Jan. 8, 1935. L. R. MASON 1,987,151

BITUMINOUS COMPOSITION FOR USE IN SEA WALLS

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Fig. 1.

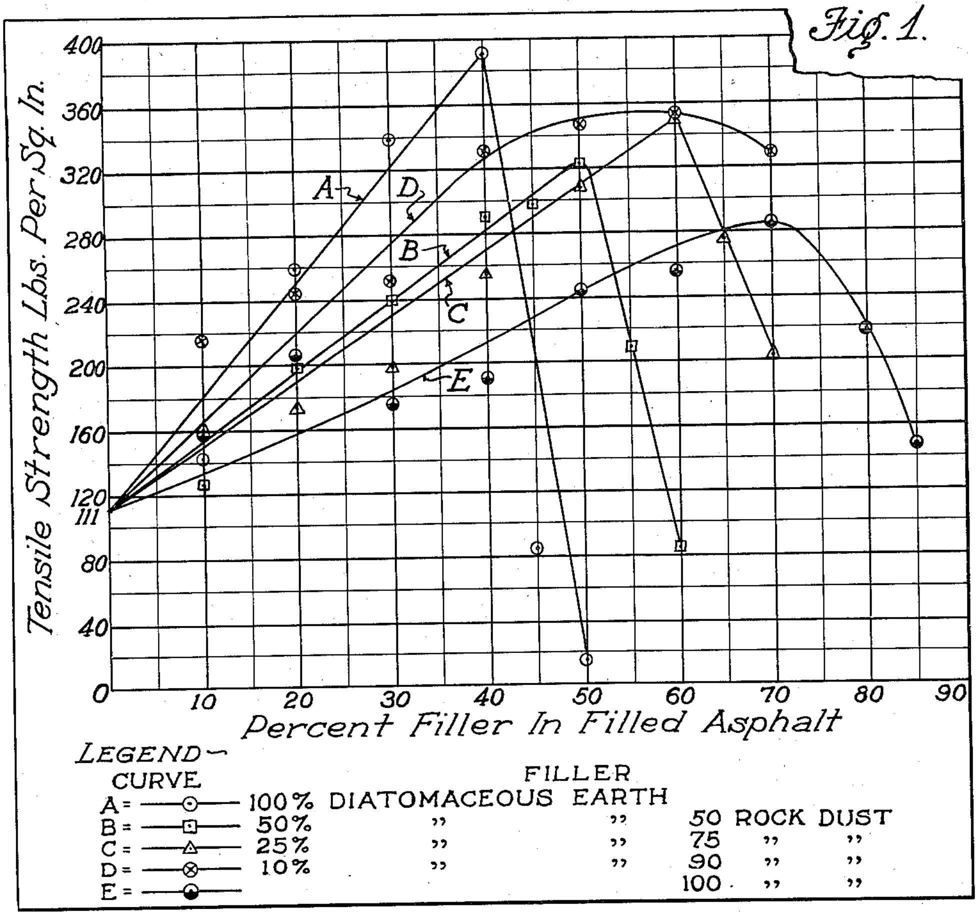
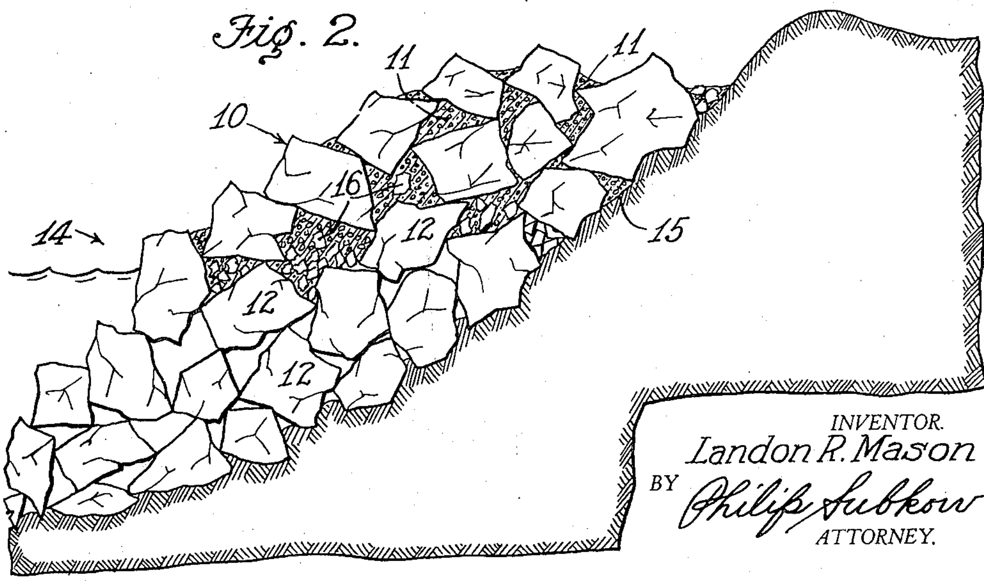


Fig. 2.



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BITUMINOUS COMPOSITION FOR USE IN SEA WALLS

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The present invention relates to a bituminous composition adapted for use in sea walls, breakwaters, ripraps, revetments, levees and the like.

It is generally known to construct rubble sea walls, breakwaters, ripraps, levees and the like by placing stones one above the other in irregular courses. Reliance is placed upon the weight of the stones to hold them into a fairly compact wall. However, this type of construction is subject to the destructive action of large waves of water impacting against the wall structure. It has not been uncommon for large waves or swells to lift massive stones weighing many tons and and to throw them completely off the structure, thus resulting in a gradual and almost complete destruction of the wall. Furthermore, this type of structure has sufficient amounts of voids which permit the waves to penetrate through and come into contact with the earth protected by the wall, thus causing the receding waves to carry considerable amounts of the earth protected by the wall. Eventually, when sufficient amounts of the protected earth has been washed away, there will be a settlement and consequent tumbling of the rock structure and perhaps, an almost complete destruction of the sea wall. Sea walls and the like are also subject to the destructive action of impacts of floating logs and similar objects tossed by the sea against the wall.

Repeated attempts have been made to prevent the foregoing destructive action by filling the voids between the stones with Portland cement concrete. However, the use of Portland cement concrete has proven unsatisfactory since sea walls and breakwaters are necessarily subjected to constant motion due to their unstable foundations and their necessarily inflexible construction results in breaking of the bond of concrete retaining the large stones. Once this bond is broken, the sea wall is subject to destruction by the wave or water action.

One of the primary objects of my invention is to correct the aforementioned difficulties and disadvantages attending prior sea wall, breakwater, etc. construction and to present structures which cannot be easily destroyed by wave or water action.

Another object of this invention resides in an asphaltic mastic or concrete adapted for filling the voids of sea walls, etc. which is tough, dense, adhesive, flexible and self-healing.

It is another object of this invention to present an asphaltic mastic or concrete having its ingredients proportioned in such manner as to present a mastic or concrete of extremely high tensile strength and resistance to impact.

Other ancillary objects of my invention will be suggested in the following description taken from the drawing and in the uses to which my invention is put.

Referring to the drawing:

Fig. 1 represents a series of curves showing the effect of mineral fillers upon the tensile strength of asphalt.

Fig. 2 is a section of a sea wall or the like.

In its broadest aspects, my invention comprises a composition of matter containing a mixture of a bituminous substance, such as asphalt and a finely comminuted filler such as diatomaceous earth, the mixture having a tensile strength greater than that of the bituminous substance in the mixture. An important feature of my invention resides in the production of a filled asphalt having an extremely high tensile strength, a reasonably high ductility, a moderately low penetration and a high melting point. Another important feature of my invention resides in a filled asphalt having such a concentration of filler as to produce a mastic of maximum tensile strength and impact resistance and which is adapted for filling the voids in sea walls and the like. In some instances, my filled asphalt may have tensile strengths between 150 and 400 lbs. per square inch depending upon the concentration and character of filler or combination of fillers in the composition.

More specifically, my invention resides in a filled asphalt comprising a mixture of asphalt and between approximately 5% and 40% by weight of diatomaceous earth and having a tensile strength between approximately 150 and 400 lbs. per square inch.

My invention also comprises a sea wall or the like and a method for constructing the same, the wall comprising a plurality of large stones placed in irregular courses and provided with a sticky asphaltic mastic or concrete of high tensile strength in the voids presented by the stones in order to prevent impacts from disturbing the position of the stones and also to prevent rapidly moving masses of water from penetrating through the wall and washing the protected earth out with the receding water.

I have discovered that when the voids in sea walls, breakwaters and the like are filled with a specially designed bituminous mastic or concrete hereinafter described, the life of these structures is lengthened considerably due to the great strength and permanent flexibility of the bituminous mastic or concrete and due also to the self-healing properties of said bituminous mastic or concrete.

The composition which I desire to particularly employ for filling the voids of the aforesaid structures is composed of asphalt, a carefully selected and graded finely comminuted filler or combination of such fillers, graded sand and carefully graded sharp, crushed stone. The combination of asphalt and filler shall be hereinafter referred to as filled asphalt or asphaltic mastic and the combination of filled asphalt with sand and the crushed rock comprising aggregate shall hereinafter be termed asphaltic concrete.

I have discovered that filled asphalt, rather than pure asphalt, is most suitable for filling the voids of sea walls and the like because filled asphalts possess greater toughness, reasonable high ductility, high melting point and moderately low penetration and have very little tendency to become unstable even when mixed with mineral aggregate in extremely high concentration as I have found necessary in asphaltic concretes for filling the voids of sea walls and the like. "D" grade asphalt is preferable over other grades of asphalt for this purpose due to its extreme purity, high ductility, great adhesive powers and absolute freedom from decomposition products so common in asphalts carelessly refined. This type of asphalt is also free of paraffin and contains less than 1% of sulfur. Paraffin in asphalt renders the same less adhesive so that it will not stick to rock, whereas sulfur makes the asphalt brittle. However, the small amount of sulfur which is ordinarily present in "D" grade asphalt renders the same more adhesive but asphalts containing larger quantities of sulfur should be avoided. A "D" grade asphalt is a steam refined asphalt having a 40 to 90 penetration at 77° F., a melting or softening point of 110–130° F. and a ductility of greater than 100 at 77° F. I prefer to employ an asphalt having a penetration of approximately 40 to 60, although asphalts of higher and lower penetrations may be used with success and are within the scope of my invention.

It will be observed that all mention herein of penetration, softening or melting point and ductility are according to the methods outlined by the American Society of Testing Materials as follows:

Penetration	D- 5–25
Melting point (ball and ring)	D- 36–26
Ductility	D-113–26—T

Any type of filler may be employed for admixture with asphalt. The best results are secured when using diatomaceous earth due to the absorptive properties of this type of filler which absorbs the oil in the asphalt and prevents it from evaporating, such as occurs when unfilled asphalt is exposed to the atmosphere. The evaporation of the oil from the asphalt shortens the life of the asphalt. Diatomaceous earth is also to be preferred due to the fact that it fills the minute voids in the asphalt which can be filled only by fine materials such as diatomaceous earth. This phenomenon aids in the production of a bituminous composition of great tensile strength and resistance to impact.

The diatomaceous earth which I prefer to use is one of sufficient lightness as to remain in suspension during the process of hot mixing with asphalt. Diatomaceous earths lighter than 12 lbs. per cubic foot are suitable. However, other types of fine fillers, such as fillers of the rock dust type which includes limestone dust, marble dust and slate dust, may be used either alone or in admixture with diatomaceous earth. It is preferable to mix a certain amount of diatomaceous earth with the rock dust due to the oil absorptive characteristics and due also to the fact that diatomaceous earth fills the voids in the asphalt. Rock dust does not have these properties, except in a minor degree.

Other types of fillers may be employed for admixture with asphalt, such as clay, infusorial earths, talc, coke, chalk, terra alba, lampblack, fuller's earth, ashes, kaolin, coal, peat, bone meal, ores, shale, marl, quartz meal, serpentine and asbestos. The only requirement in the use of these materials is that they be ground or pulverized prior to their admixture with asphalt. These materials may also be employed with diatomaceous earth and/or rock dust. When using coarse fillers such as rock dust, it is preferable that they be ground to such extent as to pass 200 mesh screens and finer. Fillers such as diatomaceous earth may be readily pulverized to pass screens of 1000 mesh and finer.

I have discovered that there is an optimum proportion of any given filler to obtain a filled asphalt of maximum tensile strength with respect to the filler employed and when two or more different fillers are used simultaneously, there is again an optimum proportion which may be added to asphalt to obtain a maximum tensile strength. My experiments have revealed that for any given composition of filler, there is a maximum percentage of filler which can be added to asphalt with beneficial effect upon the tensile strength of the asphalt, but that an excess above the maximum merely produces a non-cohesive, mealy mixture entirely unsuitable for the production of a sticky mastic. Thus, by mixing various percentages of filler to the asphalt, I have found that the tensile strength of the asphalt increased gradually with the admixture of filler in the asphalt until a condition is reached where the filled asphalt has a maximum tensile strength. Upon addition of more filler to the asphalt, the tensile strength sharply decreased and merely produced a filled asphalt having substantially little or no tensile strength. I have found that by adjusting the proportion of filler in the asphalt, a filled asphalt may be produced having an extremely high tensile strength and impact resistance than filled asphalts heretofore produced.

In order to determine the optimum concentration and kind of filler to be used to obtain a filled asphalt of high or maximum tensile strength and resistance to impact, I have conducted experiments with filled asphalt composed of the aforementioned "D" grade asphalt and fillers, such as diatomaceous earth and rock dust. A series of mixtures of the foregoing ingredients was prepared and the various mixtures which are designated herein as filled asphalt were used with Ottawa sand of 20 to 30 mesh to prepare a large number of cubical briquets for determining tensile strengths. Standard Ottawa sand was used as the mineral aggregate due to the uniformity of successive batches as determined by the U. S. Bureau of Standards and the American Society of Testing Materials. This sand is invariably employed as aggregate in determining tensile strengths of Portland cement concrete as anyone skilled in the art will readily understand.

I have also discovered that the maximum tensile strength and resistance to impact is obtained when the voids of the mineral aggregate are completely filled with the filled asphalt. Since the voids in Ottawa sand have been determined experimentally to comprise 32½%, all of the tensile strength determinations were made with a mixture of 67.5% by volume of Ottawa sand and 32½% by volume of filled asphalt. In preparing the briquets for tensile strength tests, all of the ingredients for each separate mixture were weighed together into the same iron dish and were heated to about 400° F. The ingredients were hand stirred until a homogenous mixture was obtained. The hot mixture was then rammed by hand into the molds ordinarily used for making tensile strength briquets of Portland cement concrete and then were allowed to cool in the molds. After removing the briquets from the mold they were allowed to stand overnight at room temperature and were then placed in a water bath at 77° F. for one hour or more before testing. The briquets were then pulled apart in a tensile strength testing apparatus. Table I illustrates the results of the test, that is, the tensile strengths of briquets composed of filled asphalt and Ottawa sand. It will be observed that the volume percentage of sand was maintained constant throughout the series of tests thus giving a direct comparison of the various filled asphalts. Only the amount of filler in the filled asphalt and the proportions of various types of fillers were varied.

TABLE I

The effect of mineral fillers upon the tensile strength of asphalt

Composition of filled asphalt % by weight		Composition of filler % by weight		Tensile strength of asphaltic concrete at 77° F in lbs. per square inch
Filler	Asphalt	Diat. earth	Rock dust	
0	100	----	----	111
10	90	100	0	142
20	80	100	0	259
30	70	100	0	339
40	60	100	0	391
45	55	100	0	84
50	50	100	0	14
10	90	50	50	126
20	80	50	50	198
30	70	50	50	240
40	60	50	50	288
45	55	50	50	295
50	50	50	50	322
55	45	50	50	209
60	40	50	50	85
10	90	25	75	161
20	80	25	75	173
30	70	25	75	198
40	60	25	75	256
50	50	25	75	308
60	40	25	75	350
65	35	25	75	276
70	30	25	75	203
10	90	10	90	216
20	80	10	90	244
30	70	10	90	252
40	60	10	90	330
50	50	10	90	347
60	40	10	90	352
70	30	10	90	328
10	90	0	100	159
20	80	0	100	206
30	70	0	100	175
40	60	0	100	191
50	50	0	100	245
60	40	0	100	257
70	30	0	100	285
80	20	0	100	219
85	15	0	100	148

The observed data of Table I has been charted as shown in Fig. 1 of the drawing where curve A represents a filled asphalt containing a filler comprising 100% diatomaceous earth; curve B represents one containing 50% diatomaceous earth and 50% rock dust; curve C, one containing 25% diatomaceous earth and 75% rock dust; curve D, one containing 10% diatomaceous earth and 90% rock dust and curve E represents one containing 100% rock dust. It will be observed that in each combination of filler or combination of fillers and asphalt, the tensile strength increased with the addition of filler until a maximum tensile strength was reached, after which the addition of more filler to the asphalt produced a sharp decrease in the tensile strength of the filled asphalt. Furthermore, in each instance, a filled asphalt was produced having an extremely high tensile strength. The highest maximum tensile strength was obtained when using the optimum concentration of filler comprising 100% diatomaceous earth which approximated 400 lbs. per square inch as represented by curve A. With the substitution of rock dust for the diatomaceous earth, the maximum tensile strength that could be reached was lower than when using straight diatomaceous earth. In the discussion of my invention, that percentage or concentration of filler in asphalt which will result in the production of a filled asphalt of maximum tensile strength for the given filler or combination of fillers shall be termed the optimum percentage or concentration of filler.

In terms of cost, rock dust is the cheaper filler for producing filled asphalt of high tensile strength, but it requires a lower concentration of asphalt in the mastic to produce a mastic of high tensile strength than does diatomaceous earth and a visual comparison of diatomaceous filled and rock dust filled mastics indicates clearly that the former type of filled mastics are greatly superior with regard to self-healing after fracture. This characteristic is important when the asphaltic mastic or concrete is employed for filling the voids in sea walls, breakwaters and the like when the stones are dislodged by large waves or swells and the bond of asphaltic concrete holding the stone together is broken. Furthermore, I have determined that in order to obtain an asphalt for use in sea walls having long life, it is necessary to incorporate as much asphalt as possible and at the same time to obtain the high tensile strengths necessary to resist impacts. Consequently, diatomaceous earth will permit the use of larger amounts of asphalt for a given tensile strength such as 300 lbs. per square inch.

From Table I and the curves in Fig. 1, it is evident that any one of the five filler combinations shown is capable of forming a filled asphalt having a tensile strength of approximately 300 lbs. per square inch or greater. The combinations listed in Table II have tensile strengths of approximately 300 lbs. per square inch when mixed with standard Ottawa sand in exactly the correct proportions to fill the voids in the sand, i. e. 67½% by volume of Ottawa sand to 32½% by volume of filled asphalt. A filled asphalt having a tensile strength of approximately 300 lbs. per square inch is more than satisfactory to fill the voids in sea walls, breakwaters, etc., under atmospheric temperatures ordinarily present where this type of construction is employed. In fact, by using filled asphalts either alone or with admixture with aggregate having tensile strengths of approximately 250 lbs. per square inch for filling voids in sea walls and the like, such structures will resist impacts from waves and the like much better than when the voids are filled with the best mixtures of Portland cement concrete and will additionally possess the property of self-healing, which, of course, is not apparent in Portland cement concrete. Tensile strength tests performed upon one inch cubical briquets composed of one part of Portland cement to three parts of Ottawa sand revealed tensile strengths of only 210 lbs. per square inch. The tensile strength of a briquet composed of one part of Portland cement, two parts of commercial sand and four parts of small rock, i. e. passing a screen having circular openings of one-quarter inch in diameter and under, was 229 lbs. per square inch.

Furthermore, it will be observed by inspection of the curves in Fig. 1 that it is possible to produce two filled asphalts of the same tensile strength with the same type of filler or combination of fillers when producing filled asphalts containing an amount of filler other than the optimum concentration. This may be accomplished by choosing an amount of filler which will produce a filled asphalt of the desired tensile strength either on the rising slope of the curve or on the falling slope beyond the optimum concentration of filler. For example, if it were desired to produce a filled asphalt having a tensile strength of approximately 300 lbs. per square inch using straight diatomaceous earth (curve A), this may be accomplished by employing either from 27 to 28% of diatomaceous earth or from 42 to 43% of the filler with the asphalt. However, it is preferable to choose the lower concentration of filler for producing a filled asphalt of the desired tensile strength for filling the voids in sea walls because it is desirable to use as much asphalt as possible in order to give the structure as long a life as possible and to give the structure the self-healing characteristics heretofore mentioned. Moreover, it is possible to control the production of a filled asphalt of the desired tensile strength much easier when using the smaller concentration of filler than when employing the larger concentration because the slope of the rising curve is not as sharp as the falling portion of the curve after reaching the optimum concentration. In other words, small variations in the amount of filler in the asphalt will not affect the tensile strength materially when using the lower concentration, whereas a small variation in filler when using the higher concentration may vary the tensile strength considerably from the one desired.

Briquets of the proportions of asphalt and filler resulting in tensile strengths of approximately 300 lbs. per square inch were tested for melting or softening points, penetrations, ductilities and specific gravities. The results are tabulated in Table II.

TABLE II

Comparison of physical characteristics and impact resistance of various filled asphalts having tensile strengths of approximately 300 lbs. per sq. in.

Composition by weight of filled asphalt			Physical characteristics of filled asphalt					Impact at cube destruction at 77° F. ft. lbs.
			Softening point (B. and R.)	Penetration at			Ductility at 77° F.	
Asphalt	Diat. earth	Rock dust		32° F.	77° F.	115° F.		
Percent	*Percent*	*Percent*	*°F.*					
72	28	0	178	4	23	111	16.5	3.32
57	21.5	21.5	219	4	18	75	6.5	3.13
50	12.5	37.5	180	3	21	91	9.2	3.32
62	3.8	34.2	128	6	32	220	60	2.35
25	0	70	180	3	17	58	2.9	3.22

It is evident from Table II that by selection of the proper fillers and filler concentration, it is permissible to produce a filled asphalt having unusually high ductilities as compared with air blown and steam refined asphalts of the same melting point. A filled "D" grade asphalt composed of 57% by weight of asphalt, 21.5% diatomaceous earth and 21.5% rock dust has a softening point of 219° F., a penetration of 4 at 32° F., 18 at 77° F. and 75 at 115° F., and a ductility of 6.5 at 77° F. Unfilled "D" grade asphalt merely has a melting point of 119° F. and penetrations of 8 and 52 at 32° F. and 77° F., respectively, (the asphalt being too soft at 115° F. for measurement of penetration) and a ductility of over 100 at 77° F. The tensile strength of the unfilled asphalt is merely 111 lbs. per square inch as compared with approximately 300 lbs. per square inch for the various filled asphalts shown in Table II. The penetrations of filled "D" grade asphalt compare favorably with air blown asphalts of the same melting point as filled asphalt, i. e. 219° F. The penetrations of air blown asphalt are 10, 18 and 30 at 32° F., 77° F. and 115° F., respectively, while the ductility is only 2 at 77° F. which is lower than that of filled asphalts. A steam refined asphalt having a melting point of 219° F. has a penetration of 2 at 32 and 77° F., respectively, while its penetration at 115° F. is zero and its ductility is zero at 77° F. An asphalt of this character is entirely unsuitable for use for filling the voids in sea walls, etc. due to the fact that it has no ductility.

It is thus evident, filled steam refined asphalts have most of the physical advantages of air blown asphalts which are more expensive to produce than "D" grade steam refined asphalts containing a filler. In other words, the addition of diatomaceous earth to steam refined asphalt imparts air-blown characteristics to the steam refined asphalt, i. e. it increases the melting point and produces a reduction in penetration and ductility in a manner similar to the chemical action of the air blowing process. However, it will be observed that for any given melting point, a filled asphalt will have a higher ductility at 77° F. than an air-blown asphalt.

In order to compare the relative brittleness of the foregoing filled asphalts, having tensile strengths of approximately 300 lbs. per square inch, 2 inch cubical briquets made by hot mixing Ottawa sand and filled asphalts in the proportions of 67.2% by volume of sand to 32.5% by volume of filled asphalt and cooling in exactly the same manner as that employed in making tensile strength tests were tested at 77° F. by dropping a 2 inch steel ball weighing 1.175 lbs. upon the cube, allowing the ball first to drop 6 inches and then progressively increasing the height of fall one inch per blow until destruction of the cube resulted. The proportions of asphalt to filler and the results of the tests are also shown in Table II. The impact at cube destruction was calculated by multiplying the height of fall in feet at cube destruction by the weight of the steel ball in pounds, i. e. 1.175.

To show the relative impact resistance of filled asphalt to Portland cement concrete, tests for impact resistance were performed on 2 inch cubical briquets of Portland cement concrete in the proportions by weight of one part cement, two parts sharp, clean sand and four parts sharp, clean, broken stone. The briquets had been cured seven days under water. The tests revealed an impact resistance of nearly 2.85 ft. lbs. which is considerably lower than the impact resistance for most of the filled asphaltic concretes.

While practically all of the foregoing data with regard to both tensile strength and impact resistance had been obtained by using Ottawa sand aggregate due to the fact that this type of sand is more uniform than other types and consequently more accurate comparisons may be made, I have obtained similar results using commercial aggregates with filled asphalts and have found the same to be superior to Portland cement concrete. For example, I have tested slabs of asphaltic concrete 27 inches wide, 36 inches long and 2 inches thick with reinforcing wire through the slab. These were constructed by placing a one inch course of small crushed stone in a form and filling the voids with filled asphalt composed of 72% by weight of "D" grade asphalt and 28% by weight of diatomaceous earth at 450° F. Wire fencing for reinforcement was placed over this course and then a second one inch course of crushed stone was laid over the reinforcing and first course. Hot filled asphalt was again applied to the crushed stone. Immediately after the second application of asphalt, screenings were broomed over the slab and the entire slab was consolidated by hard tamping.

Portland cement concrete slabs of exactly the same size as those made with asphaltic concrete and with the same type of reinforcing mesh wire were prepared. The concrete had a composition by weight of one part Portland cement to four parts of clean, sharp, graded sand. This composition is stronger than concrete containing by weight one part Portland cement, two parts sand and four parts crushed stone. These slabs were cured for seven days under water prior to testing.

After seven days of aging, a slab of Portland cement concrete was tested by impacting a falling hammer weighing ten pounds dropped from a height of three feet on the slab which was placed on a dry sand bearing three to four inches thick and in such position that the falling hammer struck exactly the center of the slab. On the second blow, the Portland cement concrete slab cracked through its entire length and was held together merely by the reinforcing. It was completely destroyed a few blows thereafter. The reinforced asphaltic concrete slab was tested in exactly the same manner. One hundred blows from a height of three feet produced no fracture whatever and merely beat down a slight depression under the hammer due to chiefly to the smashing of the sceenings which formed the upper course of the slab.

To illustrate the flexibility of the asphaltic concrete slab, it was placed across a pile of sand so that the slab was supported only at its center. This test showed that although the slab bent to follow the contour of the sand pile, it did not crack. To illustrate the self-healing characteristics, the slab was purposely cracked by a sharp blow and was then placed on a flat surface and in a short course of time, the crack disappeared.

In order to employ filled asphalts with commercial aggregates, it is preferable to adjust the percentage of filled asphalt to exactly fill the voids in the commercial aggregate and to select a commercial aggregate comprising a mixture of sand and rock having a maximum density and a minimum of voids. The percentage of voids in aggregate using a mixture of graded sand and small rock capable of passing a screen having circular openings of one-half inch diameter and under and its density may be determined by filling a container level full of the aggregate and compacting the same until no more of the aggregate could be placed in the container. By first weighing the dry mixture and then weighing the mixture with water added thereto in amounts sufficient to fill the can, the true specific gravity and the percentage voids by volume can easily be calculated as understood by those skilled in the art. I have found that the percentage of voids in the aggregate was considerably high when the aggregate contained no graded sand. With addition of the sand in the aggregate, the percentage voids gradually decreased until a mixture of 50.5% by volume rock and 49% by volume sand was reached which had about 20.5% voids, after which an increase in the proportion of sand gradually increased the percentage of voids in the mixture of sand and crushed rock. I have thus found that the maximum density of asphaltic concrete using commercial aggregate could be obtained by mixing 20.5% by volume of filled asphalt and 79.5% by volume of commercial aggregate comprising a mixture of 50.5% by volume rock and 49.5% by volume of sand.

It will be observed that my filled asphaltic mastics or concretes are entirely dissimilar to ordinary paving bituminous concretes since my mastics or concretes are much richer in asphalt than any mixture that can be practically successful for paving. The particular objects in view in selecting the composition for my mastic or concrete are to use as much asphalt as can be absorbed by the stone, sand and filler so as to obtain maximum toughness and cementing power and at the same time to protect the asphalt within the mastic against the action of sun, air and moisture and to thus obtain an indefinitely long life for the asphaltic concrete. Paving mixtures are too lean in asphalt to meet the foregoing requirements and are too rigid, requiring constant compaction by traffic to maintain them in good condition. Excessive asphalt, over the requirements for good pavement is essential to my system of sea wall, breakwater, etc. protection in order to obtain maximum adhesiveness and flexibility, whereas excess asphalt in paving mixture forms poor pavements which will "push" and "bleed". However, it is one of the essential features of my invention of my mastic for sea wall protection that exactly the correct quantity of filled asphalt to fill the voids in the aggregate shall be used in order to obtain the greatest tensile strength and impact resistance. Neither a deficiency nor an excess of filled asphalt to exactly fill the voids in the aggregate will result in an asphaltic concrete of maximum strength, although a slight excess will give good results.

Moreover, I am able to incorporate considerable more asphalt into my asphaltic concrete than can be added in asphaltic concretes suitable for paving or other purposes. The reason that my asphaltic concrete could stand considerable more asphalt is due to the fact that I employ considerable more filler than can be used in asphaltic concrete for use in pavements or other purposes. The excess filler and asphalt makes for a concrete which is a tougher, more stable, cementing agent than any asphalt suitable for paving purposes.

The method for constructing sea walls, ripraps or breakwaters such as the one represented by 10 in Fig. 2 consists in dumping the plastic asphaltic concrete or mastic 11 at a temperature of 250 to 450° F. upon each course of stone 12 above low tide level and subsequently laying the next course of stone upon the mastic while the latter is still in a plastic state. The stones 12 employed should be large, weighing from 15 to 30 tons. Each stone laid upon the concrete then sinks into the latter and thus forms a perfect bed. In a short time, the large stones and asphaltic concrete will form a monolithic structure. It is not desirable to fill in the large voids on the water side 14 of the sea wall with mastic or concrete excepting to such extent as is required to form a firm bed for each stone, since it has been found that sea walls and breakwaters should preferably have very rough and irregular faces in order to most effectively absorb, deflect and break-up the impact of waves or swells. However, it is desirable to fill as completely as possible with asphaltic concrete all of the voids within the wall in order to prevent rapidly moving masses of water from striking the rocks from below and thus lifting them out of place and from preventing receding water from carrying the protected earth 15 out with the wave. Preferably, where extremely large voids are presented by the large stones, the voids are filled with smaller stones 16 of approximately 50 to 100 lbs. These are placed in the voids either prior to filling of the voids with asphaltic concrete or afterwards. This increases the stability of the asphalt against flow due to the fact that the asphaltic concrete fills the voids in the stones.

For sea walls and breakwaters which have already been completed without the use of asphaltic mastic or concrete, the concrete may be placed in the voids by any convenient method, such as, for example, buckets, conveyors, pipes, chutes and the like. Where necessary to insure complete filling of the voids spading, rodding or ramming by means of hand or machine driven implements may be used. By applying the asphaltic mastic or concrete sufficiently hot or considerably above its melting point, the use of implements is not necessary since the hot mastic or concrete will readily flow into the voids and crevices of the lower courses of stone until it contacts the sea water, whereupon it will harden to prevent further flow. However, it is believed that if the hot cementing agent reaches the low tide level, the sea wall is sufficiently protected to combat large waves or swells, since it has been found that substantially all of the destructive action of the waves or swells occurs above water level. Large stones forming the foundation below the water level are rarely, if ever, disturbed by the waves.

Sea walls or breakwaters constructed in the above manner and with my asphaltic mastic or concrete are capable of withstanding the destructive action of large waves or swells even in stormy weather. In extreme storms it may be possible to lift the large stones from their embedment to some small extent, thus breaking the bond of asphaltic concrete. However, the protection afforded by the asphaltic mastic or concrete will never permit the waves to lift the large stones completely off the wall. Furthermore, the fracture will occur in the asphaltic mastic or concrete itself. Considerable amounts of the asphaltic material will adhere to the large stones and when they fall back to their former positions, the effective healing characteristics of the asphaltic material will soon bind the fracture to again form a monolithic structure.

Any of the filled asphalts disclosed in Table II which have tensile strengths of approximately 300 lbs. per square inch may be employed with commercial aggregate for filling the voids in sea walls, breakwaters, etc. A specific example would be a filled asphalt composed of equal parts by weight of "D" grade steam refined asphalt and filler where the filler is composed of one part by weight of diatomaceous earth to three parts by weight of rock dust. The only care that must be exercised is to so proportion the amounts of filled asphalt to aggregate that the former exactly fills the voids in the aggregate, neither in deficiency nor in excess. The voids in dense aggregates may comprise from 15 to 25% by volume so that approximately 75 to 85% by volume of filled asphalt should be employed to exactly fill the voids in the aggregate. I have shown that when using an aggregate comprising graded sand and small crushed rock of one-half inch or less that the voids are about 20.5% and consequently this percentage of filled asphalt should be used in the proportion of 50.5% by volume of rock to 49.5% by volume of sand. However, I do not wish to be limited to the size of aggregate employed nor to the use of any aggregate since I have obtained equally good results with merely the use of sand as aggregate.

In some instances, it is desirable to use an asphaltic concrete of greater than 300 lbs. per square inch tensile strength. For this purpose, any of the combinations of asphalt to filler disclosed in Table I having tensile strengths of greater than 300 lbs. per square inch may be employed and if necessary the optimum concentration of filler may be used to produce a filled asphalt of maximum tensile strength. If it is desired to use filled asphalts of lower tensile strength than approximately 300 lbs. per square inch, any of the combinations of filler to asphalt disclosed in Table I having approximately the desired tensile strength may be employed. However, it will be observed that the ductilities rise proportionately to the decrease in tensile strength, varying with the quantity of filler used. In other words, I do not wish to be limited to filled asphalts having approximately 300 lbs. per square inch tensile strengths since both higher and lower tensile strength filled asphalts may be used for filling the voids in sea walls and the like. However, I prefer to employ an asphaltic concrete or mastic having an amount of filler approaching the optimum concentration.

While the above invention has been described using "D" grade asphalt as the preferred asphalt, it is evident that other grades of asphalt having both higher and lower penetrations, softening or melting points and ductilities than "D" grade asphalt may be employed in combination with fillers and with a certain degree of success. Furthermore, it must be understood that this invention is not limited to the use of the preferred steam refined asphalt since other types of asphalt, such as air blown asphalt, may be employed, nor is the invention limited to an asphalt as the plastic ingredient since other bituminous products having more or less cementing characteristics may be employed such as cracked and uncracked petroleum residues, cracked and uncracked coal tar residues, pitch, tar and the like.

The above disclosure is to be taken merely as illustrative of a preferred embodiment of my invention and is not to be considered limiting, since many variations thereof may be made within the scope of the following claims:

I claim:

1. An asphalt composition comprising asphalt and a finely divided filler, the filler comprising more than 35 percent of the composition by weight and the asphalt in said composition having a penetration at 77° F. between 40 and 90, a melting point between 110 and 130° F. and a ductility greater than 100 at 77° F.

2. An asphalt composition comprising asphalt and a finely divided filler, the filler comprising more than 35 percent of the composition by weight and the filler including diatomaceous earth, and the asphalt in said composition having a penetration at 77° F. between 40 and 90, a melting point between 110 and 130° F. and a ductility greater than 100 at 77° F.

3. An asphalt concrete adapted to be used for filling the voids presented by massive stones used in constructing breakwaters, sea walls and the like, said concrete containing approximately 75 to 85 percent by volume of aggregate and 25 to 15 percent by volume of an asphalt composition containing a finely divided mineral filler, the asphalt in said composition having a penetration at 77° F. between 40 and 90, a melting point between 110 and 130° F. and a ductility greater than 100 at 77° F., the asphalt concrete having self healing properties, high tensile strength, high impact resistance, low penetration, marked flexibility and strong adhesive qualities for the stones, whereby breakwaters and sea walls constructed therewith show marked resistance to destructive wave action.

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