,800	1420

Remarks: Slight bleeding at bottom of mold.

EXAMPLE II

	Percent	Weight of Batch
Cement Kiln Dust	8.0%	2.4#
Fly Ash	12.0%	3.6#
Limestone	80.0%	24.0#
Retarder	----	0.96 oz
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molder (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested.	Mach. Load	P.S.I.
A	10.1	4.73	141.9	128.9	12.57	10-16	---	---
B	10.1	4.73	141.9	128.9	12.57	10-16	---	---
C	10.2	4.73	141.9	128.8	12.57	10-23	1,650	130
D	10.2	4.73	141.9	128.8	12.57	10-23	1,930	150
E	10.3	4.73	141.9	128.6	12.57	11-06	2,300	180
F	10.3	4.73	141.9	128.6	12.57	11-06	2,100	170

Remarks: Slight bleeding.
Samples 2-A and 2-B fell apart during the four (4) hour soaking. There was no intact sample to subject to compression test. Samples C,D,E, and F were not subjected to the four (4) hour soaking, prior to testing.

EXAMPLE III

	Percent	Weight of Batch
Cement Kiln Dust	8.0%	2.4#
Fly Ash	12.0%	3.6#
Limestone	80.0%	24.0#
Calcium Chloride Solution	---	(0.24#)
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	10.4	4.77	143.1	129.6	12.57	10-16	15,160	1210
B	10.4	4.77	143.1	129.6	12.57	10-16	15,750	1250
C	10.0	4.73	141.9	129.0	12.57	10-23	17,250	1370
D	9.9	4.73	141.9	129.1	12.57	10-23	18,950	1510
E	9.8	4.73	141.9	129.2	12.57	11-06	20,600	1640
F	9.7	4.72	141.6	129.1	12.57	11-06	20,700	1650

Remarks: Slight bleeding.

EXAMPLE IV

	Percent	Weight of Batch
Cement Kiln Dust	8.0%	2.4#
Stack Dust	3.0%	0.9#
Fly Ash	12.0%	3.6#
Limestone	77.0%	23.1#
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	8.5	4.53	135.9	125.3	12.57	10-17	8,200	652
B	8.5	4.54	136.2	125.5	12.57	10-17	8.900	708
C	8.7	4.58	137.4	126.4	12.57	10-24	10,950	871
D	8.8	4.56	136.8	125.7	12.57	10-24	11,775	937
E	9.0	4.58	137.4	126.1	12.57	11-07	16,050	1280
F	9.0	4.56	136.8	125.5	12.57	11-07	14,850	1180

Remarks: No bleeding.

EXAMPLE V

	Percent	Weight of Batch
Cement Kiln Dust	12.0%	3.6#
Fly Ash	88.0%	26.4#
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	9.5	2.87	86.1	78.6	12.57	10-17	2,350	187
B	9.7	2.90	87.0	79.3	12.57	10-17	2,300	183
C	9.7	2.90	87.0	79.3	12.57	10-24	2,075	165
D	9.7	2.90	87.0	79.3	12.57	10-24	1,900	151
E	9.7	2.90	87.0	79.3	12.57	11-07	3,040	240
F	10.0	2.96	88.8	80.7	12.57	11-07	3,230	260

Remarks: Had difficulty in reaching the desired moisture content because of the dust's extremely dry condition. Extremely "fluffy" material.

EXAMPLE VI

	Percent	Weight of Batch
Cement Kiln Dust	8.0%	2.4#
Fly Ash	8.0%	2.4#
Limestone	79.0%	23.7#
Limestone Fines	5.0%	1.5#
Total	100.0%	30.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	9.8	4.85	145.5	132.5	12.57	10-20	13,900	1110
B	9.8	4.81	144.3	131.4	12.57	10-20	15,000	1190
C	9.8	4.79	143.7	130.9	12.57	10-27	17,350	1380
D	9.9	4.81	144.3	131.3	12.57	10-27	18,200	1448
E	9.9	4.81	144.3	131.3	12.57	11-10	17,050	1356
F	9.9	4.78	143.4	130.5	12.57	11-10	16,600	1321

Remarks: Good compactability. Material was relatively easy to work with.

EXAMPLE VII

	Percent	Weight of Batch
Fly Ash	8.0%	2.40#
Kiln Dust	10.0%	3.00#
No. 304 Limestone (Screened over 3/4" screen)	82.0%	24.60#
Total	100.0%	30.00#

Cyl. No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
1	11.5	4.73	141.9	127.3	12.57	4-01	9350	745
2	11.1	4.71	141.3	127.2	12.57	4-01	8610	685
3	11.1	4.73	141.9	127.7	12.57	4-01	9290	740
4	11.1	4.74	142.2	128.1	12.57	4-22	14050	1120
5	11.0	4.75	142.5	128.4	12.57	4-22	13500	1075
6	10.7	4.74	142.2	128.5	12.57	4-22	13620	1085

A. Slight bleeding at bottom of mold during compaction.
B. Material appeared deficient in linestone fines (-#4 material).
C. Some free noisture noted, giving slight "glossy" appearance.
D. Samples slumped, following extraction from molds.

EXAMPLE VIII

	Percent	Weight of Batch
Fly Ash	10.0%	3.00#
Kiln Dust	8.0%	2.40#
No. 304 Limestone (Screened over 3/4" screen)	82.0%	24.60#
Total	100.0%	30.00#

Cyl. No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
1	9.3	4.72	141.6	129.6	12.57	4-01	8060	640
2	9.4	4.71	141.3	129.2	12.57	4-01	7750	615
3	9.4	4.71	141.3	129.2	12.57	4-01	8000	635
4	9.5	4.69	140.7	128.5	2.57	4-22	9730	775
5	9.6	4.68	140.4	128.1	12.57	4-22	10450	830
6	9.5	4.69	140.7	128.5	12.57	4-22	11490	915

A. Samples retained shape following extraction from molds.
B. No free water noticed bleeding during compaction.

EXAMPLE IX

	Percent	Weight of Batch
Fly Ash	8.0%	2.40#
Kiln Dust	10.0%	3.00#
Fill Sand	82.0%	24.60#
Total	100.0%	30.00#

Cyl. No.	Percent Water	Wt. As Molded (Lbs.)	Wet. Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
1	9.8	4.09	122.7	111.7	12.57	3-31	1800	145
2	10.0	4.12	123.6	112.4	12.57	3-31	1700	135
3	9.9	4.10	123.0	111.9	12.57	3-31	1690	135
4	9.9	4.11	123.3	112.2	12.57	4-21	2810	225
5	10.0	4.10	123.0	111.8	12.57	4-21	2880	230
6	9.8	4.09	122.7	111.7	12.57	4-21	2670	210

A. No bleeding of sample during compaction.
B. Material stayed in a ball when packed by hand.
C. Slight bulking noticed.
D. Easily compacted.

EXAMPLE X

	Percent	Weight of Batch
Fly Ash	8.0%	2.40#
Kiln Dust	10.0%	3.00#
Glass (Crushed to approx. 1/2" size)	32.0%	9.60#
Fill Sand	50.0%	15.00#
Total	100.0%	30.00#

Cyl. No.	Percent Water	Wt. As Molded (Lbs.)	Wet. Wt Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
1	9.4	4.50	135.0	123.4	12.57	4-02	4390	350
2	9.4	4.50	135.0	123.4	12.57	4-02	4590	365
3	9.3	4.51	135.3	123.8	12.57	4-02	4200	335
4	9.2	4.52	135.6	124.2	12.57	4-23	6750	535
5	9.1	4.51	135.3	124.0	12.57	4-23	6870	545
6	9.1	4.47	134.1	122.9	12.57	4-23	6280	500

A. Material originally mixed to 10.3% moisture, looked wet, probably because non-absorbancy of glass.
B. Air dried the mix out to approximately 9.4% mositure, did not bulk at this moisture content.
C. Surprisingly good cohesion of mix, even with the smooth faces of glass particles.
D. Strength of cylinders higher than expected, thought the mix would slip off the smooth glass faces, when put under compression.

EXAMPLE XI

	Percent	Weight of Batch
Cement Kiln Dust	16.0	3.2#
Fly Ash	24.0	4.8#
No. 304 Crushed Limestone	60.0	12.0#
Total	100.0	20.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	16.6	4.50	135.0	115.8	12.57	12/22	5890	470
B	15.1	4.46	133.8	116.2	12.57	12/22	6000	480
C	15.0	4.46	133.8	116.3	12.57	12/22	6150	490

EXAMPLE XII

	Percent	Weight of Batch
Cement Kiln Dust	4.0	0.8#
Fly Ash	6.0	1.2#
No. 304 Crushed Limestone	90.0	18.0#
Total	100.0	20.0#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	11.1	4.94	148.2	133.4	12.57	12/22	2950	230
B	11.2	4.93	147.9	133.0	12.57	12/22	3570	280
C	11.2	4.93	147.9	133.0	12.57	12/22	3250	260

EXAMPLE XIII

	Percent	Weight of Batch
Cement Kiln Dust	6.9%	140#
Fly Ash	11.8%	240#
Limestone Screenings	39.4%	800#
No. 57 Crushed Limestone	39.4%	800#
Water	2.5%	50#
Total	100.0%	2030#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	5.6	4.49	134.7	127.6	12.57	11-22	8,950	712
B	5.1	4.51	135.3	128.7	12.57	11-22	8,225	654
C	5.5	4.51	135.3	128.2	12.57	11-22	9,050	720
D	5.4	4.50	135.0	128.1	12.57	11-29	9,610	760
E	5.5	4.49	134.7	127.7	12.57	11-29	8,080	640
F	4.9	4.50	135.0	128.7	12.57	11-29	9,630	770
G	5.1	4.46	133.8	127.3	12.57	12-13	8,820	700
H	5.3	4.51	135.3	128.5	12.57	12-13	9,380	750
I	5.4	4.50	135.0	128.1	12.57	12-13	9,400	750
J	5.3	4.46	133.8	127.1	12.57	02-03		
K	5.1	4.51	135.3	128.7	12.57	02-03		
L	4.9	4.48	134.4	128.1	12.57	02-03		
M	5.0	4.54	136.2	129.7	12.57	For Durability Test		
N	4.9	4.54	136.2	129.8	12.57	For Durability Test		
O	4.8	4.47	134.1	128.0	12.57	For Durability Test		

EXAMPLE XIV

	Percent	Weight of Batch
Cement Type I	1.0%	20#
Cement Kiln Dust	6.8%	140#
Fly Ash	11.7%	240#
Limestone Screenings	39.0%	800#
No. 57 Crushed Limestone	39.0%	800#
Water	2.5%	50#
Total	100.0%	2050#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	5.4	4.58	137.4	130.4	12.57	11-21	10,030	800
B	5.4	4.58	137.4	130.4	12.57	11-21	11,780	940
C	5.4	4.58	137.4	130.4	12.57	11-21	14,120	1120
D	5.3	4.58	137.4	130.5	12.57	11-28	15,500	1230
E	5.0	4.58	137.4	130.9	12.57	11-28	18,500	1470
F	5.8	4.46	133.8	126.5	12.57	11-29	14,910	1190
G	5.8	4.46	133.8	126.5	12.57	12-13	17,900	1420
H	5.7	4.46	133.8	126.6	12.57	12-13	20,010	1590
I	5.7	4.46	133.8	126.6	12.57	12-13	14,980	1190
J	5.7	4.46	133.8	126.6	12.57	02-13		
K	5.6	4.46	133.8	126.7	12.57	02-13		
L	5.6	4.46	133.8	126.7	12.57	02-13		
M	5.4	4.49	134.7	127.8	12.57	For Durability Test		
N	5.4	4.49	134.7	127.8	12.57	For Durability Test		
O	5.4	4.49	134.7	127.8	12.57	For Durability Test		

EXAMPLE XV

	Percent	Weight of Batch
Cement Kiln Dust	7.8%	160#
Fly Ash	11.7%	240#
Limestone Screenings	39.0%	800#
No. 57 Crushed Limestone	39.0%	800#
Water	2.5%	50#
Total	100.0%	2050#

Specimen No.	Percent Water	Wt. As Molded (Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	8.1	4.24	127.2	117.7	12.57	11-29	4,650	370*
B	7.9	4.24	127.2	117.9	12.57	11-22	5,700	450
C	8.3	4.29	128.7	118.8	12.57	11-22	6,030	480
D	7.8	4.25	127.5	118.3	12.57	11-29	7,220	570
E	7.7	4.24	127.2	118.1	12.57	11-29	6,850	540
F	7.6	4.26	127.8	118.8	12.57	11.29	8,080	640
G	7.6	4.30	129.0	119.9	12.57	12-13	10,000	800
H	7.6	4.27	128.1	119.0	12.57	12-13	9,500	760
I	7.6	4.27	128.1	119.0	12.57	12-13	8,890	710
J	7.5	4.27	128.1	119.2	12.57	02-13		
K	7.3	4.28	128.4	119.7	12.57	02-13		
L	7.2	4.26	127.8	119.2	12.57	02-13		
M	7.2	4.27	128.1	119.5	12.57	For Durability Test		
N	7.1	4.24	127.2	118.8	12.57	For Durability Test		
O	7.2	4.25	127.5	118.9	12.57	For Durability Test		

*Sample fractured horizontally during capping.

Remarks: This product was produced on November 6, and sampled on November 13. Materials are the same as in Example XIII - This example is a check to see if the age of the product, before use, has any effect on the strength results.

EXAMPLE XVI (COMPARATIVE)

	Percent	Weight of Batch
Fly Ash	11.6%	232#
Lime	3.4%	68#
No. 304 Crushed Limestone	85.0%	1700#
Water	----	----
Total	100.0%	2000#

Specimen No.	Percent Water	Wt. As Molded(Lbs.)	Wet Wt. Per Cu. Ft.	Dry Wt. Per Cu. Ft.	Area (Sq. In.)	Date Tested	Mach. Load	P.S.I.
A	10.4	4.60	138.0	125.0	12.57	11-28	10,325	820
B	10.4	4.70	141.0	127.7	12.57	11-28	11,950	950
C	10.2	4.62	138.6	125.8	12.57	11-28	10,650	850
D	10.2	4.67	140.1	127.1	12.57	12-05	19,600	1559
E	10.2	4.66	139.8	126.9	12.57	12-05	18,950	1508
F	11.1	4.65	139.5	125.6	12.57	12-05	19,825	1577
G	10.8	4.66	139.8	126.2	12.57	12-19	21,860	1740
H	10.8	4.66	139.8	126.2	12.57	12-19	20,790	1650
I	10.8	4.64	139.2	25.6	12.57	12-19	21,000	1670
J	10.8	4.70	141.0	127.3	12.57	02-19		
K	10.9	4.65	139.5	125.8	12.57	02-19		
L	10.9	4.68	140.4	126.6	12.57	02-19		
M	10.9	4.66	139.8	126.1	12.57	For Durability Test		
N	10.9	4.68	140.4	126.6	12.57	For Durability Test		
O	9.9	4.63	138.9	126.7	12.57	For Durability Test		

The results of the tests are summarized in Figures 1-3.

As shown in Figure 1, mixtures containing cement kiln dust vary but in each instant produce a base that is stabilized.

As shown in Figure 2, the addition of additives or admixtures generally do not affect the strength except that a retarder tends to prevent the early development of strength as might be expected.

As shown in Figure 3, the strength of mixtures including cement kiln dust compare favourably with a lime, fly ash, aggregate mixture. In addition, even a mixture of cement kiln dust and fly ash produces a stabilized base.

Thus, the mixtures of the present invention result in a stabilized base that is comparable in strength and required performance characteristics to cement-aggregate or lime-fly ash-aggregate stabilized bases and yet are not energy intensive. The mixtures of the present invention cost less than the predominantly used asphalt-aggregate bases. Also, the use of mixtures of the invention releases asphalt for use in resurfacing or as a heavy industrial fuel.

Figure 4 is a curve showing the BTU's per mile versus thickness for various road paving materials taken from Highway Research Circular titled "Fuel Usage Factors for Highway Construction", Number 158, July, 1974. It can be seen that asphalt concrete and cement type mixtures require substantial energy and only granular base or sub-base of aggregate has minimal energy requirements in hauling, spreading, compacting and finishing. Since the mixtures of the present invention utilize waste materials, namely, cement kiln dust and fly ash, the energy requirements for making a stabilized base are only in hauling, spreading, compacting and finishing. As a result, the mixtures of the present invention have minimal energy requirements and thereby obviate the energy intensive materials of prior stabilized bases.

The mixtures of the present invention utilize cement kiln dust which is a waste product that is relatively available from cement plants and fly ash which is readily available from power plants.

WHAT WE CLAIM IS:

1. A mixture comprising about 88% by dry weight of pozzolan and about 12% by dry weight of cement kiln dust which, through pozzolanic reactions occurring on setting of the mixture with water, produces a hard, strong, durable mass capable of supporting surfacing.

2. A mixture as claimed in claim 1, in which the pozzolan is fly ash.

3. A composition which comprises a mixture as claimed in claim 1 or claim 2 and Portland cement.

4. A composition as claimed in claim 3 in which the amount of Portland cement is 1% by dry weight based on the weight of the mixture.

5. A mixture comprising 6 to 24% by dry weight of pozzolan, 4 to 16% by dry weight of cement kiln dust and 60 to 90% by dry weight of aggregate which, through pozzolanic reactions occurring on setting of the mixture with water, produces a hard, strong, durable mass capable of supporting surfacing.

6. A mixture as claimed in claim 5 comprising 12.0% by dry weight of pozzolan, 8.0% by dry weight of cement kiln dust and 80% by dry weight of aggregate.

7. A mixture as claimed in claim 5 or claim 6, in which the pozzolan is fly ash.

8. A mixture as claimed in any of claims 5 to 7 including calcium chloride.

9. A method of making a stabilized load bearing material which comprises mixing about 88% by dry weight of pozzolan, about 12% by dry weight of cement kiln dust and water, compacting the mixture and permitting the mixture to react at ambient temperatures to produce a hard, strong, durable mass capable of supporting surfacing.

10. A method of making a stabilized load bearing material which comprises mixing 6 to 24% by dry weight of pozzolan, 4 to 16% by dry weight of cement kiln dust, 60 to 90% by dry weight of aggregate and water, compacting the mixture and permitting the mixture to react at ambient temperatures to produce a hard, strong, durable mass capable of supporting surfacing.

11. A method as claimed in claim 10, in which the pozzolan is fly ash.

12. A mixture as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

13. A mixture as claimed in claim 1 and substantially as hereinbefore described with reference to Example V.

14. A mixture as claimed in claim 5 and substantially as hereinbefore described with reference to any of Examples I to IV or VI to XV.

15. A mixture as claimed in claim 5 and substantially as hereinbefore described with reference to the accompanying drawings.

W.P. THOMPSON & CO.,
Coopers Building,
Church Street,
Liverpool, L1 3AB,
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1576234 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.2

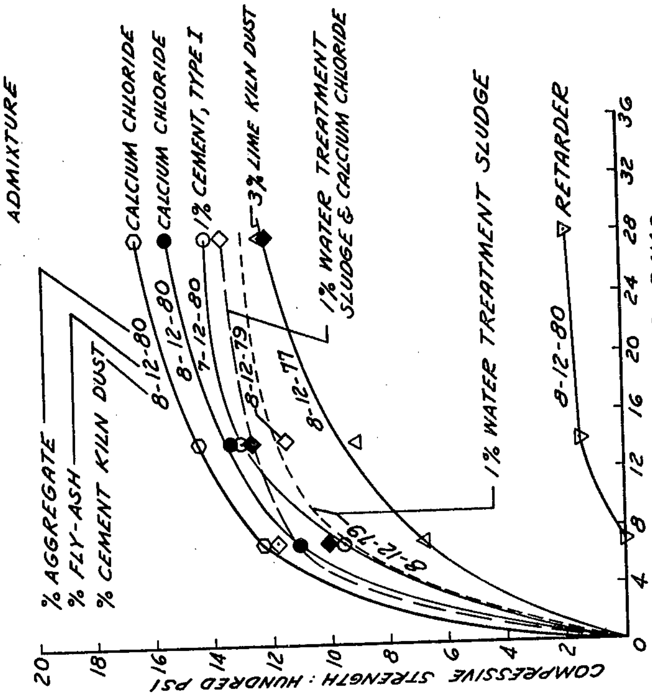
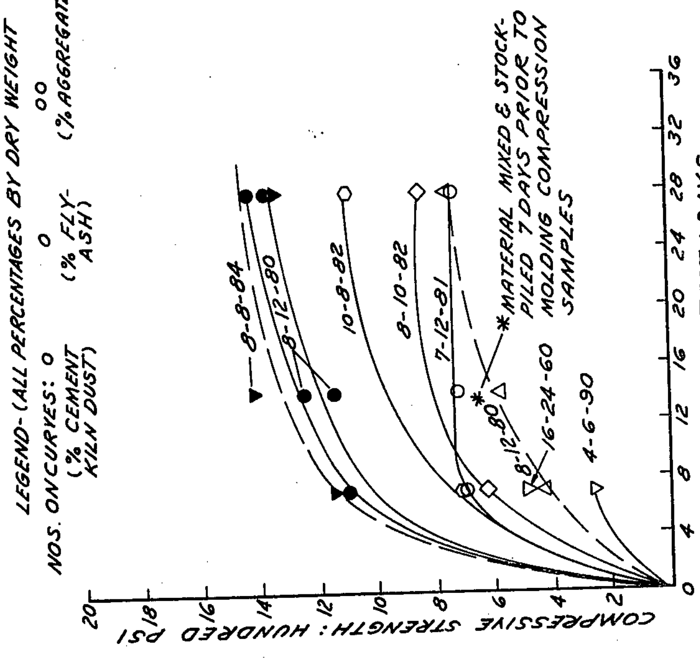


FIG.1



1576234 COMPLETE SPECIFICATION

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Sheet 2

FIG.4

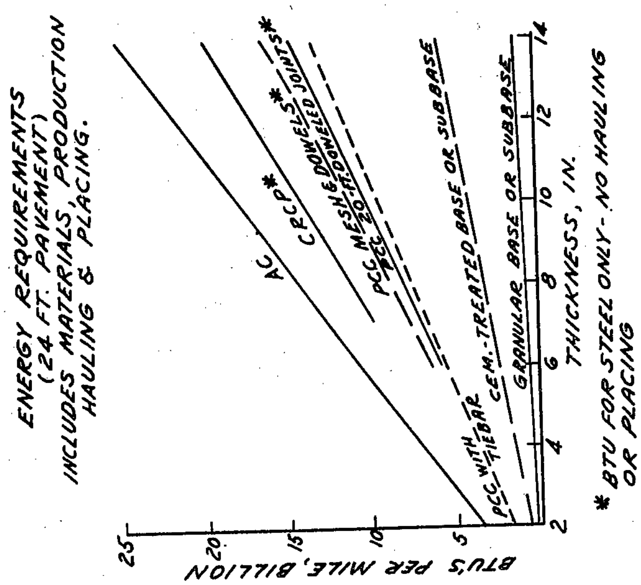

FIG.3