RUBBERIZED ASPHALT PAVEMENTS

By

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ABSTRACT

Probably 95 percent of the major damage to our highways and streets is the result of fatigue failure due to the high repetition of vertical deflections to which they are subjected by today's heavy traffic. In order to overcome this fatigue failure, which is characterized by "alligator" pattern cracking, it is necessary to build more flexibility in maintenance seal coats or pavement overlays, and in construction of new pavements. The problem was recognized many years ago and attempts were made to increase flexibility by the addition to the asphalt of small percentages of rubber, generally three to five percent, by weight of the asphalt. The results obtained were uncertain, and disappointment often resulted.

The procedure described in this paper utilizes 25 percent or more, by weight of the asphalt-rubber composition, of ground tire rubber, a waste product, as an additive to asphalt. The two are reacted at high temperatures to form a composition that is tough and elastic and whose properties are different from either rubber or asphalt. It has been successfully used in both the seal coat and plant mix processes in the prevention of reflection cracking in maintenance and new construction, and has proven to be a solution to the damage from fatigue type cracking.

RUBBERIZED ASPHALT PAVEMENTS

The title of this paper may be a little misleading, as it will conjure up in the minds of those who have been connected with the construction of highways and streets for many years the old familiar rubberized bituminous mixes and rubberized seal coats containing small quantities of rubber in the range of three to five percent, by weight, of the asphalt. Small quantities of rubber, in the range of three to five percent, by weight of the asphalt used, have generally resulted in uncertain degrees of success in the prevention of reflective cracking. The primary reason is that such small quantities of rubber do not adequately modify the asphalt properties enough to insure the flexibility required of the surface of the highway under the deflections from our heavy traffic.

I am going to talk about an entirely different concept wherein the percentage of rubber employed is 25 percent or more, by weight, of the combined asphalt and rubber (12)*. It is an entirely different product from either asphalt or rubber, and we refer to it as an asphalt-rubber composition.

As you are all aware, probably 95 percent of the major damage to our highways and streets is the result of fatigue failure due to the high repetition of vertical deflections to which they are subjected by today's heavy traffic (3) (5) (11). It is, therefore, necessary to design new pavements so that the magnitude of the deflections is reduced to approximately .010 to .015 of an inch on major arterial highways or to design a pavement that will take repeated vertical deflections without developing fatigue failure characterized by "alligator" cracking (4) (8) (6). Similarly in overlaying all pavements that have already failed from fatigue, it

*Numbers in parenthesis refer to the reference bibliography at the end of this paper.

is necessary to build into these overlays either much greater rigidity or much greater flexibility. This paper will discuss the incorporation of greater flexibility in either new construction or in the correction of fatigue failure in old construction.

I have been concerned with this problem since the early 1950's when traffic first began to build up in this state and I was Division Materials Engineer for the then United States Bureau of Public Roads. The need for more flexibility in asphalt pavements, and possible solutions, was discussed in a paper delivered at the Arizona Roads and Streets Conference in 1954 (9). The concept has been developed and tried out on a large scale here in the City of Phoenix with the assistance of our Street Maintenance Department, headed by Mr. James A. Stokely (18) and by the Arizona and New Mexico Highway Departments. Other smaller cities in Arizona and California have also used the process. The process can be used in either a seal coat type of treatment or in an open-graded bituminous mix finishing course. The major use to date has been in the seal coat mode.

The asphalt-rubber binder composition is made by combining ground tire rubber of No. 16 to No. 25 mesh size with hot asphalt at a temperature range of 350°F to 450°F. At this temperature, a reaction occurs within a short time, generally less than 30 minutes, which results in a thick jelly-like material, when hot, and changing to a tough elastic material at room temperature.

The composition has much lower temperature susceptibility than conventional asphalt (2) and, therefore, is less prone to brittleness in cold weather or to bleeding in hot weather. (See Appendix for graph). The adhesion characteristics in the presence of water have proven to be superior to that of asphalt alone, so the susceptibility to stripping of aggregates is also reduced (13).

In order to apply this material through a distributor, it is necessary that the viscosity be reduced by adding a small amount of kerosene, or another petroleum solvent. The kerosene is usually added after the temperature of the composition drops below 350^{O}F, the approximate boiling point of kerosene, in the amounts of 5-1/2 percent to 7-1/2 percent, by volume of the asphalt-rubber composition.

The combining of the rubber with the asphalt must be carried out in some sort of mixing device. The one presently used in this state was devised by a local applicator and involves the use of a shaft with paddles extending the length of the distributor tank. This shaft can be driven by either a power takeoff from the truck engine or an auxiliary power source. After mixing, the material is spread on the roadway by the distributor and followed by the application of cover aggregate in the usual manner employed in normal seal coat operations. The quantities of materials used are also greater than in a conventional seal coat, ordinarily ranging from .47 to 0.5 of a gallon per square yard of the asphalt-rubber composition and 37 to 39 pounds per square yard of 3/8" nominal sized cover aggregate.

The restrictions necessary in the application of the material are essentially the same as those necessary to good seal coat practice and are covered in the copy of a specification that will be found in the appendix of this paper. High traffic volumes should be restricted from using the completed treatment for several hours after placing in order to avoid damage from occasional vehicles who attempt to "spin out" on loose chips. This damage is most apt to occur at signalized intersections and can be corrected by applying a second application utilizing the same application rates used on the first application. The material is unique in this respect in that it does not tend to develop bleeding with successive, equal applications of the composition and cover aggregate.

The safety factor of these applications is good as they show high skid resistance with skid numbers varying between 60 and 80, using our local aggregates of the hard, siliceous variety.

We use this process on pavements that would ordinarily require either major reconstruction or very heavy three or four inch overlays to remedy the distress involved. Since most of our pavements are confined by curbs and involve underground drainage facilities, heavy overlays are out of the question. Major reconstruction of an arterial street in our city costs approximately $24,000 per block as opposed to $2,400 per block for the hot asphalt-rubber treatment. This, of course, is not to say that the two procedures are equal in all respects. The economic and service benefits are very significant, however, if the asphalt-rubber treatment indefinitely postpones reconstruction. As a sequel, there is a strong probability that it can be indefinitely maintained in the future with an additional asphalt-rubber treatment after an estimated five to ten years of service. The surface resulting from this process is approximately 3/8" thick so that it does not significantly reduce curb height, or interfere with, or require changes in subsurface drainage structures, manhole covers, and so forth.

At this point, you might ask why such a thin surface will prevent the reflection of "chicken wire" or "alligator" pattern cracking from reflecting through to the surface. One of the reasons, of course, is the additional elasticity and reduced temperature susceptibility of this material when compared with asphalt. The other reason is that the rubber component only partially dissolves in the composition so that the rubber particles themselves serve as elastic interference units to prevent crack propagation from below. When a crack begins to propagate through the membrane, it will stop when encountering one of the rubber particles, whereupon it will start at another location and be similarly stopped, and so forth. Ground rubber has been used in a similar manner for the same purpose in the manufacture of plastics for a number of years to reduce their tendency to shatter on impact (14).

One often finds small localized areas of elastic, or fatigue, type failure where repair with massive equipment is not justified. Common maintenance practice is to surface patch with bituminous material, which soon fails and requires repeated expensive attention, or to dig out the area to a depth estimated to be adequate and replace with new base and surfacing. This latter treatment may, or may not, solve the problem depending on the individual judgment of the foreman.

These small localized areas may be repaired with this asphalt-rubber composition by using a conventional concrete pavement rubberized asphalt joint sealing kettle, oil jacketed type for spreading the material. This type of equipment has a self-contained agitator and positive displacement pump for mixing and applying the asphalt-rubber. The material can be placed on small areas using a spray nozzle or using the joint filling wand and spreading the material with a squeegee. The area should then be hand sanded or chipped (17).

Another long term advantage is obtained by an asphalt-rubber treatment. Since it forms an impervious surface, water does not enter the base and subgrade through cracks as it can in the original underlying surface. This results in a long term stabilization of the subgrade and base moisture, which in itself tends to reduce the magnitude of deflections in the more stabilized subgrade. The rapid progression of local failure is often due to reduced subgrade support due to the entrance of surface water through initial surface cracks (7).

We have found that this composition ages far more slowly than asphalt alone. The combination of the rubber and asphalt seem to be mutually protective from oxidation, and the composition remains pliable and elastic over a period of many years (14). We do not know the reason for this property. It is probable that the antioxidants and carbon black used in the tire rubber are a major factor in the prevention of oxidation and ultraviolet light damage to the composition which are such prominent factors in the aging of asphalt alone (1) (2) (10).

We have developed another process with this material where the existing surface requires leveling as well as increased flexibility, or where loose seal coat aggregate would be objectionable as in the case of airport runways. This procedure involves the use of open-graded mixes utilizing the asphalt-rubber composition as a binder in lieu of asphalt.

The procedures are the same for mixing and placing as with the conventional open-graded finishing course. The only change required in the mechanics of the process is provision for introducing the asphalt-rubber composition into the asphalt lines of the hot plant and provision for pumping it into the hot plant weigh buckets, or in the case of a continuous mixing plant, into the mixing chamber spray bars. The pumps provided in most hot plants should be sufficient to do the job.

Although our experience to date has been somewhat limited with the asphalt-rubber plant mix, we have experimented with both ground tread rubber and ground whole tire rubber and there is a significant difference in the amount of binder that is used in either case when compared with ordinary asphalt. With the ground tread rubber we use ten percent, by weight, of the completed mixture of the asphalt-rubber composition. With the whole ground tire rubber, 1/4" maximum size, we use 13 percent to 14 percent of the binder composition to compensate for the absorption and additional surface area introduced by the tire fiber.

With ordinary open-graded mixes, where asphalt binder alone is used, we have noticed that mixing temperatures must be held below 250°F in order to prevent "rundown" in the truck beds of the asphalt where it is hauled over long distances. On the other hand, we have not noticed this problem where the asphalt-rubber composition was used as a binder when temperatures as high as 300° have been used.

It was noticed that the ground whole tire open-graded mixture was somewhat more prone to pickup by the rollers and more difficult to hand rake with an asphalt lute because of a tendency of the fibers to stick and pull up on the lute. No other differences were noted by the contractor in application by the machine or cleanup of machinery after use.

We have, at present, two test areas of the asphalt-rubber open-graded mixes in place in the Phoenix area. One is on a commercial jet taxiway at Sky Harbor International Airport in Phoenix which was placed in November, 1971, and the other is on a major street and intersection in the City placed in September, 1972. It is a little early to accurately predict results from these two full-scale, machine-laid operations. However, earlier small hand laid test panels indicate that the surface crack resistance of these installations will be as good, and probably better, than the seal coat version. Certainly both methods have their proper place in any major maintenance program.

We are also taking advantage of the increased tolerance to damage from deflections that this material offers by utilizing it in the design of new construction on low to moderate traffic streets, such as those in residential areas. This is being done by reducing the pavement section and placing an asphalt-rubber treatment over the completed asphaltic concrete surface. Alternate designs are being offered to the contractors for bids as alternatives to our standard design (See Appendix for further information).

This program was begun only recently, and further comment is not warranted at this early date. However, in preparation for gaging the effectiveness of this material in withstanding increased deflections resulting from a reduced sub-structure, we deliberately placed an asphalt-rubber treatment directly over a primed clay loam subgrade in April, 1971. The street on which this was placed is in the collector classification and carries approximately 4,000 vehicles per day. The test area consisted of a section 600 feet long where there was an existing half street with a full width street on each end. The area involved was occupied by a portion of an irrigated alfalfa field that was higher than the street. We bladed back the alfalfa field and found that the soil was so wet and spongy that it was two weeks or more before we could get on it with compaction equipment. Even then the surface was so cloddy that it could not be properly finished and we had to place a thin layer, 1" or less, of disintegrated granite to fill the voids between the clods before priming the surface with "Peneprime" (a cutback asphalt). After only one week, the "Peneprime" was starting to fail from fatigue, as shown by "alligator" cracking, due to excessive deflection. At this time, the asphalt-rubber chip seal was placed and has been serving satisfactorily without maintenance, other than correction of construction defects, as of this writing. At the time of placement, the deflections were visually apparent under the rolling equipment. Details of this experiment are in the appendix.

This experiment would indicate the possibility of utilizing this type of surfacing for low traffic rural roads to get them out of the dust and mud without either high construction or high future maintenance costs. Reasonably good drainage would be required. In this case we treated the ditch and its backslope with the asphalt-rubber composition.

The cost of the asphalt-rubber seal type treatment under our regular contracts has been between 50 cents and 70 cents per square yard, complete in place except for preliminary preparation and final sweeping which the City does with its own forces.

It has been stated by a United States Government publication (16) that the rubber industry produces some 10.7 billion pounds of rubber products annually, almost all of which eventually finds its way into the nation's solid waste mass. A huge segment of this consists of rubber tires which constitute a difficult disposal problem. Some landfills will not accept tires because their elastic properties cause them to work back up and out of the fill, necessitating reburial. They cannot be burned because of air pollution from sulfur dioxide and smoke. Obviously, one problem of the ecology would be solved if these tires could be used to benefit our streets and highways, thus "killing two birds with one stone".

In summary, it is a waste of money to use this material for maintenance applications where a conventional seal coat will suffice. Likewise, it is a waste of money to use a seal coat, or thin overlay, where the use of this asphalt-rubber material is indicated. This asphalt-rubber treatment is for use where the condition of the pavement from fatigue cracking is such that a three or four inch asphaltic concrete overlay, or reconstruction, would be required to prevent reflective cracking. Where new construction is involved, the use of this asphalt-rubber composition will permit designing pavement structures for greater allowable deflections without fatigue crack reflection.

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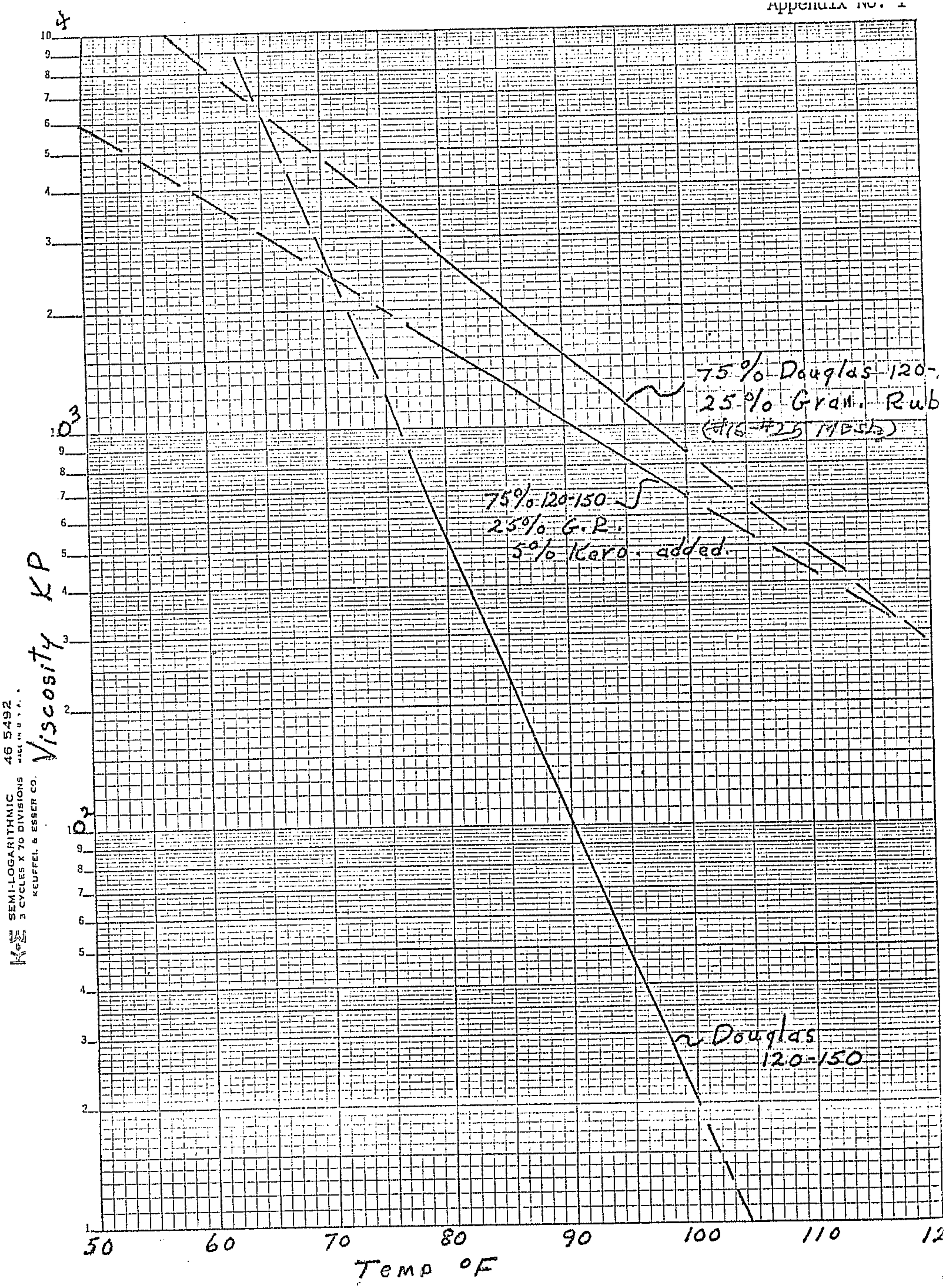
4
75% Douglas 120-
25% Gran. Rub
(#16-#25 Mesh)
75% 120-150
25% G.R.
5% Kero. added.
Douglas
120-150
Viscosity KP
Temp °F
50
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SEMI-LOGARITHMIC
3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
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CITY OF PHOENIX, ARIZONA
PUBLIC WORKS DEPARTMENT
DIVISION OF ENGINEERING

STANDARD SPECIFICATION NO. 566

HOT ASPHALT-RUBBER SEAL TREATMENT

.01 General

(a) This work involves the placing of a hot asphalt-rubber seal treatment on an existing pavement surface in accordance with the following specifications.

.02 Materials

(a) The asphalt shall be 120-150 penetration grade complying with the latest provisions of the Asphalt Institute, Pacific Coast Division.

(b) The granulated rubber shall meet the following requirements:

(1) Where the mixing procedure involves intimate contact between the hot asphalt and rubber for a period of five minutes or more, 95% shall pass the #16 sieve and not more than 10% shall pass the #25 sieve. Where the contact period is less than five minutes, 98% of the rubber shall pass a #25 sieve. The sieves shall comply with AASHO Designation M-92.

a. The specific gravity of the material shall be 1.15 $\pm$ .02 and shall be free from fabric, wire, or other contaminating materials except that up to 4% of calcium carbonate may be included to prevent the particles from sticking together.

(2) Cover Aggregate

a. The cover aggregate shall have a percentage of wear not to exceed 40 at 500 revolutions when tested in accordance with AASHO test Designation T-96.

b. Sodium Sulphate soundness test shall be in accordance with AASHO test Designation T-104 and shall not show a loss in excess of 12%.

c. It shall be clean and free of any clay coating. A minimum of 75% of the material, by weight, retained on the #8 sieve, shall have at least one fractured face produced by crushing.

April, 1972

d. Grading of the stone cover aggregate, when tested in accordance with AASHO test Designations T-11 and T-27, shall comply with the following:

3/8" Nominal Chip

Sieve Size	Percent Passing
½"	100
3/8"	70-100
¼"	0-10
#8	0-5
#200	0-2

NOTE: A smaller chip may be used where traffic volume is light.

e. The cover aggregate shall be preheated to a temperature between 290° F. and 350° F. and precoated with .35% to .75% of penetration grade asphalt, as directed by the Engineer.

f. Canvas or similar covers that completely cover each load shall be used to minimize temperature drop of the exposed material whenever it is found that the temperature of the top three inches of the cover aggregate loads are dropping below the minimum requirement at the time of application.

.03 Equipment

(a) The equipment used by the Contractor shall include a power broom for cleaning the existing pavement surface, and three pneumatic tired rollers, each carrying a minimum of 5,000# on each wheel and a minimum of 100 pounds per square inch in each tire; aggregate spreading equipment that can be so adjusted as to spread accurately the given amounts per square yard, a self-powered pressure distributor equipped with a separate power unit, distributing pump capable of pumping the specified material at the specified rate through the distributor tips, and equipment for heating the bituminous material. The distribution bar on the distributor shall be fully circulating with nipples and valves so constructed that they are bathed in the circulating asphalt to the extent that the nipples will not become partially plugged with congealing asphalt upon standing, thereby causing preliminary streaked or irregular distribution of the asphalt. Distributor equipment shall include a tachometer, pressure gages, volume measuring devices, and a thermometer for reading temperatures of tank contents. The spray bars on the distributor shall be controlled by a bootman riding at the rear of the distributor in such a position that operation of all sprays is in full view and accessible to him for controlling spread widths.

(1) The method and equipment for combining the rubber and asphalt shall be so designed and accessible that the engineer can

readily determine the percentages, by weight, of each of the two materials being incorporated into the mixture.

(2) The distributor trucks shall be equipped so as to be capable of guiding from the right within a tolerance of two inches. Distributor trucks used shall demonstrate their capability to comply with this requirement to the engineer prior to their use on the project.

.04 Construction Details

(a) Mixing

(1) The materials shall be intimately combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semi-fluid material. The temperature of the asphalt shall be between 300° F. and 475° F. At the lower temperature, it may require up to an hour for the reaction to take place. At the higher temperature, the reaction will take place within seconds; therefore, the temperature used will depend on the type of application and the Contractor's methods used. The engineer shall be the sole judge of when the material has reached application consistency. After reaching the proper consistency, application shall proceed immediately and in no case shall the material be held at temperatures over 325° F. for more than one hour after reaching that point.

(2) When the mixing period is less than five minutes, the minimum temperature of the asphalt shall be 440° F.

(3) The proportions of the two materials, by weight, shall be 75% ± 2% asphalt and 25% ± 2% rubber. After the full reaction described in (a) (1) Mixing above has occurred, the mix shall be cut back with kerosene. The amount of kerosene used shall be 5½% to 7½%, by volume, of the hot asphalt-rubber composition as required for adjusting viscosity for spraying or better "wetting" of the cover aggregate. The kerosene shall have a boiling point of not less than 350° F., and the temperature of the hot composition shall not exceed this temperature at the time of adding the kerosene.

(b) Spreading

(1) Prior to the hot asphalt-rubber treatment, the surface to be sealed shall be cleaned, patched, and treated with a "bituminous tack coat" consisting of 0.05 ± gallons per square yard of SS-1h emulsified asphalt, diluted 50-50 with water.

(2) The application rate of the hot asphalt-rubber mixture shall be 0.47 to 0.49 gallons per square yard unless otherwise specified for special conditions (based on 7½ lbs. per hot gallon).

(3) Any hot asphalt-rubber binder spread in excess of the rate and/or high range figure per square yard for the entire number of square yards sealed, shall be at the expense of the Contractor.

(4) The application rate of the cover aggregate shall be 37 to 39 pounds per square yard except as directed by the engineer to prevent pickup by the equipment involved in the spreading and compacting of the cover aggregate. Any precoated chips spread in excess of the rate and/or high range figure per square yard, for the entire number of square yards sealed, shall be at the expense of the Contractor. A minimum of four complete coverages shall be made with the pneumatic roller. The rolling of the cover aggregate shall proceed immediately after application in order to insure maximum embedment of the aggregate. Traffic shall not be permitted on the completed surface until permitted by the Engineer.

(5) Hot asphalt-rubber seal shall be placed only when the pavement temperature is 60° F., or above, and rising. The ambient temperature in the shade shall also not be less than 50° F.

(6) All joint edges shall be swept clean of overlapping cover material prior to the adjacent application of asphalt-rubber material. All reasonable precautions shall be taken to avoid "skips" and "overlaps" at joints and to protect the surfaces of adjacent structures from being spattered or marred. Correction of any such defects will be required at the Contractor's expense. All transverse joints shall be made by placing building paper over the ends of the previous applications, and the joining application shall start on the building paper used. Once the application process has progressed beyond the paper used, the paper shall be removed and disposed of to the satisfaction of the Engineer.

(7) It has been found that maldistribution of the asphalt-rubber material occurs when distributor bars, in excess of ten feet wide, are used for spreading. Therefore, the maximum distribution bar width permitted shall be ten feet, and this may be reduced by the Engineer if specification requirements on the uniformity of distribution are not met.

(8) After final sweeping, and prior to striping, a flush coat shall be applied to the asphalt-rubber treatment consisting of 0.05 to 0.10 gallons per square yard of undiluted SS-1h emulsified asphalt.

.05 Measurement and Payment

(a) Certified weight slips of all materials shall be delivered to the inspector before the materials are applied. Certified weight slips of any bituminous material being weighed back in for credit, shall be delivered to the inspector before starting the next day's work.

(b) Quantities of materials for this work will be paid for at the contract price per unit of measurement for each of the following pay items:

Hot precoated cover aggregate	-	ton
Granulated rubber	-	ton
120-150 pen. gr. asphalt	-	ton
SS-1h emulsified asphalt (undiluted)	-	ton

(c) Quantities shown in the proposal are for bidding purposes only. Payment will be full compensation for furnishing and placing all materials as specified, including kerosene, with no allowance for waste, and shall include labor, equipment, tools, and incidentals necessary to complete the work prescribed and as directed by the engineer.

(d) Asphalt cement for precoating cover aggregate shall be included in the price per ton for "Hot Precoated Cover Aggregate".

(e) Cost of materials placed in the absence of the inspector, or materials rejected due to improper placing, improper proportions of materials, or materials found to be defective, will not be paid.

.06 Sequence of Work

(a) City Streets

(1) Asphalt-rubber sealing of major streets shall be performed during the hours from 9:00 a.m. to 4:00 p.m., unless otherwise directed by the Engineer.

.07 Schedule of Work

An approved Schedule of Work to be performed shall be submitted to the engineer, prior to start of contract.

.08 Preliminary Preparation

Clean, tack, and seal all pavement and cracks; repair pot-holes, repair base failures and sweep prior to, and after, resurfacing; and notify all residents in advance of construction. Furnish and handle all traffic cones, signs, barricades, etc., for traffic control in connection with sweeping and cleaning up excess cover aggregate.

.09 Traffic Control

The Contractor shall be responsible for furnishing cones, signs, barricades and handling traffic during all phases of the sealing work.

.10 Protection of Covers and Gratings

Manhole covers, valve box covers, monument covers, cleanout covers and gutter inlet gratings shall be covered and completely protected prior to application of the asphalt-rubber composition.

.11 Cleanup

(a) Upon completion of the work and before final acceptance, the Contractor shall cleanup all ground occupied by him in connection with the work, including rubbish, trash, signs, barricades, equipment, etc.

(b) The pavement shall be given a final sweeping for the purpose of removing and disposing of the excess cover aggregate. All signs, barricades, cones, etc., shall be removed. All parts of the work shall be left in a neat, presentable condition.

(c) Correction shall be made in kind of all defects that occur after placement, whether or not the defect was the fault of the Contractor, traffic elements involved, or the City of Phoenix.

ASPHALT-RUBBER PLANT MIX

Proposed Special Provisions for Standard Specification No. 558.

NOTE: These special provisions may be adapted to almost any standard hot asphaltic plant mix specification.

.01 (a) Delete the word "asphalt" and substitute "asphalt-rubber composition".

Add following section: .01 (c) the words "asphalt-rubber composition" shall be substituted for the word "asphalt" where applicable.

.02 Delete in its entirety: Materials, except for Tables No. I and No. II, and substitute the following:

.02 Materials

(a) The asphalt shall be 120-150 penetration grade complying with Table I.

(b) The granulated rubber shall meet the following requirements:

(1) Ninty percent shall pass the #16 sieve and not more than ten percent shall pass the #25 sieve. The sieves shall comply with AASHO Designation M-92.

a. The specific gravity of the material shall be 1.15 $\pm$ .02 and shall be free fron fabric, wire, or other contaminating materials except that up to four percent of calcium carbonate may be included to prevent the particles from sticking together.

(2) Mineral Aggregate

a. The aggregate shall have a percentage of wear not to exceed 40 at 500 revolutions when tested in accordance with AASHO test Designation T-96.

April, 1972

Proposed Special Provisions for
Standard Specification No. 558

.02 (b) (2) Cont.

b. Sodium Sulphate soundness test shall be in accordance with AASHO Test Designation T-104 and shall not show a loss in excess of 12 percent.

c. It shall be clean and free of any clay coating. A minimum of 75 percent of the material, by weight, retained on the #8 sieve, shall have at least one fractured face produced by crushing.

d. Grading of the aggregate, when tested in accordance with AASHO Test Designations T-11 and T-27, shall comply with the following:

¼" Nominal Open Graded Aggregate

Sieve Size	Percent Passing
3/8"	100
1/4"	80-100
#8	0-5
#200	0-2

(3) a.

Mix Designation	% Asph. Rubber
¼" nominal open graded mix	10% by weight of the total mix, plus or minus 0.3%, of asphalt-rubber composition shall be used.

.03 (b) (5) a. Add the following:

0.1 The asphalt and rubber materials shall be intimately combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semi-fluid material. The temperature of the asphalt shall be between 350°F and 400°F. The engineer shall be the sole judge of when the material has reached proper consistency. After reaching the proper consistency, use shall proceed immediately and in no case shall the material be held at temperatures over 325°F for more than one hour after reaching that point.

Proposed Special Provisions for
Standard Specification No. 558

.03 (b) (5) a. Cont.

0.2 The proportions of the two materials, by weight, shall be 75 percent ± 2 percent asphalt and 25 percent ± 2 percent rubber. After the full reaction described in a., 0.1 Mixing has occurred, the mix shall be cut back with kerosene. The amount of kerosene used shall be not more than 7½ percent, by volume, of the hot asphalt-rubber composition as required for adjusting viscosity for pumping. The kerosene shall have a boiling point of not less than 350°F, and the temperature of the hot composition shall not exceed this temperature at the time of adding kerosene.

.03 (b) (5) a. 1. Delete the word "asphalt" and substitute "asphalt-rubber composition".

.03 (c) (6) Delete in its entirety.

CITY OF PHOENIX
ARIZONA

TO Mr. A. L. Samson

FROM Mr. Charles H. McDonald

SUBJECT Subgrade design alternates for residential streets based on a minimum of five years of trouble-free service as outlined in the September 2, 1971 conference on this subject.

A-2 SECTIONS FOR TYPICAL GOOD SUBGRADE

	Select	ABC	Soil Cement	AC	Asphalt-Rubber
Standard	0	6"	0	2"	0
*1st Alternate	0	0	4½"	1½"	0.5 GSY
2nd Alternate	0	0	0	3½"	0
3rd Alternate	0	0	0	2½"	0.5 GSY

A-2 SECTIONS FOR TYPICAL AVERAGE SUBGRADE

	Select	ABC	Soil Cement	AC	Asphalt-Rubber
Standard	3"	4"	0	2"	0
*1st Alternate	0	0	4½"	1½"	0.5 GSY
2nd Alternate	0	0	0	4"	0
3rd Alternate	0	0	0	3"	0.5 GSY

A-2 SECTIONS FOR TYPICAL POOR SUBGRADE

	Select	ABC	Soil Cement	AC	Asphalt-Rubber
Standard	5"	4"	0	2"	0
*1st Alternate	0	0	**6" 4½"	**2" 1½"	0.5 GSY
2nd Alternate	0	0	0	**7" 5"	0
3rd Alternate	0	0	0	**5" 3½"	0.5 GSY

A preservative seal at six cents per square yard will be required for the standard and second alternates.

*This design (1st alternate) is adequate for the poor subgrade condition, but cannot be significantly reduced for the better subgrade conditions for practical reasons. For the same reasons it is also good for much more than five years without maintenance

**For use on commercial or industrial streets.

Mr. Charles H. McDonald

The standard section is also good for better than five years, provided that extra precautions are taken to keep surface water out of the base course.

The second and third alternates would probably require an additional treatment of some sort at approximately the five-year interval.

Lignin treatment could be substituted on an equal basis for cement where an A-1 section is used and surface water into the base is eliminated.

Charles H. McDonald

Charles H. McDonald
Engineering Supervisor

CHM:lem

cc: Mr. Glendening
Mr. Attebery
Mr. Harmon
Mr. Nelson
Mr. Schnormeier
Main Reading File

MIX DATA

MATERIAL	TIME	TEMP. F	LBS.	GALS.	% OF MATERIAL	REMARKS
120/150 Penetration Grade Asphalt	10:15	350°	16,050	(Stick) 2,100	by wt. 75.6%	Scale Weight
Ninety 60# Bags of Ground Tire Rubber	Began 11:15 Ended 11:45	340° 290°	(5,400)	(Stick) 2,830		Theoretical Weigh by Bag Count
	11:55	295°	5,190		by wt. 24.4%	Actual
Total Asphalt-Rubber			21,240		100%	Scale Weight
Total Asphalt-Rubber	2:35	285°		(Stick) 2,750	100%	Receded Volume
Kerosene Added	Began 12:40 Ended 12:45	285° 275°		215	7.82%	% of Asphalt-Rubber by Volume (7.5% by volume intended)
Total Mixture				(Stick) 2,965		

CITY OF PHOENIX
ENGINEERING DEPARTMENT
MATERIALS SECTION

EXPERIMENTAL PROJECT

Kerosene Diluted Asphalt-Rubber Surface on Clay Subgrade

INITIAL REPORT

EXPERIMENT NO. 109 PROJECT NO. None

DATE OF EXPERIMENT April 13, 1971

LOCATION:

The east 27' of 55th Avenue and the adjacent shoulder slope from south of Indian School Road at Clarendon to 674' north. Also the west 8' of 55th Avenue from the centerline of Clarendon, 40' north.

LOCATION and/or CHARACTER OF UNTREATED CONTROL:

Untreated subdivision pavement adjacent to the test section.

PURPOSE OF THE EXPERIMENT:

To provide a durable, flexible, and economical roadway surface over untreated clay subgrade without benefit of an intervening base course.

MATERIALS USED:

Disintegrated granite; "Peneprime"; 120/150 penetration grade asphalt (75.6%); Atlos ground tire rubber, #16-#25 mesh (24.4%) kerosene in the proportion of 7.8% of the asphalt-rubber mixture as a diluent; 3/8" nominal sized cover aggregate varying in moisture content from dry to wet (2% $\pm$ H_2O).

TESTING CONSTRUCTION METHODS:

The previously compacted (95%+) subgrade was finished and leveled with 1"- of disintegrated granite after which the entire area was treated with "Peneprime" at the rate of .50 gallon per square yard and allowed to cure. The asphalt and rubber were combined in an especially constructed distributor truck at the plant. Kerosene was added to the mix at the job site, and the designated areas treated in 8' passes. Cover aggregate was spread immediately behind the distributor and rolled. See attached for details.

WERE PHOTOGRAPHS TAKEN?

Yes

- - - - - - - - - - - - - - - -

PROGRESS REPORT

DATE:

October 27, 1972 (1-1/2 years after placement)

INSPECTION MADE BY:

Mr. Charles H. McDonald

CONDITION OF EXPERIMENT:

The asphalt-rubber roadway surface is in excellent condition and shows no "alligator" pattern cracking. It is recalled that the cutback asphalt prime coat showed "alligat pattern cracking from fatigue failure one week after placing, attesting to the magnitude of pavement deflections on this project.

A flush coat of 0.1 gallons per square yard of diluted (50-50) emulsified asphalt was applied in September, 1971.

There has been no patching except for repair of minor construction defects in 1971.

APPLICATION DATA

Shot Location (See Sketch)	Time of Application	Time Elapsed from Start of Adding Rubber	Pavement Temperature	Ambient Temperature	Chip Temperature	Mixture Temperature	Rate of Application of Mixture, Hot Gals. per Square Yar: Goal	Gross	Net
1 (backslope only)	1:10 p.m.	1 hr., 55 min.	140°F	98°F		270°F	.50	1.57	1.46
		- Net Gallons Per Square Yard Excludes Kerosene -							
		- BAR PRESSURE 60 POUND SPEED 400' PER MINUTE -							
2		- BAR PRESSURE 60 POUND SPEED 400' PER MINUTE -					.50	1.00	.93
3		- BAR PRESSURE 30 POUND SPEED 400' PER MINUTE -					.50	.50	.46
4		- BAR PRESSURE 30 POUND SPEED 400' PER MINUTE -					.50	.58	.54
5	2:05 p.m.	2 hr., 50 min.	118°F	98°F		270°F	.50	.67	.62
		- BAR PRESSURE 30 POUND SPEED 400' PER MINUTE -							
					Total Square Yards Shot - 2,225 Job Average		.50	.74	.68

Total Gallons Used - 1,640
Total Chips Used - 73,360 pounds
Total Square Yards covered - 2,225

33# Chips Averaged Per Square Yard

Distributor (No. 9) Equipped With No. 5 (8/32") Tips and 5/32" Screen

RUBBER EXTRACTION TEST ON ASPHALT-RUBBER
PLACED ON 55TH AVENUE, SOUTH OF INDIAN SCHOOL ROAD
APRIL 13, 1971

Kerosene Content as a % of Asphalt-Rubber	Solvent Used: Benzene (B) Methyl Ethyl Ketone (MEK)	Total Weight in Grams of Sample Tested	Weight in Grams of Extracted Residue	Rubber as a % of Total Sample	Rubber as a % of Asphalt-Rubber	Disolved Rubber as a % of Asphalt-Rubber	Undisolved Rubber Aggregate as a % of Asphalt-Rubber
7.82%	B	15.31	3.25	21.22	22.88		
	MEK	16.73	4.52	27.02	29.12	6.24	22.88

4-65

CITY OF PHOENIX, ARIZONA
Division Of Engineering

Date April 7, 1971

Materials Section

TEST REPORT SUMMARY SHEET

Lab No. ______ Name of Material Natural Soil

Project No. 57821 Source finished grade Contractor ______

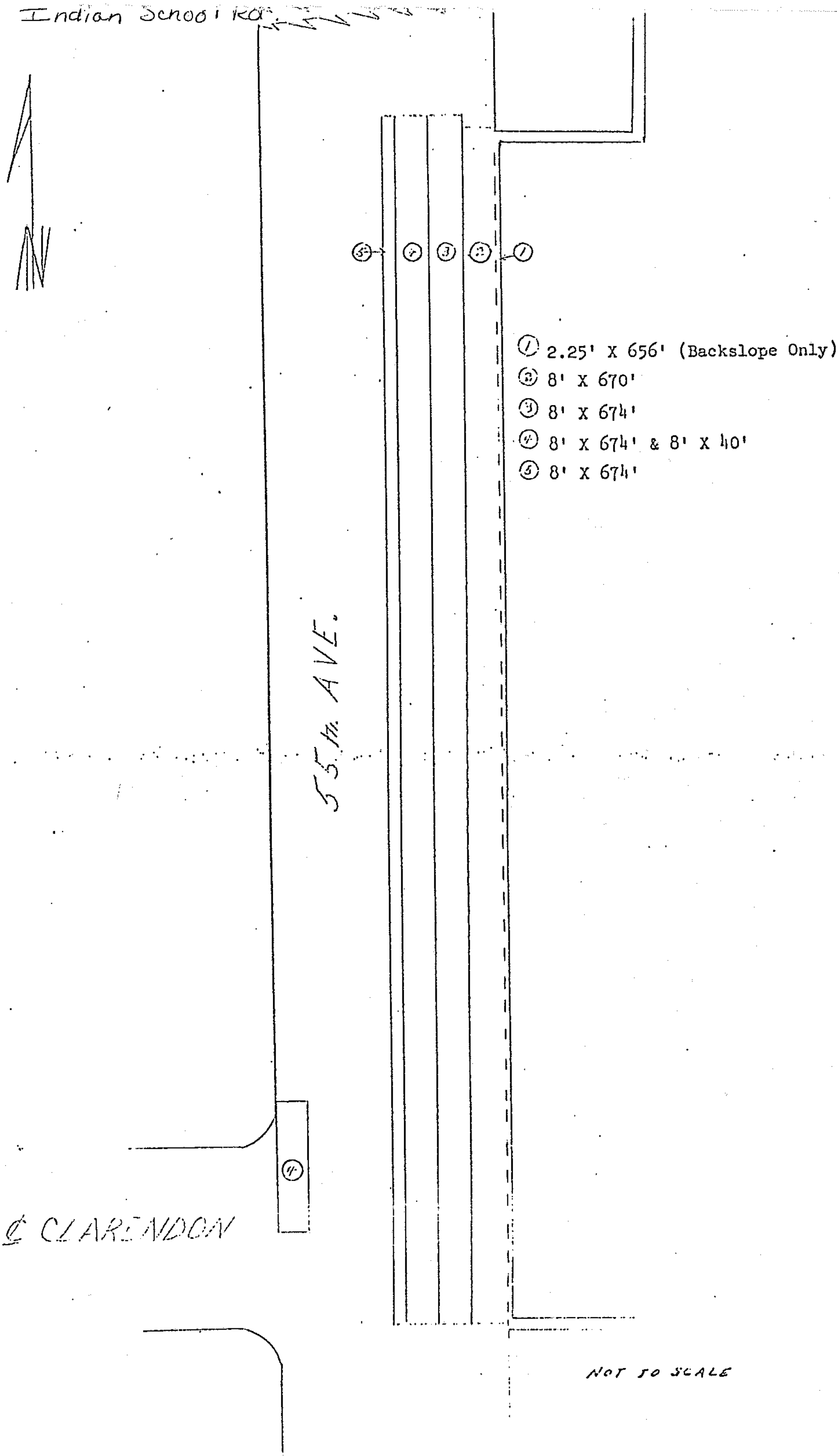
Sampled By Anderson Date April 7, 1971 Inspector McDonald

Sample Location 55th Avenue north of Clarendon

Quantity Represented 674' of one-half width street

Designated as source for: treatment with asphalt-rubber

Field or hole number	Depth from surface	Station	Existing pavement thickness	PI	Pass 200	Pass 40	Pass 10	Pass 8	Pass 4	Pass 3/8	Pass 3/4	Pass 1	Laboratory number
1	0"-6"	75' N. of south end	None	13	59								
2	0"-6"	100' N. of south end	None	18	70								
3	1' - 2'	250' N. of south end	None	15	88								
4	0"-12"	300' N. of south end	None	18	70								



Indian School Rd
N
① ② ③ ④ ⑤
① 2.25' X 656' (Backslope Only)
② 8' X 670'
③ 8' X 674'
④ 8' X 674' & 8' X 40'
⑤ 8' X 674'
55th AVE.
④
℄ CLARENDON
NOT TO SCALE

Appendix NC

Engineering Division
MATERIALS TESTING SECTION

COMPACTION REPORT

TYPE OF MATERIAL Soil

DATE OF REPORT 4/8/71

GRANULAR ______ NON-GRANULAR ✓

PROJECT NO. 57821

DATE SAMPLED 4/7/71

CONTRACTOR Street Maintenance

SAMPLED BY R.G.

INSPECTOR Street Maintenance

LAB NO.	LOCATION	Depth of Hole From - To	Optimum Moisture	% of Moisture	Maximum Density	% Density	% Required
50720	55th Avenue North of Clarendon 75' South of North End	0-0.5'	14	10	115	98	95
50723	55th Avenue 300' ± North of Clarendon	0-1.0'	14	14	115	96	95
50724	55th Avenue 100' North of Clarendon	0-0.5'	14	8	115	98	95

REMARKS:

Copies to:

122-50D

CITY OF PHOENIX, ARIZONA
ENGINEERING DEPARTMENT
MATERIALS SAMPLE CARD

Appendix No.

MATERIAL 3/8 Chips (Nominal)	DATE 4-1-71 / TIME
SOURCE Union S. Creek	LAB NO. 50553
CONTRACTOR B.C. Maint	PROJECT NO. 1110 57821
INSPECTOR	DEPTH OR THICKNESS
PROJECT LOCATION	
SAMPLE LOCATION	
TESTS REQUIRED Gradation	SAMPLED BY Cano

122-130 NEW 3-69

SIEVE SIZE	WT. RET. Accum.	WT. RET. Individ.	% RET. Individ.	% Passing	SPEC.# ______ % Passing
3"					
1-1/2"					
1-1/8"					
1"					
3/4"					
1/2"		.0		100	100
3/8"		4.04		(78)	80-100
1/4"	17.47	13.43		5	0-10
-1/4"		.92			
- No. 4					
No. 8					
No. 10					
No. 16					
No. 30					
No. 40					
No. 50					
No. 80					
No. 100					
No. 200					
Pass. 200					
TOTAL					

REMARKS:

COARSE

Total Weight of Sample 18.39

FINE

Wt. of Sample used ______

Wt. Oven dried ______

Wt. washed & Dried ______

Wash ______

MATERIAL PASSING #40 SIEV

L.L. ______ P.L. ______ P.I. ______

Maximum Density ______

Optimum Mositure ______

FRACTURED FACES

Results		Req'd
0	%	
1	%	
2	%	

TESTED BY [illegible signature]

DATE TEST COMPLETED 4-1

122-8
Rev.

PHOTO NO. 1

Loading ground tire rubber into distributor truck (modified for mixing) containing hot asphalt to make the asphalt-rubber composition.

PHOTO SECTION - PAGE #1
PHOTO #1

Charles H. McDonald

PHOTO NO. 2

Equipment production chain placing the asphalt-rubber seal type treatment.

PHOTO SECTION - PAGE #2
PHOTO #2

Charles H. McDonald

PHOTO NO. 3

Placing the asphalt-rubber open-graded mix type overlay.

Charles H. McDonald

PHOTO SECTION - PAGE #3
PHOTO #3

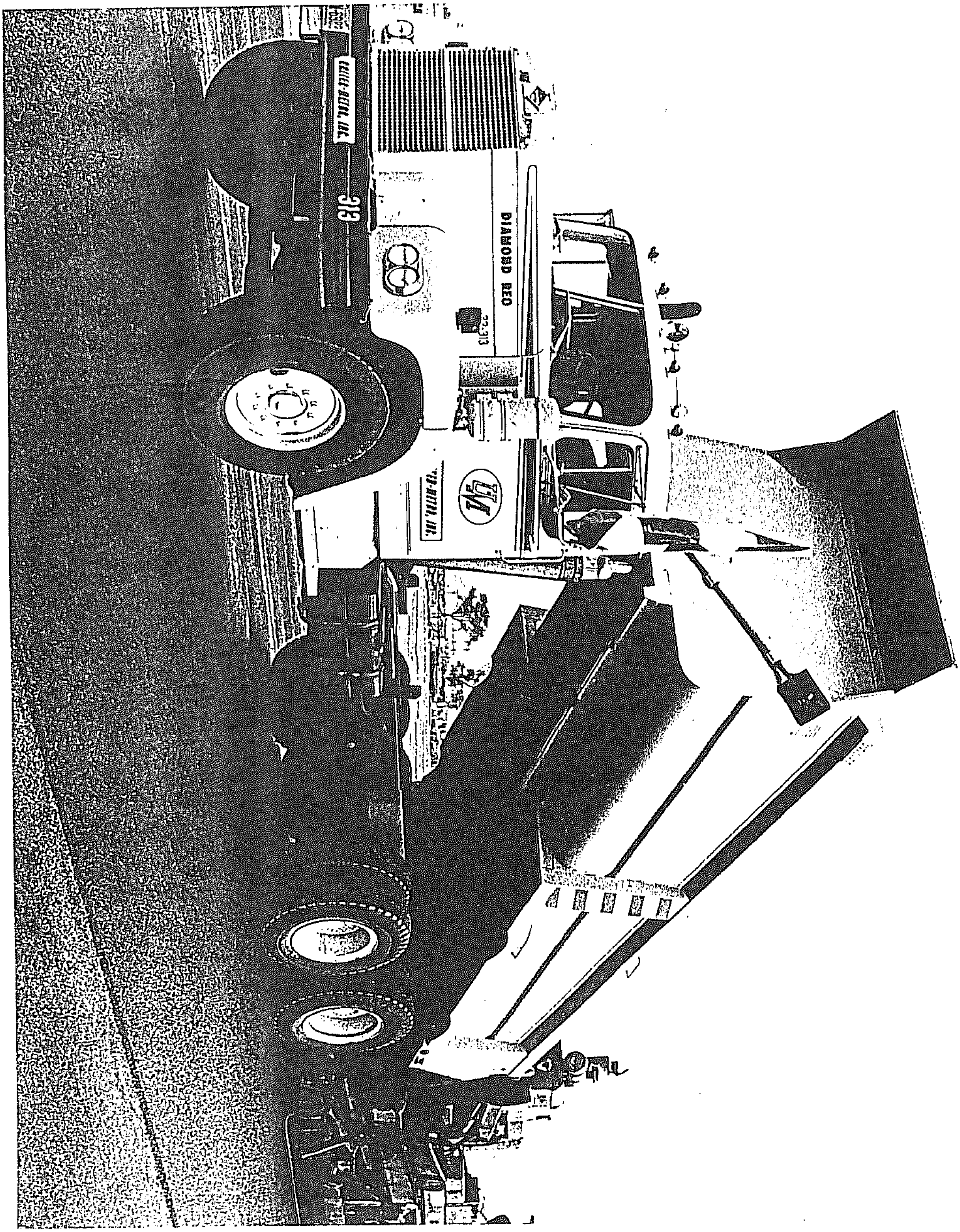


PHOTO NO. 4

Air National Guard runway in Phoenix, Arizona. Asphalt-rubber treatment in left quarter of photo was placed May 25, 1971. Photo was taken after one year of service. Right three-quarters of photo was untreated. Note no crack reflection in treated area.

PHOTO NO. 5

This area is at a fuel tanker loading depot subjected to heavy truck loading. Approximately three years ago it was treated with 1 ± gallon per square yard of hot asphalt-rubber and before the material cooled down, a vehicle ran over this area and picked up the material from the middle third of the photo except for the spot where the pen lies. Note that this little spot, and the asphalt-rubber treated area on either side, shows no signs of the severely distressed underlying asphaltic surface after all these years of service.

PHOTO NO. 6

April 26, 1971 "Before"

McDowell Road, 7th Street to 12th Street. Asphalt-rubber diluted with five percent kerosene. Driveway to 753 East McDowell, four feet from south curb.

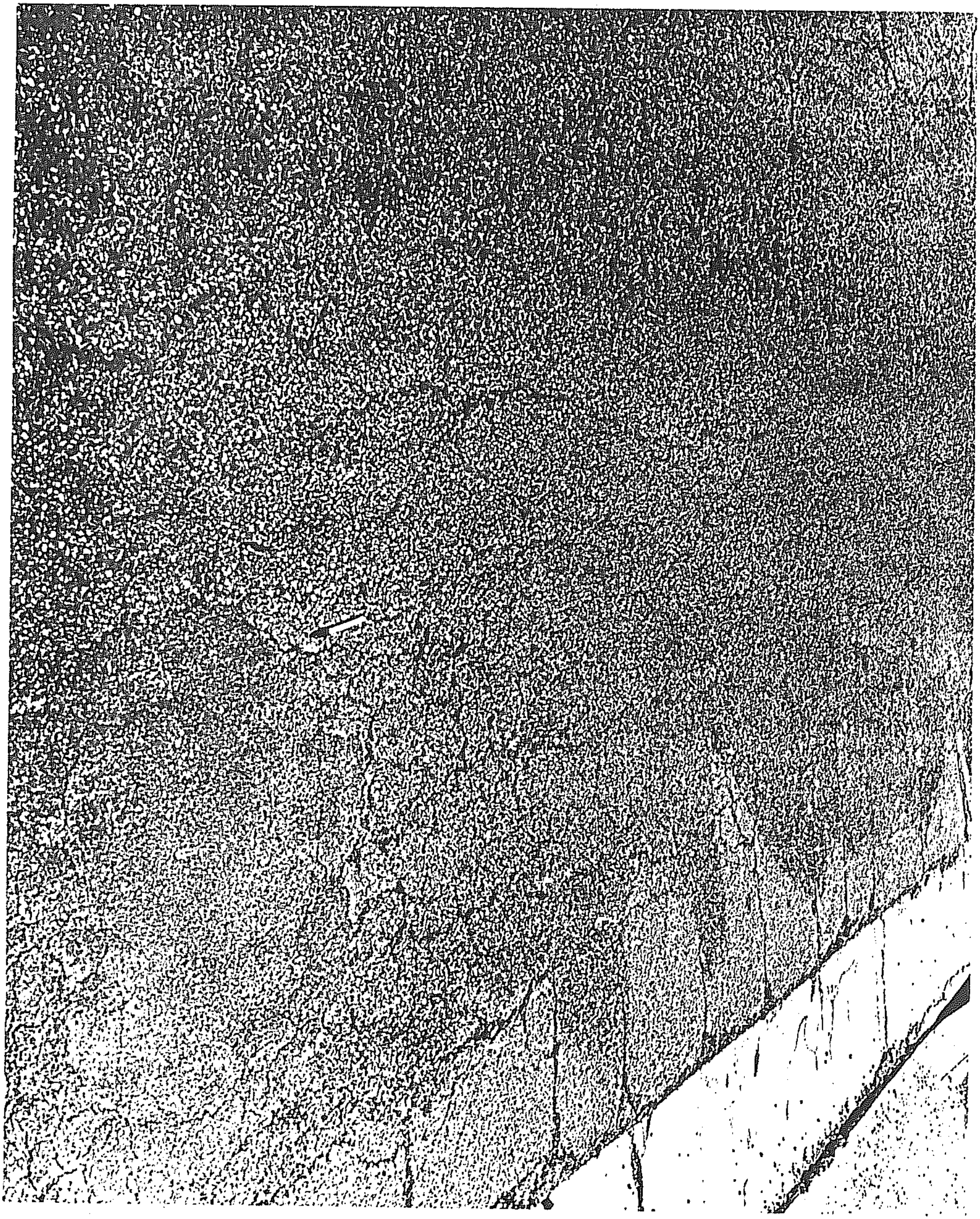


PHOTO NO. 6A

"After" One Year
Photo - April 25, 1972
Placed - April 26, 1971

McDowell Road, 7th Street to 12th Street. Asphalt-rubber diluted with five percent kerosene. Driveway to 753 East McDowell, 4' from south curb.

Charles H. McDonald

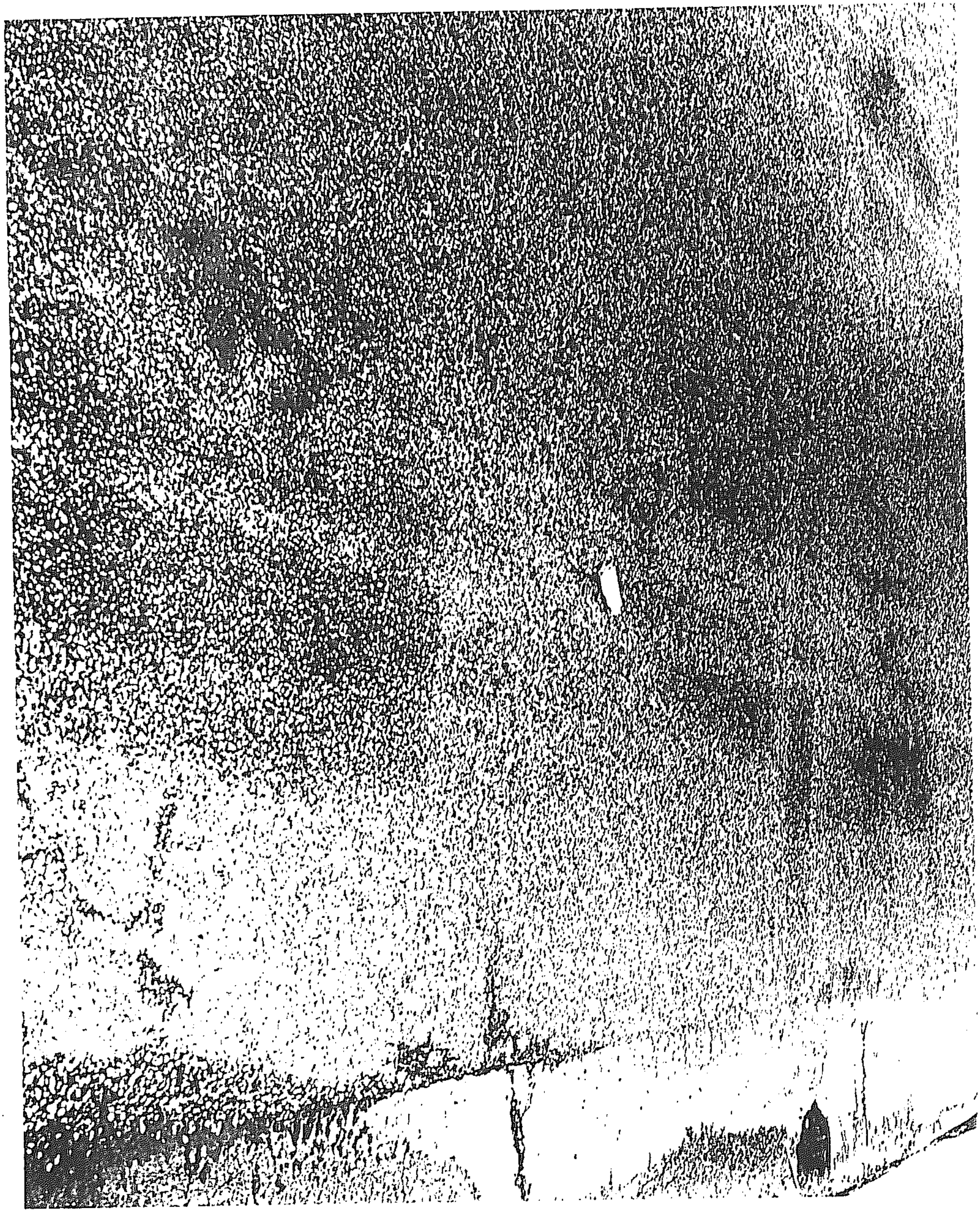


PHOTO NO. 7

Asphalt-rubber treatment placed on primed native clay loam soil April 13, 1971. This photo shows the condition after 1-1/2 years of service under average daily traffic of 4,000, plus or minus, vehicles.

55th Avenue, north of Clarendon Avenue in Phoenix, Arizona.

Looking north, asphalt-rubber on right lane. Old pavement on left lane. Asphalt-rubber overlaps old pavement two feet, plus or minus, on left.

PHOTO #7