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F. S. BESSON

METHOD FOR TESTING BITUMINOUS PAVING MIXTURES

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Fig. 1.

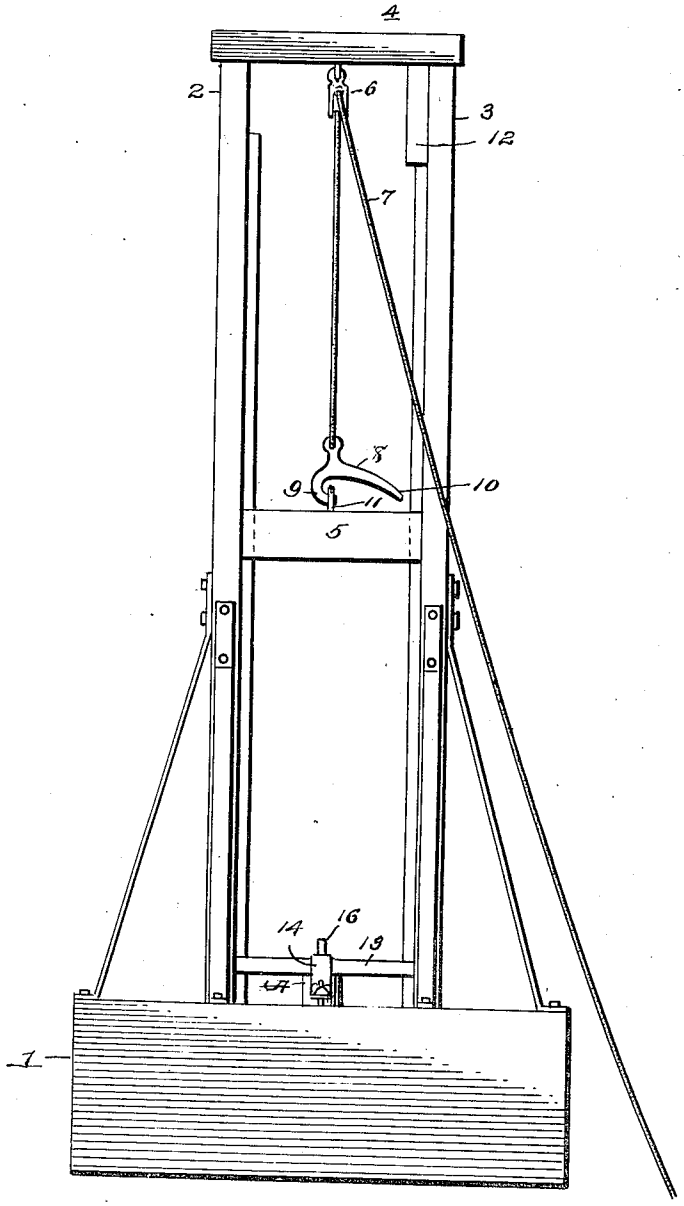
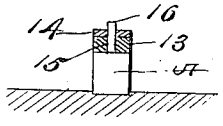


Fig. 2.



Inventor

Frank S. Besson

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UNITED STATES PATENT OFFICE.

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METHOD FOR TESTING BITUMINOUS PAVING MIXTURES.

Application filed August 5, 1921. Serial No. 490,172.

(FILED UNDER THE ACT OF MARCH 3, 1883, 22 STAT. L., 625.)

To all whom it may concern:

Be it known that I, FRANK S. BESSON, a citizen of the United States, and a resident of Washington, District of Columbia, have invented an Improvement in Methods for Testing Bituminous Paving Mixtures, of which the following is a specification.

The invention described herein may be used by the Government, or any of its officers or employees in prosecution of work for the Government, or by any other person in the United States, without payment to me of any royalty thereon.

This invention relates to the production of paving mixtures, more especially it is directed to a new and improved method for rapidly and accurately determining the worth of an untried aggregate, based on known conditions and results.

One of the principal objects of this invention is to provide a method of the character designated which will enable an accurate diagnosis of bituminous paving mixtures in advance of laying and permit of a uniform mode of procedure, affording definite dependable data relative to the durability and probable life of such mixtures under traffic conditions.

Another important object of this invention is to provide a method, through the instrumentality of which it becomes possible to accurately ascertain the character of mineral aggregate best suited to the purpose for which the mixture is to be used.

Another object of this invention is to provide a method of mixing bituminous pavings which will enable the use of aggregates locally available and eliminate the necessity of employing artificial mixtures which in some parts of the country, by virtue of their cost, are almost prohibitive.

Other objects of this invention are to eliminate so far as it is possible the factors giving rise to defective bituminous paving mixtures, and to place the theory of paving design upon a practical basis.

With these and other objects in view this invention consists in certain novel details of procedure and proportioning of materials as will be more specifically hereinafter set forth and claimed.

In the companion application entitled "Bituminous paving," filed May 26, 1920, Serial No. 472,887, there is described a method by which the bituminous binding agent and mineral aggregate are proportioned and combined in accordance with a previously arranged diagram to effect what may be termed a "normal mix." This diagram, while affording accurate and satisfactory results in respect to the amount of bitumen required for any particular aggregate, fails to impart information concerning the character of the aggregate to be used, or the worth of the resulting mixture for specific purposes.

In order to definitely determine these problems, it has been necessary to supplement the data initially obtained with additional developments to the end, that the haphazard and indefinite "mix and try" methods heretofore employed may be replaced with an accurate mode of procedure which will, to a large extent, standardize the production of bituminous pavings.

In bituminous surfaces, embodying binder and topping, there are three elements to which failure may be attributed: (*a*) binder course, (*b*) bitumen in the topping, (*c*) mineral aggregate, but which of these should be blamed for defective paving mixtures has always been a matter of conjecture.

As a result of investigations, it has been found the question of binder can best be eliminated by omission of this course, especially as the surface without the binder is but one half the usual thickness and would therefore require much less material for maintenance.

As to the second factor of uncertainty, that is to say, bitumen in the topping, which involves both the character of the bitumen and the amount to be employed with any particular aggregate, this question has now been largely determined by accurate specifications guaranteeing uniform bitumen products, and the diagram method disclosed in the application hereinbefore referred to.

In regard to the third factor productive of defective paving mixtures, namely, mineral aggregate, it has been found that when:

(*a*) An aggregrate is mixed with a normal amount of bitumen it, in some cases, is particularly adaptable to certain purposes.

(*b*) Reducing or increasing the bitumen beyond the normal, makes the mixture applicable to widely different usages.

The prevailing practice to determine the worth of a mixture has been to lay and subject it to traffic extending over a period of years, noting in the meantime the effect of such traffic as a guide in the preparation of future mixtures. Manifestly this is a highly unsatisfactory procedure, owing to time required, to say nothing of the expense involved, and it is therefore the aim and purpose of this invention to provide a means whereby tests can be quickly made in the laboratory which will provide reliable information as to both the character of aggregate, the probable life of the mixture and the usage to which it is best suited.

In the accompanying drawing in which corresponding facts are indicated by similar reference characters,—

Figure 1, is an elevation of one form of testing apparatus, with a test-block operatively positioned, and

Figure 2, is a sectionized detail partly in elevation, illustrating the assembly of guide, clamp and test-block.

Briefly stated, this improved method consists in selecting a series of samples from various streets which have long been subjected to extreme traffic conditions, forming these samples into blocks of a predetermined size, subjecting each block to the penetration of a pin at a known temperature, the pin being actuated by a weight falling through a given distance, recording the number of blows required to either crack or penetrate the sample, the nature of the fractures, and utilizing this data as a basis in the diagnosis of original mixtures.

In actual practice, cylindrical, compressed blocks, 10 c.m. in diameter, are made of the mixture to be tested, each block containing 1,000 grams of mineral aggregate and as many grams of bituminous cement as may be found necessary to give the required percentage of bitumen. A steel pin 19 mm. in diameter is centered over the block and subjected to a series of blows delivered by a miniature pile driver weighing 20 kilograms and falling through a distance of .8 meters.

Although various forms of apparatus may be employed in carrying out the tests forming the subject matter of this application, the design found to afford the most satisfactory results is shown in the accompanying drawings and embraces a base (1), parallel guides (2) and (3), and cross-head (4). Between guides (2) and (3) is slidably positioned a 20 kilogram weight (5), suspended by a block and tackle (6) and (7). Weight 5 is releasably secured to the tackle by means of a trip (8), consisting of a bill portion (9) and an extended leg portion (10). The bill portion (9) normally engages an eyelet (11) secured to the weight (5), while the leg portion (10) cooperates with a contact piece (12) located on the guide (3) to effect disengagement of bill portion (9) when the weight has attained the desired elevation.

In operation a cylindrical specimen (A) is properly positioned on support (1) and upon said specimen is disposed a pin guide (13) secured in position by a clamp (14). This guide is formed with a central aperture (15) in which is seated a pin (16) adapted to be driven into the specimen by the falling weight for the purpose hereinbefore alleged.

With the use of the apparatus just defined after a number of blows, the pin either completely fractures the block, or perforates it to its full available length, 60 mm., accompanied by more or less cracking. A record of the blows delivered, their general effect, together with a close study of the fractured blocks, will either suggest the use of similar mixtures or warn against them.

In the application of this improved method, photographic records are made of the results of the tests and used as laboratory models; but for the purpose of this application these results have been set forth in tabulated form as will hereinafter appear.

To obtain suitable models of specimens for laboratory determinations, samples were selected from various streets in and about the District of Columbia, formed into blocks as previously stated, and tested. The results of the tests are as follows:

No.	Street descriptions.	Blows.	Result.
1	Economical service rendered over a number of years. No noticeable defects.	5 to 7 at 77° F.	The block specimens break into 2 or 3 pieces with clean planes of fracture.
2	Contain a network of cracks, dividing the surface into patches, each containing an area of a sq. yd. or more. Give better service in summer than in winter.	1 to 3 at 77° F.	Specimens break into three or more large pieces with more or less crumbling.
3	Extreme old age accompanied by some cracking.	1 to 3 at 77° F.	Specimens break into three or more large pieces with more or less crumbling.
4	The surface pushed into waves or bumps. Uncomfortable to ride over. Give better service in winter than in summer.	1 to 4 at 77° F.	Specimens give varying results and at 77° F. little inference can be drawn. See No. 5—Tests at 140° F.
5	The surface pushed into waves or bumps. Uncomfortable to ride over. Give better service in winter than in summer.	1 or 2 at 140° F.	The pin penetrates to its full depth with little or no cracking of the specimens.
6	Contain a network of cracks, dividing the surface into patches, each containing an area of a sq. yd. or more. Give better service in summer than in winter.	3 to 5 at 140° F.	The specimens break as do those from good streets described in No. 1 when tested at 77° F.

With reference to the preceding tabulation, the first specimen represents a sample

of a mixture taken from a pavement that may be placed among the oldest serviceable sheet asphalts in this country. The fact that it is a most excellent mixture has been proved by a life of 42 years, its service rendered to-day being more economical than that of most surfaces but half the age.

Comparing samples 1, 2, 3 and 4, while the difference between good and cracked pavings becomes instantly apparent, considerable difficulty was at first experienced in distinguishing between the mixtures which would result in cracked pavements and those which shoved into waves, inasmuch as both, at a temperature of 77° F., gave substantially the same results as shown by specimens 2 and 4 of the above list.

To solve this problem, a study of the waved streets was made whereupon it was noted that maintenance during the hot months was heavier than in the cooler ones, and that the waves iron out in the winter to reappear in the summer. The idea was thus obtained that these tests should be made at a temperature higher than the usual room temperature, accordingly a thermometer was buried in a street and a temperature of 140° F. noted. Tests were then made at this temperature, and the difference between mixtures resulting in cracked or wavy pavements became immediately manifest as evidenced in specimens 5 and 6 of the preceding tabulation. In the case of mixtures producing a wavy pavement at a temperature of 140°, the pin penetrated the block to its full depth, while with mixtures resulting in cracked pavements the block broke somewhat similar to good specimens tested at average temperatures. This coincident is in accord, however, with the fact that though badly cracked streets generally show much disintegration during the winter, they render fair service in the summer.

While a comparison of the results between tests made at 77° F. and 140° F., establishes a clear line of demarkation between cracked and wavy pavements, it is more expedient to collect specimens from three classes of pavements (*a*) good, (*b*) cracked, (*c*) wavy; form five blocks from each specimen and then test the blocks of the respective specimens at 32°, 50°, 80°, 110°, and 140° F., a comparison of the results of these tests will supply sufficient data for satisfactory conclusions concerning the different mixtures.

In view of the above it will be seen with the aid of these laboratory samples it is possible to make up new mixtures and readily diagnose the possible worth of such mixtures by comparison with such models. In this connection it may be said, in order to have the blocks on a strictly comparative basis, the same bituminous cement is used in all.

The necessity of subjecting bituminous cements to rigid tests has long been recognized, but heretofore no tests have been commonly applied to determine the relative suitability of mixtures as effected by the mineral matter employed. With the aid of this block test, however, it becomes possible to readily ascertain the influence of dust upon an aggregate, and the effect of changing the quantity of bitumen, the susceptibility of aggregates to temperature changes and the action of aggregates as influenced by the consistency of bitumen predetermined by the penetration test. These determinations will be considered and illustrated in the order mentioned.

Variations in behavior of different aggregates when mixed with a percentage of bitumen other than normal, is illustrated in the following tabulation showing the influence of dust upon an aggregate and the effect of changing the quantity of bitumen, test being made at 77° F., the asphalt having a penetration of 50 units.

Description of aggregate.	Too little bitumen.	Normal bitumen.	Too much bitumen.
100% sand passing the No. 10 mesh. Well graded. 47.1% voids.	9.1% bitumen. 3 blows breaks the specimen in two with slight crumbling.	12.3% bitumen. 6 blows breaks the specimen cleanly in two.	15.2% bitumen. With 8 blows the pin fully penetrates with one radial crack.
85% No. 10 sand with 15% limestone dust. 45.6% voids.	8.3% bitumen. 3 blows breaks the specimen in two with slight crumbling.	11.4% bitumen. 5 blows breaks the specimen cleanly in two.	14.6% bitumen. With 8 blows the pin fully penetrates with one radial crack.
70% No. 10 sand with 30% limestone dust. 47.1% voids.	9.1% bitumen. 4 blows breaks the specimen in two with slight crumbling.	12.3% bitumen. 8 blows breaks the specimen cleanly in two.	15.2% bitumen. 6 blows. The pin penetrates with no cracking of the specimen.
50% No. 10 sand. 50% limestone dust. 50.7% voids.	12.3% bitumen. 7 blows breaks the specimen cleanly in two.	15% bitumen. 6 blows. The pin penetrates with no cracking.	17.4% bitumen. 5 blows. The pin penetrates with no cracking of the specimen.
30% No. 10 sand. 70% limestone. 56.6% voids.	13.4% bitumen. 9 blows breaks the specimen cleanly in two.	15.6% bitumen. 6 blows. The pin penetrates with no cracking.	18% bitumen. 4 blows. The pin penetrates with no cracking of the specimen
100% limestone. 60% voids.	17.4% bitumen. 4 blows breaks the specimen cleanly in two.	20% bitumen. 6 blows. The pin penetrates with no cracking.	22.5% bitumen. 4 blows. The pin penetrates with no cracking of the specimen.

In the light of the above test, it is evident that bituminous requirements depend upon the voidage and not on the presence or absence of certain sizes in the mineral matter, as has long been assumed.

Because of the known influence of temperature changes on a bituminous paving, it is essential that the mixture be as insensi-

tive to temperature as possible. When conducting investigations as to the character of mixture best suited to the conditions to which it is to be subjected, it is necessary to make a temperature test of the sample.

As an illustration, a test has been made using a No. 10 sand having a voidage of 44.6%; the bitumen percentage being 11, and the asphalt penetration 50 units, the result being as follows:

Temperature.	Result.	
32° F.	2 blows.	The specimen breaks cleanly into three.
50	2 blows.	The specimen breaks cleanly into two.
70	3 blows.	The specimen breaks cleanly into three.
90°	6 blows.	About one-third of the specimen breaks off. One radial crack in the larger portion.
100	8 blows.	About one-third of the specimen breaks off. One radial crack in the larger portion.
130	6 blows.	The pin penetrates. Several radial cracks showing.
150	5 blows.	The pin penetrates. Several radial cracks showing.
180	3 blows.	The pin penetrates. Several radial cracks showing.

With reference to the above tabulation, it is to be noted when heated to more than 100° F., the mixture becomes soft and is penetrated by the pin thus indicating that in pavings subject to high temperature, such a mixture would produce a wavy street.

In the foregoing, the effect of the addition of dust in the mixture and the influence of temperature changes has been discussed and shown. It now remains to illustrate the action of aggregates as influenced by the consistency of bitumen predetermined by the penetration test. Accordingly, a test has been made using a No. 10 sand with 45.6 voids having a bitumen requirement of 11.5. The results of this test are as follows:

Penetration.	Result.	
15	1 blow.	The specimen breaks cleanly in two.
35	2 blows.	The specimen breaks cleanly into three pieces.
50	6 blows.	The specimen breaks cleanly into two pieces.
65	7 blows.	The pin penetrates with several radial cracks showing.
90	6 blows.	The pin penetrates but two radial cracks.

With the aid of this test it is evident for the mixture used, a cement having a penetration of about 50 units affords the best results.

In conclusion it may be said that successful experiments have conclusively demonstrated that the herein described method for designing bituminous paving mixtures will materially reduce the cost of construction, enable satisfactory laboratory diagnosis, permit usage of locally available aggregates, and in general places the production of bituminous paving on a workable basis.

Having described my invention, what I claim to be new and patentable is:

1. A method for testing bituminous paving mixtures consisting in selecting a paving specimen of known service value and composition, forming it into a block of predetermined form and weight, subjecting the block to the impact of an element actuated by a body falling through a given distance, recording the number of blows required to cause the element to become imbedded in the block or to pulverize or crack it, similarly treating a like formed block of original mixture and comparing the number and effect of the blows on the latter with those on the first mentioned block to determine the probable service value of the original mixture.

2. A method for testing bituminous paving mixtures consisting in selecting a paving specimen of known service value and composition, forming it into a block of predetermined form and weight, subjecting the block, at a definite temperature, to the impact of an element actuated by a body falling through a given distance recording the number of blows required to cause the element to become imbedded in the block or to pulverize or crack it, similarly treating a like formed block of original mixture and comparing the number and effect of the blows on the latter with those on the first mentioned block to determine the probable service value of the original mixture.

3. A method for testing bituminous paving mixtures consisting in selecting a paving specimen of known service value and composition, forming it into a series of blocks, each having a predetermined form and weight, subjecting the respective blocks, at temperatures ranging from 32 to 140°, to the impact of an element actuated by a body falling through a given distance, recording the number of blows required to cause the element to become imbedded in the block or to pulverize or crack it, similarly treating a series of like formed blocks of original mixture and comparing the number and effect of the blows on the latter with those on the first mentioned blocks to determine the probable service value of the original mixture.

FRANK S. BESSON.