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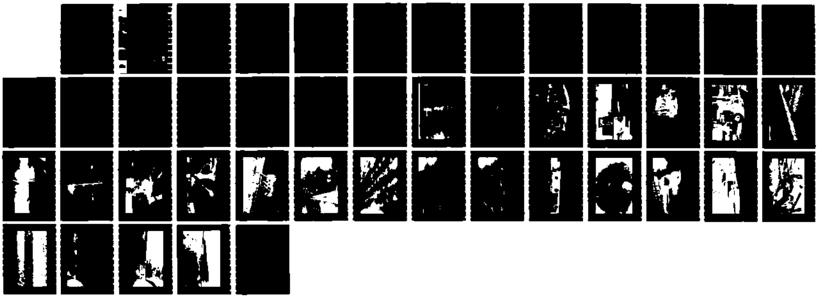

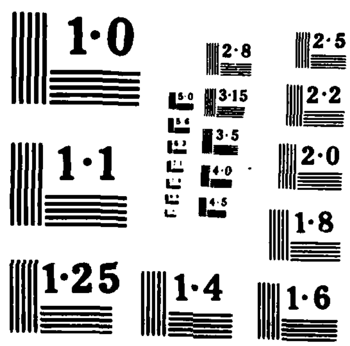
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MISCELLANEOUS PAPER GL-86-3

CRACKING AND SEATING OF PORTLAND CEMENT CONCRETE PAVEMENT PRIOR TO ASPHALT CONCRETE OVERLAY; FACILITIES TECHNOLOGY APPLICATION TEST, FY 84

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

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Asphalt concrete overlays of a jointed or cracked portland cement concrete (PCC) pavement can develop reflective cracking because of either horizontal or vertical movement of the PCC. One method that can be used to reduce the reflective cracking is cracking and seating of the PCC prior to placement of the asphalt concrete overlay. The PCC is cracked into approximately 18-in. pieces, after which a heavy pneumatic-tired roller is used to seat the pieces
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20. ABSTRACT (Continued).

of concrete to prevent rocking or movement under traffic. This report provides guidance for the application of the cracking and seating method for reducing reflective cracking.

PREFACE

This study was sponsored by the Office, Chief of Engineers (OCE), US Army, as a part of the O&MA Program, Facilities Technology Application Tests (FTAT), Demonstration Program FY 84, and was conducted in the Geotechnical Laboratory (GL) of the US Army Engineer Waterways Experiment Station (WES).

The project was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, GL; and under the direct supervision of Mr. H. H. Ulery, Jr., Chief, Pavement Systems Division (PSD); Mr. J. W. Hall, Jr., Chief, Engineering Investigation Testing, and Validation Group, PSD; and Dr. E. R. Brown, Chief, Material Research Center, PSD. The WES FTAT Project manager was MAJ R. A. Hass. Photographic support was provided by Mr. C. E. Ray of the Publications and Graphic Arts Division. Construction support was provided by Mr. C. Swynenberg of the Rock Island Facilities Engineering Office. This report was prepared by Mr. Lenford N. Godwin, PSD.

The Asphalt Institute is gratefully acknowledged for permission to reproduce Photos 3 and 4 of this report.

Director of WES was COL Allen F. Grum, USA. Technical Director was Dr. Robert W. Whalin.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
British thermal units	1,054	joules
feet	0.3048	metres
inches	2.54	centimetres
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms
square yards	0.8361274	square metres

CRACKING AND SEATING OF PORTLAND CEMENT CONCRETE PAVEMENT PRIOR TO ASPHALT CONCRETE OVERLAY; FACILITIES TECHNOLOGY APPLICATION TEST, FY 84

PART I: INTRODUCTION

History

1. Reflective cracking can occur in asphalt concrete overlays of either jointed portland cement concrete (PCC) or cracked asphalt concrete pavements, as shown in Photo 1. The reflective cracking is the result of either horizontal or vertical movement of the underlying pavement. The horizontal movement is caused by temperature or moisture changes in the pavement structure. The vertical movement is caused by traffic. Both types of movements can induce high stresses in the asphalt concrete. If the stresses exceed the strength of the asphalt concrete, a reflective crack develops.

2. Reflective cracks can result in early deterioration of a pavement structure, as shown in Photo 2. The deterioration is usually in the form of spalling and ravelling. Water can enter unsealed cracks and reduce the strength of the pavement structure. Such early deterioration will require additional maintenance or replacement of the cracked pavement. The maintenance costs resulting from reflective cracking can be very great.

3. Currently several methods are used to reduce the potential for reflective cracking. One method involves placing either an asphalt-rubber or a fabric interlayer over a cracked pavement prior to placement of the asphalt concrete overlay (Vedros 1981). Another method involves cracking the existing PCC and then seating the pieces of pavement prior to overlaying with asphalt concrete.

4. The cracking and seating method has the potential for being more effective for PCC pavement overlays than asphalt-rubber or fabric interlayer methods.

5. The cracking and seating method is not new and recent equipment developments and improvements have encouraged the use of this method. The objective of the cracking and seating method is to crack the existing PCC pavement into small, interlocking pieces and then seat the pieces of pavement

with a heavy pneumatic-tired roller prior to placing the asphalt concrete overlay. The cracked pavement should have aggregate-to-aggregate particle contact; thus, a portion of the original pavement strength is maintained. The seating with the heavy pneumatic-tired roller prevents any rocking or movement of the small pieces when subjected to traffic. By cracking the pavement into small pieces, the amount of expansion and contraction due to temperature changes is reduced, which, in turn, should reduce the potential for reflective cracking.

Purpose of Report

6. This report provides guidance for use of the cracking and seating method for reducing reflective cracking in asphalt concrete overlays of PCC pavement.

PART II: IMPLEMENTING THE METHOD

7. The cracking and seating method requires that certain equipment be used and certain procedures be followed to produce satisfactory results. General guidance for equipment and techniques is given in the following paragraphs.

Cracking Equipment

8. A variety of types of equipment can be used for the cracking of a PCC pavement including modified pile-driver hammers, falling-weight hammers (such as the Guillotine hammer), and hydraulic or pneumatic impact hammers (Crawford 1984, Eckrose, Poston, Donohue and Associates 1983, Highway and Heavy Construction 1984, Paving Forum 1984, Sherman 1982, The Asphalt Institute 1984). Photos 3-6 show some of the currently available cracking equipment. Regardless of the particular names or types, the hammers used to crack PCC pavement must provide a method for adjusting the impact force delivered to the pavement so that the cracking pattern can be varied to suit field conditions and pavement strength characteristics. The impact force is usually adjusted by changing the rate of impact, stroke height, forward speed, or impact head size and shape.

9. The hammer should produce small hairline-type cracks that extend through the full thickness of the PCC (Photo 7). The cracks must also be narrow enough to provide for aggregate particle interlock between the cracked pieces of pavement so that a portion of the pavement strength can be retained. Equipment or techniques that incorporate the use of chisel-shaped impact heads, gravity balls, or excessive energy will produce a rubble, as shown in Photo 8, which will result in the loss of the pavement's structural strength (Paving Forum 1984). Therefore, equipment or cracking techniques that produce rubble are not desirable.

Construction Techniques

Pavement preparation

10. Prior to cracking and seating, the existing PCC pavement must be prepared by cleaning the joints and cracks and by providing good drainage for

the pavement structure. Joint and crack sealing material, as shown in Photo 9, should be removed from the pavement surface and from the top 1/2 to 1 in.* of all joints and cracks. Failure to remove this sealant can lead to pavement slippage or bleeding of the sealant through the hot asphalt concrete that will be placed later. The sealant in the joints and cracks can be removed by routing (Photo 10). The sealant on the pavement surface can be removed by heating and scraping or by using a scabber, as shown in Photos 11 and 12. In addition to the sealants, any active cold patches should be removed and replaced with hot asphalt concrete prior to overlaying the PCC.

11. Providing adequate drainage (Photo 13) prior to cracking the PCC is important. Otherwise structural support will be lost which will lead to rocking of the cracked PCC pieces, resulting in a cracked asphalt concrete overlay.

12. In some cases, it may be necessary to install edge drains to prevent water from accumulating under the PCC pieces (Crawford 1984, Paving Forum 1984, The Asphalt Institute 1984).

Cracking procedures and requirements

13. As discussed previously, the cracking and seating method is intended to produce small pieces of PCC pavement that have interlocking capacity (Photo 14). The cracking pattern that is produced is dependent on several factors such as the (a) size and shape of the head of the hammer used to crack the pavement, (b) energy or impact force of the cracking equipment, (c) spacing of the points of contact, (d) strength of the PCC, and (e) strength and moisture condition of the subgrade.

14. Because there are so many variables that influence the size of the cracking pattern, it is recommended that prior to the full-scale cracking a trial section be used to determine the loading conditions that will produce the desired cracking pattern. This trial section, which should be at least 100 ft long, will allow a contractor an opportunity to develop a satisfactory cracking pattern for the existing field conditions. The intent of cracking is not to reduce the PCC to a rubble, but rather to crack the concrete full depth and into pieces that are 1-1/2 to 3 ft in size (Crawford 1984). This crack pattern will reduce reflective cracks in the asphalt concrete overlay which normally result from excessive stresses caused by, or from, rocking of slabs

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

under loads. Breaking the PCC into pieces that are 12 in. or less may result in pavement spalling and loss of structural strength.

15. When the proper equipment and techniques are used, the cracks that are produced should be very small or hairline. These cracks are nor normally visible to the eye unless the surface has been sprayed with water to make the cracks stand out (Photos 15 and 16). The cracked pieces of pavement must remain in contact to allow load transfer between the aggregate particles--otherwise the structural strength of the pavement will be reduced.

16. When cracking the pavement, continuous longitudinal cracks must be avoided because this type of crack tends to reflect through an overlay. Any cracking method that produces continuous longitudinal cracks must be adjusted to eliminate the continuous longitudinal crack.

17. During the course of cracking a pavement, the cracking technique developed in the trial section will have to be adjusted to suit the various field conditions such as a wet subgrade and changing concrete strength. Cracking should not be attempted next to a joint as this could spall the pavement. In addition, cracking should not be attempted over culverts or utility ducts as these structures could be damaged. Areas with culverts and ducts should be identified prior to cracking operations.

Seating procedures and requirements

18. Once the PCC has been cracked to the desired size, a heavy pneumatic-tired roller, such as that shown in Photo 17, should be used to seat the concrete pieces to prevent slab rocking. This heavy pneumatic roller is sometimes referred to as a proof roller. The roller should be loaded with 25,000 lb per tire.

19. In general, at least two passes of the heavy pneumatic-tired roller are required to seat the cracked PCC pavement on roads and streets, while as many as thirty passes have been used to seat the concrete on heavy-duty airfields. Field conditions may vary and influence the seating operation. For example, if the subgrade is extremely wet or weak, an excess rolling effort could result in the spalling or breaking of the PCC or nonuniform or excessive movement of the pavement (Crawford 1984; Eckrose, Poston, Donohue and Associates 1983). Therefore, the seating operation must be adjusted to suit field conditions, but in most cases (on roads and streets) at least two passes of the roller should be applied to seat the PCC pieces. Wet subgrades should be provided drainage prior to seating to reduce the possibility of rocking of the

concrete pieces or of losing structural support.

Repairs

20. During the cracking procedures, there may be areas where the cracking equipment head punches through the PCC; also, during the seating operations there may be soft areas or areas where rocking occurs. When punch through occurs, such as shown in Photo 18, hot asphalt concrete should be used to fill the void. Prior to any overlay, if rocking occurs or if soft spots are located, the affected PCC should be removed and the subgrade repaired with appropriate material. A sufficient thickness of hot asphalt concrete or PCC should be used to replace the inferior surface.

Overlaying cracked and seated pavement

21. In preparation for overlaying the cracked and seated pavement, the existing pavement surface must be swept to remove all debris and tack-coated with a bituminous material to ensure bonding between the PCC and the asphalt concrete overlay. Sweeping and tacking are shown in Photos 19 and 20.

22. Because the cracking and seating may leave an uneven surface, a leveling course of 2-in. minimal thickness is recommended prior to placing a 2-in. minimal thickness surface course. The asphalt concrete mix should be the standard mix used for flexible pavements. Photo 21 shows the placement of an asphalt concrete overlay. A cutaway section of a typical cracked and seated pavement that is overlaid with asphalt concrete is shown in Photo 22.

PART III: ECONOMICS

23. The cost per square yard of cracking and seating will vary with the number of square yards of PCC requiring cracking and seating as shown in Figure 1. However, typical costs are \$0.25 to \$0.50 per yd^2 (Paving Forum 1984,

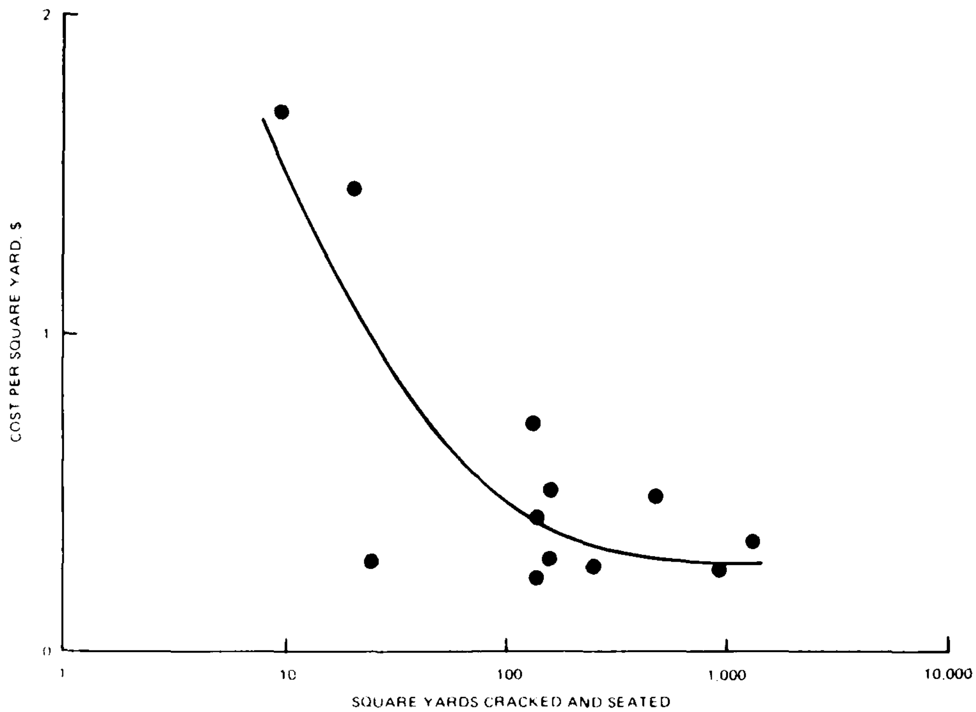

Figure 1. Cost of cracking and seating PCC
(Data from Eckrose, Poston, Donohue and Associates 1983)

The Asphalt Institute 1984) Compared with other reflective crack reduction methods in PCC, the cracking and seating method appears to be one of the most economical methods available. The unit costs for various reflective crack control methods are shown in the following tabulation taken from Eckrose, Poston, Donohue and Associates (1983).

Method	Cost per yd^2
Cracking and seating	\$0.20-1.00
1-in. hot mix asphalt concrete overlay	\$1.40-1.80
Engineering fabric	\$1.00-1.50
4-in. asphalt-treated open graded interlayer	\$5.50-7.00
6-in. granular base course interlayer	\$1.00-3.00
Stress absorbing membrane	\$1.00-1.20
Sawing and sealing hot mix asphalt concrete at 40-ft intervals	\$0.80-1.30

PART IV: ADVANTAGES AND DISADVANTAGES

Advantages

24. The cracking and seating technique is an effective method of reducing the amount of movement in each piece of PCC pavement which subsequently reduces reflective cracking and maintenance costs (Crawford 1984). Besides being a less expensive method than some of the alternatives, cracking and seating procedures are energy-efficient. For example, typical equipment used to crack PCC may require 1,000 to 2,000 British thermal units (Btu's) per yd^2; whereas, each additional inch of thickness of asphalt concrete requires 28,000 Btu's per yd^2 and each inch of thickness of nonreinforced and continuous reinforced PCC requires approximately 64,000 Btu's and 93,000 Btu's per yd^2, respectively (Eckrose, Poston, Donohue and Associates 1983). Another advantage is that almost all of the equipment required for cracking and seating is readily available. Cracking and seating procedures have been used for a number of years throughout the United States and have proven to be a successful method to reduce reflective cracks (Crawford 1984; Ekrose, Poston, Donohue and Associates 1983).

Disadvantages

25. Currently, there are no established standardized design methods for determining the strength of the cracked PCC pavement, and there are no established standard methods to determine the required overlay thickness.

26. Improper cracking techniques or overrolling of the PCC can result in loss of strength of the pavement.

27. If drainage problems are not rectified, then cracking and seating techniques will not be fully effective as a method to reduce reflective cracking.

PART V: DEMONSTRATION OF METHOD

28. The cracking and seating method was selected for demonstration at Rock Island Arsenal under the 1984 Facilities Technology Application Test Program. A PCC parking lot on the east side of Building 350 was the demonstration site. Photo 23 shows the site prior to the demonstration and Photos 24 and 25 show the site after the demonstration. Mr. C. Swynenberg of the Rock Island Facilities Engineering Office assisted in coordinating the project. The development of the plans and specifications, administration of the project contract, and site inspection were conducted by the Rock Island Facilities Engineering Office.

PART VI: RECOMMENDED GUIDANCE

29. At present, there is no guide specification for cracking and seating of PCC; however, some general recommended guidance for developing a project specification is given below.

PCC Pavement Cracking

Cracking existing PCC pavement

30. In designated areas, existing PCC shall be cracked into pieces 18-in. minimal and, no larger than, 24-in. maximal top surface dimension. Cracks shall extend the full depth of the PCC. Neither spalling of the PCC nor continuous longitudinal cracks shall be allowed.

Joint and crack sealant removal

31. Prior to cracking the PCC, all existing joint or crack sealant shall be removed from the pavement surface and from the joint or cracks to a minimal depth of 1 in. below the surface.

Equipment for cracking PCC

32. The equipment shall be capable of cracking the PCC in place without producing grade changes in excess of 1 in. from the existing grade. Equipment that uses gravity (headache) balls shall not be allowed.

Test Section

33. Prior to full-scale cracking of the designated PCC pavement areas, the contractor shall perform cracking of a test section in an area designated by the Contracting Officer's Representative. The test section shall be at least 100 ft long and one paving lane wide. If results of the cracking operation on the test section are not satisfactory, the contractor shall continue testing and modifying his equipment and methods as necessary to comply with specification requirements before proceeding with full-scale cracking operations.

PCC Pavement Seating

34. A heavy pneumatic-tired roller (proof-roller) shall be used to seat

the cracked PCC pavement. The heavy pneumatic-tired roller shall be of the type having four or more tires with each tire loaded to a minimum of 25,000 lb. Tires shall be uniformly inflated to 150 psi. Loading shall be equally distributed to all tires. Towing equipment shall be rubber-tired. The designated areas that were cracked shall receive two to five passes of the rolling equipment over the entire area. Seating shall commence only after all cracking is completed.

Repair

35. All punch throughs from the cracking equipment shall be filled with hot asphalt concrete. Pieces of PCC that rock during seating shall be removed and replaced with hot asphalt concrete meeting the same requirement as the asphalt concrete overlay mixture. Soft areas observed during seating shall be removed and repaired.

PART VII: CONCLUSIONS

36. Cracking and seating is an effective and economical method to reduce reflective cracking of PCC pavement through an asphalt concrete overlay. The cracks in the PCC should be narrow enough to provide load transfer, and the optimum size of the cracked concrete pieces should be in the range of 1-1/2 to 3 ft. All the cracked pieces must be firmly seated to prevent rocking. Seating is accomplished with a heavy pneumatic-tired roller. Failure to provide adequate drainage when using the cracking and seating method can result in loss of the structural strength or rocking of the cracked pavement pieces. Although there is no established design procedure, a minimal thickness of 4 in. of hot asphalt concrete is recommended for the overlay.

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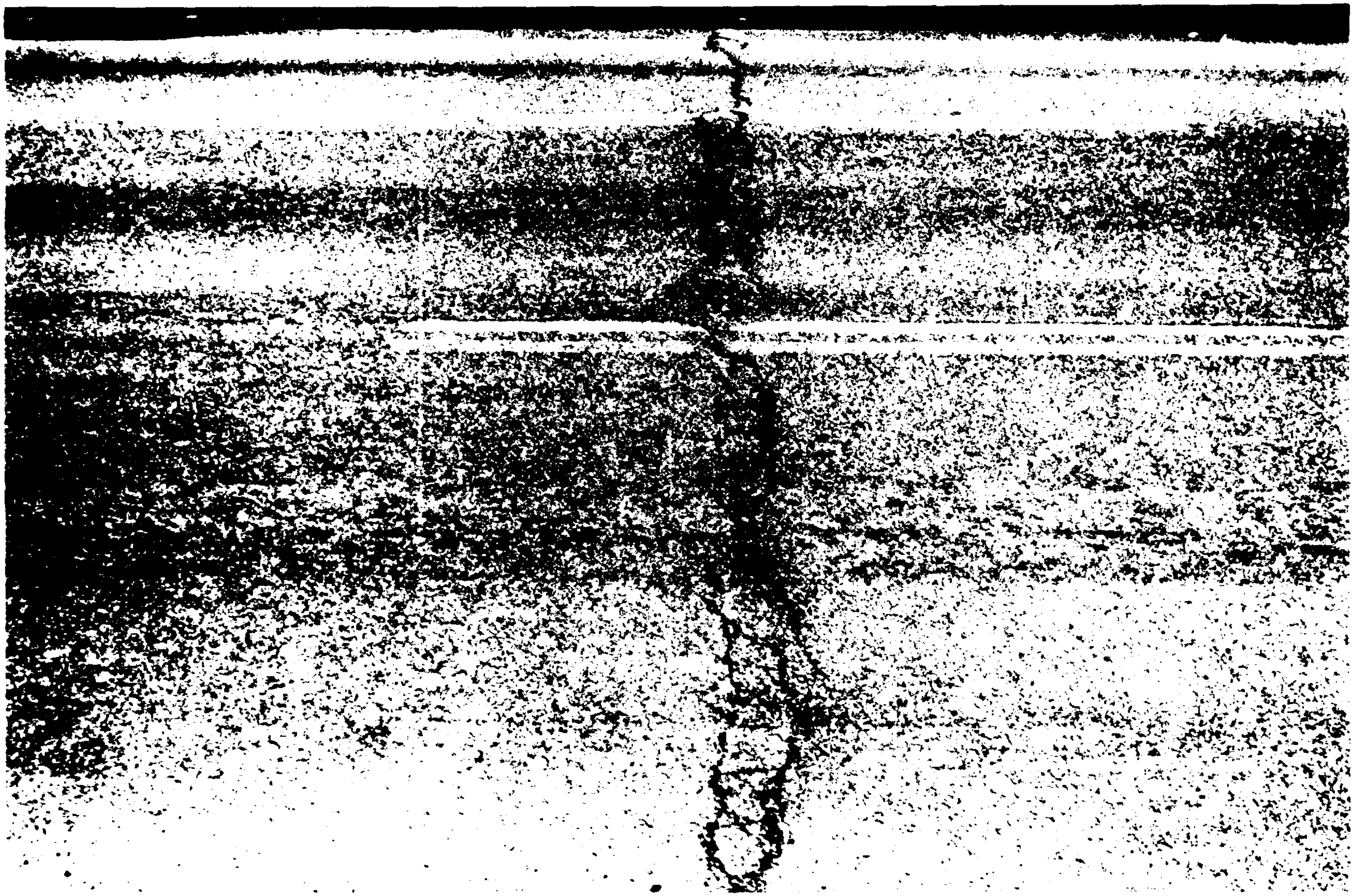

Photo 1. Reflective cracking in asphalt concrete pavement

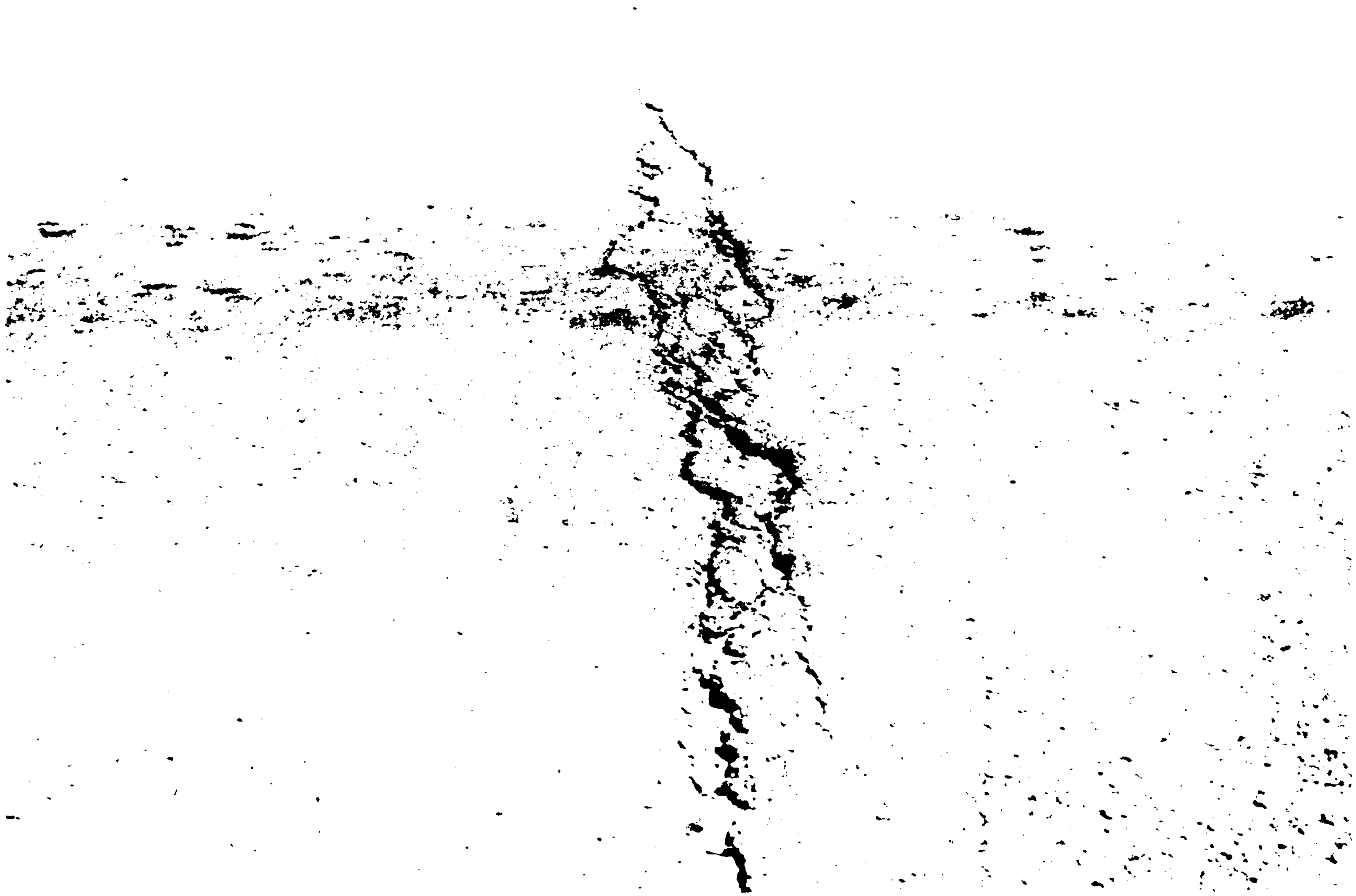

Photo 2. Deterioration of asphalt concrete as a result of reflective cracking

Photo 3. Guillotine hammer (The Asphalt Institute 1984)

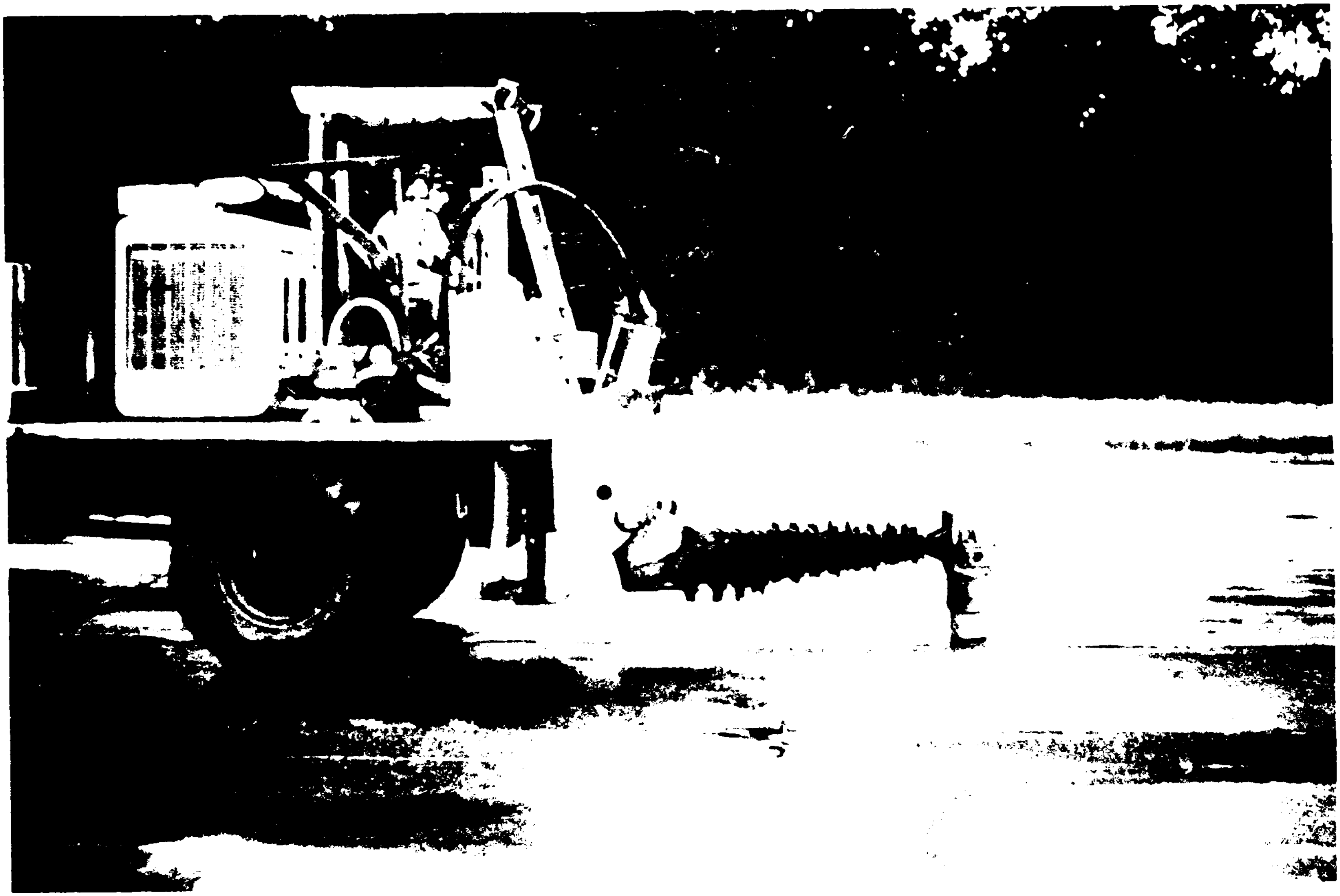

Photo [illegible]. Whip hammer (The Asphalt Institute 1984)

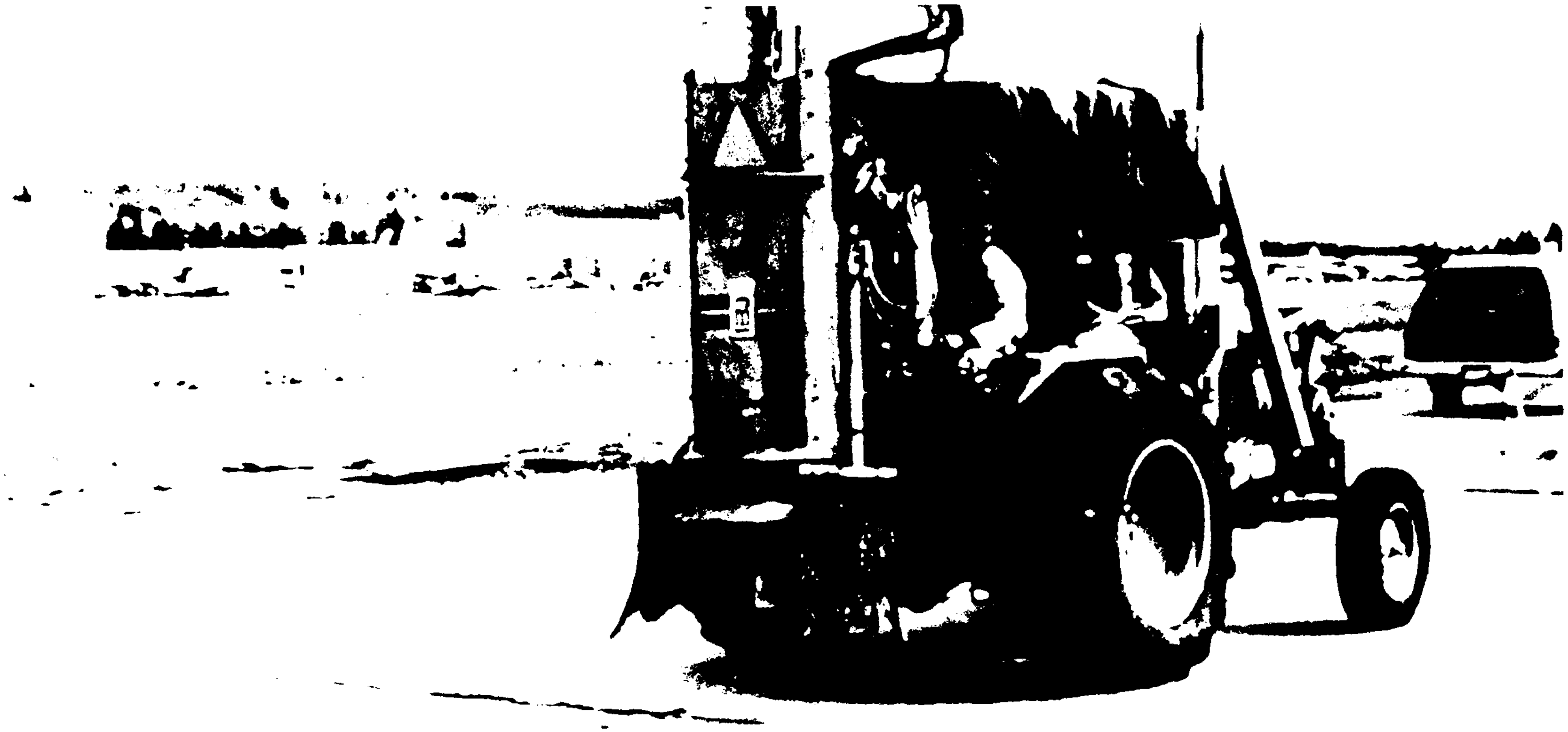

Photo 5. Hydraulic impact hammer

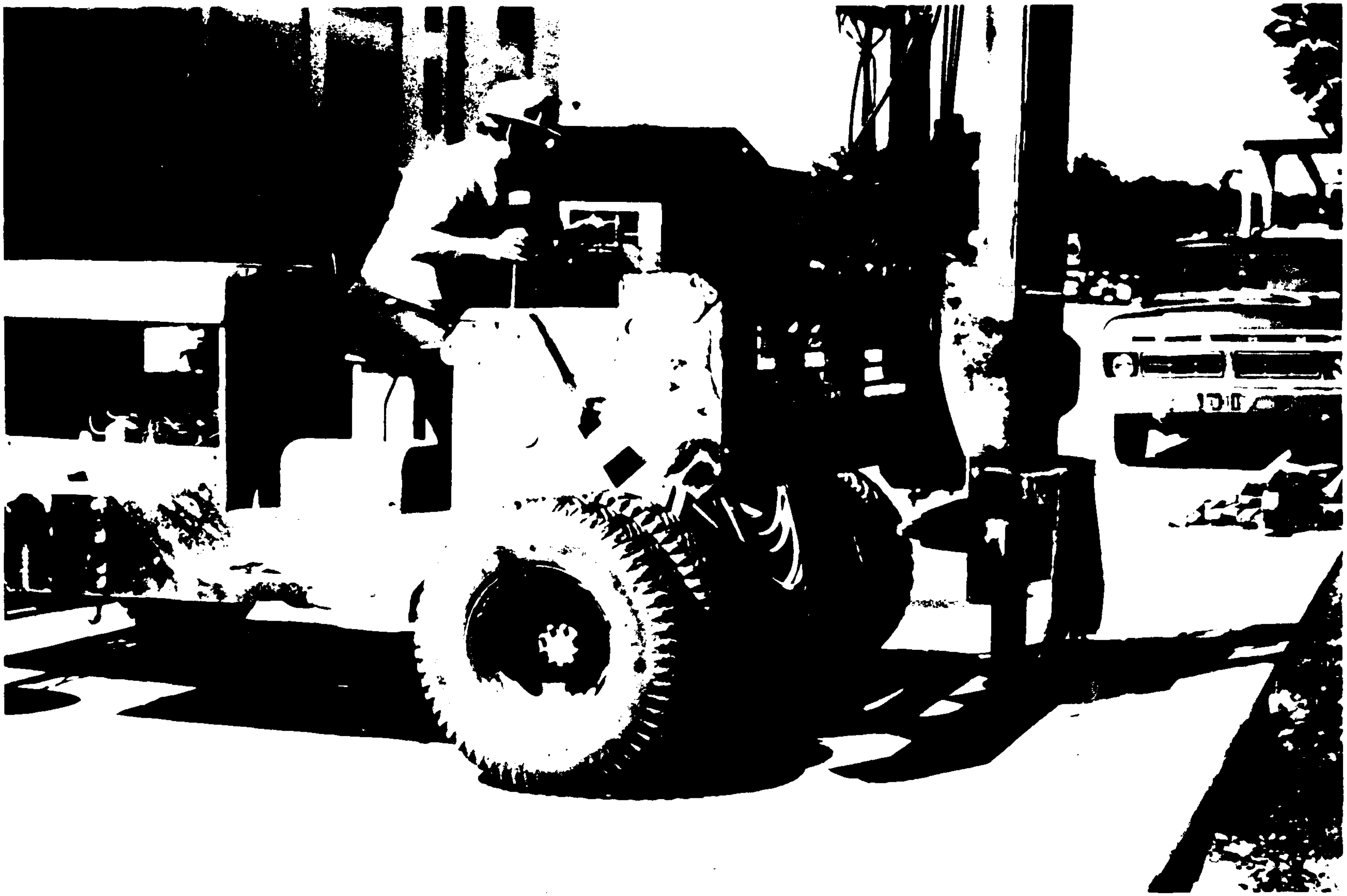

Photo 6. Falling-weight hammer used at Rock Island Arsenal

Photo 7. PCC pavement cracked through total thickness

Photo 8. Excess impact force produces pavement rubble

Photo 9. Sealant in PCC pavement joints and cracks

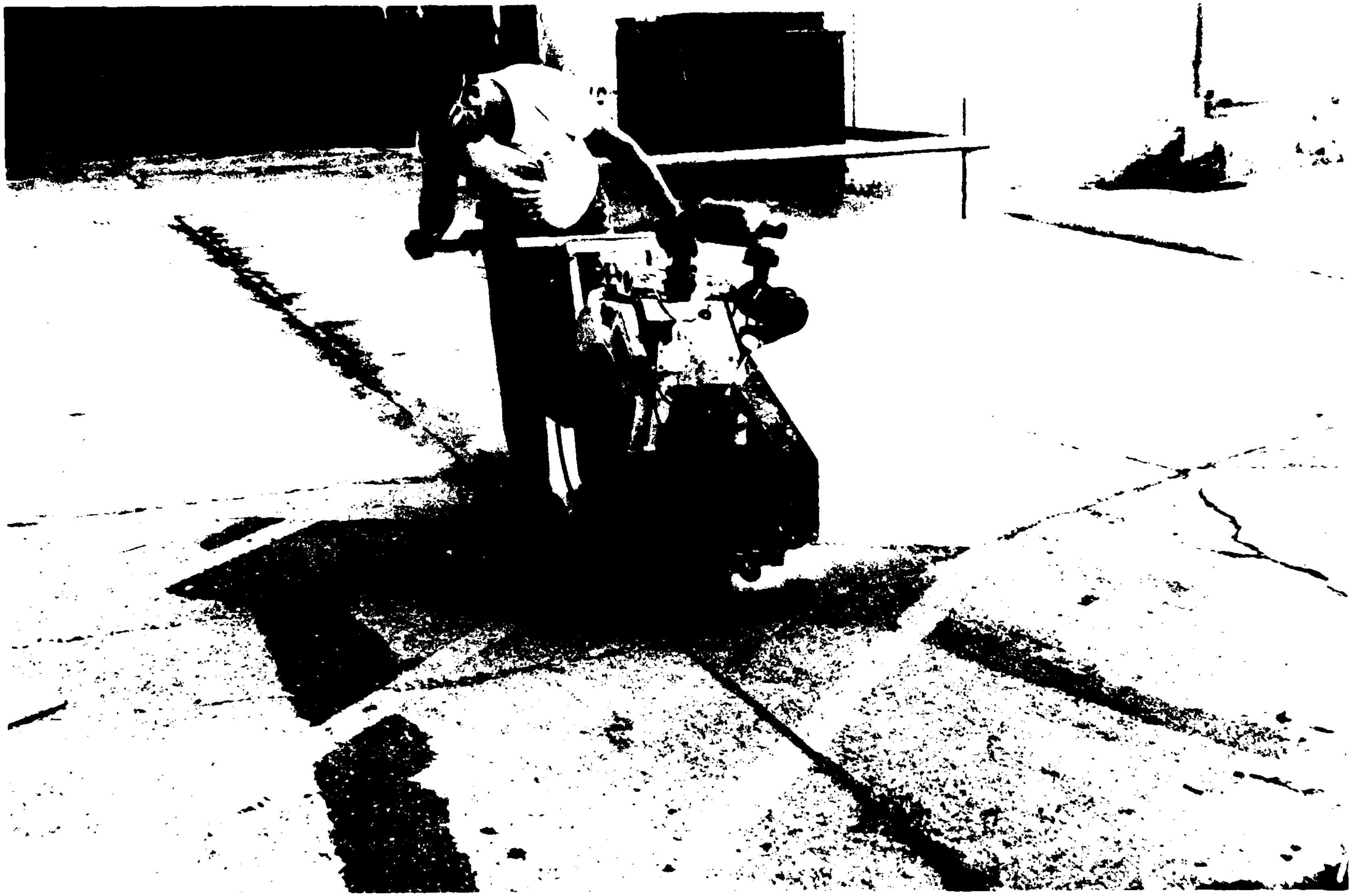

Photo 10. Routing of joint to remove sealant from top 1/2 in.

Photo 11. Scabber used to remove sealant from pavement surface

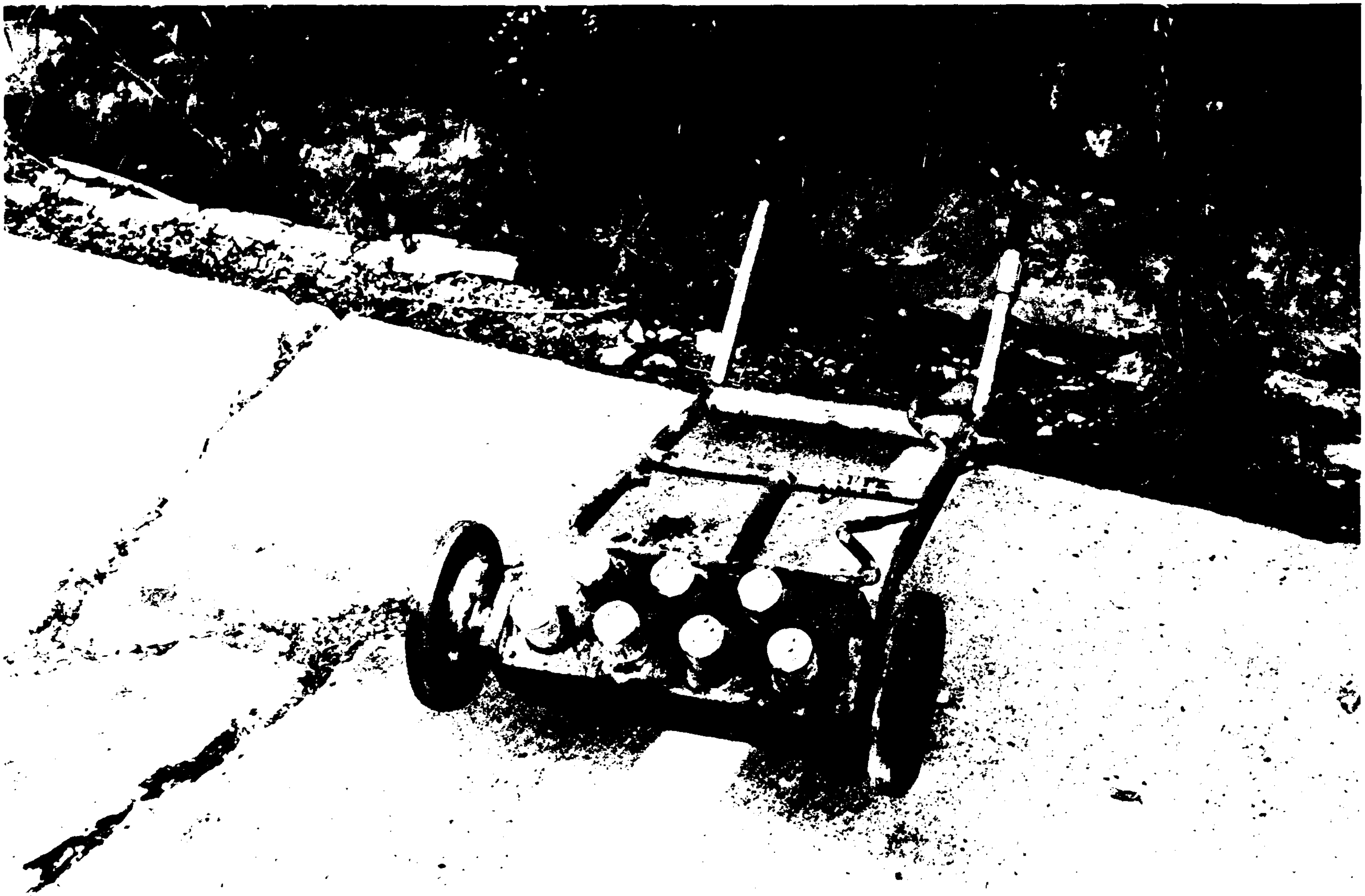

Photo 12. Underside of scabber

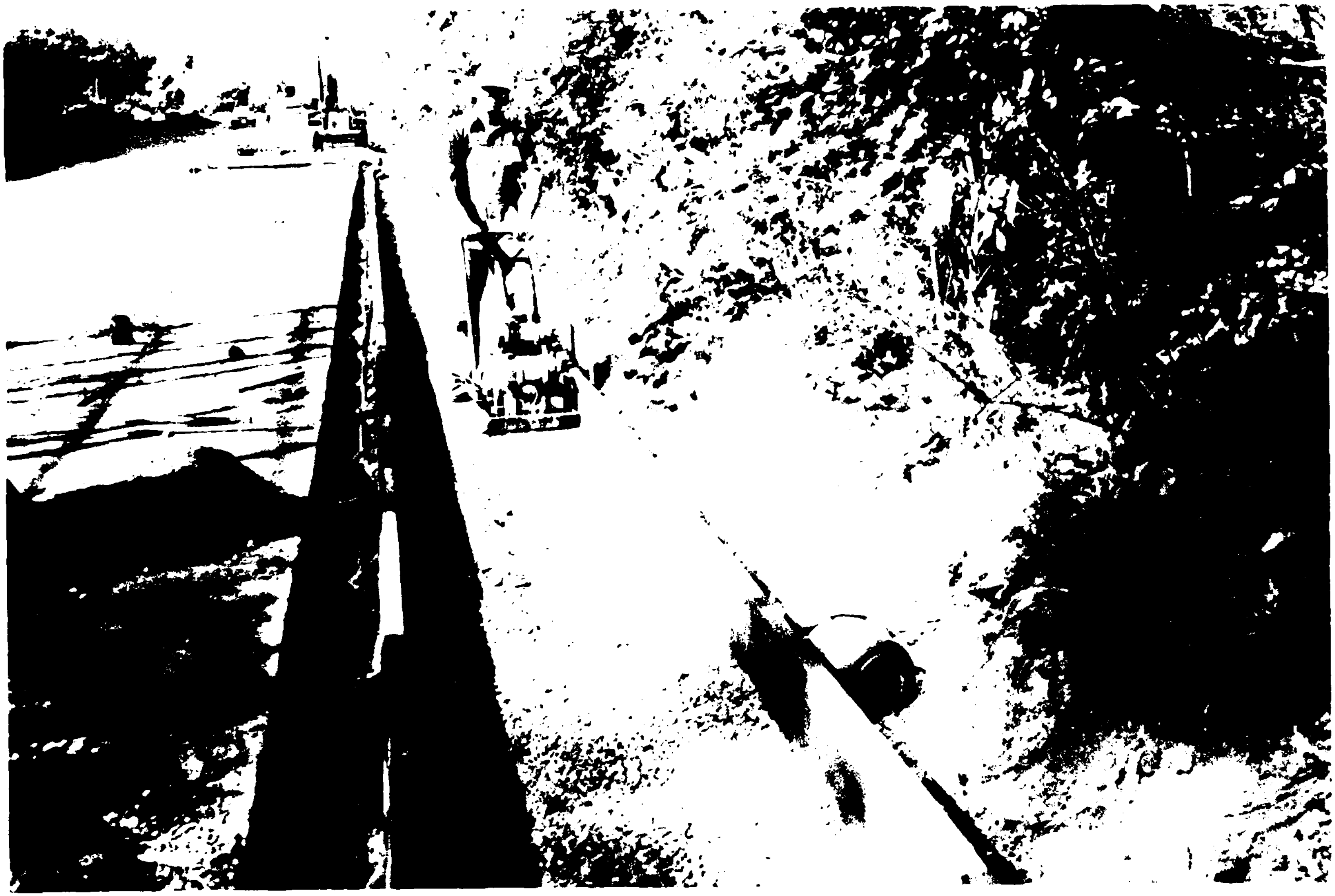

Photo 13. Installation of pavement drainage system

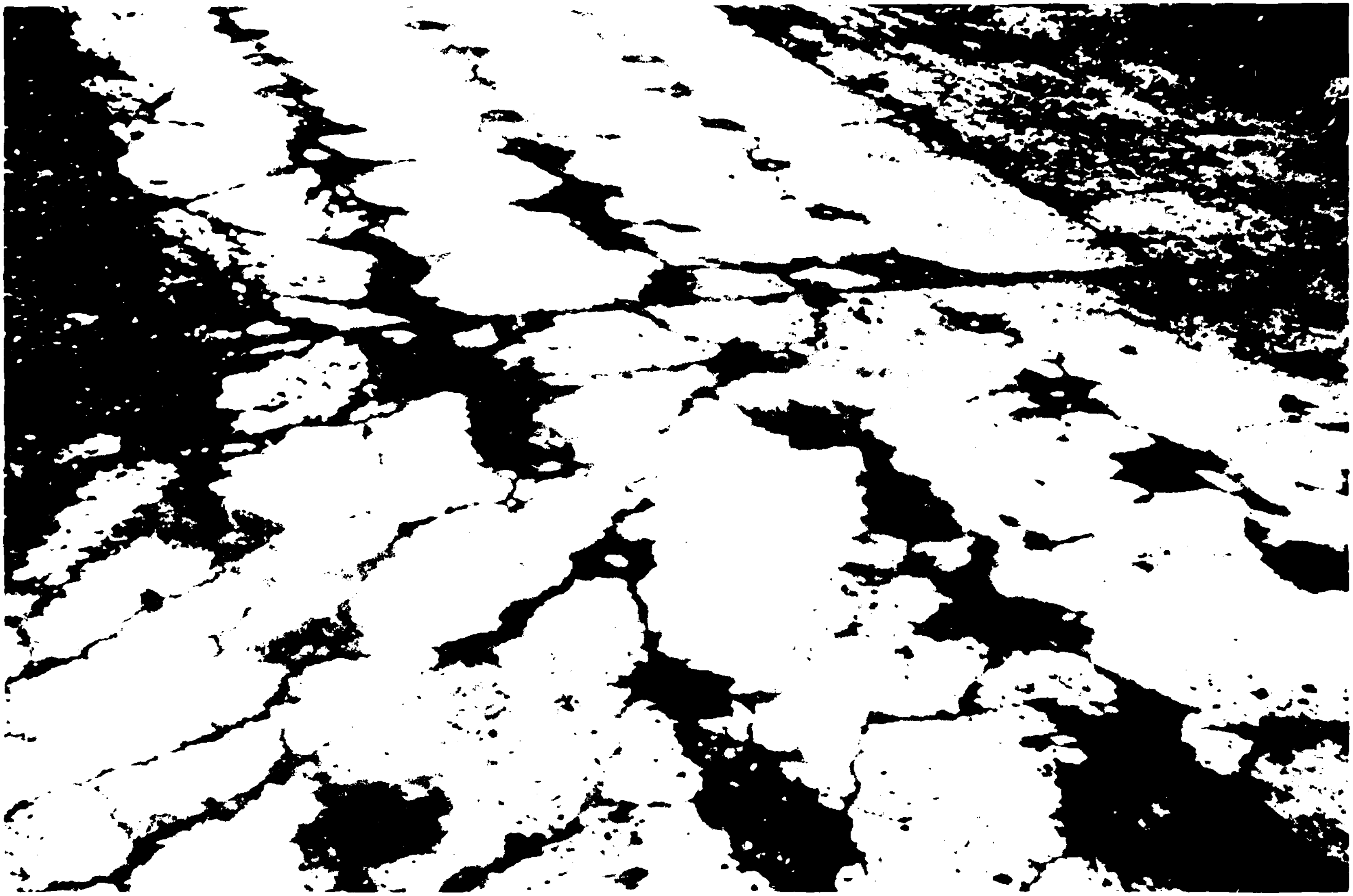

Photo 14. Cracked PCC pavement

Photo 15. Dry, cracked PCC pavement

Photo 16. Cracked PCC pavement after being sprayed with water

Photo 17. Heavy pneumatic-tired roller used to seat cracked PCC pavement

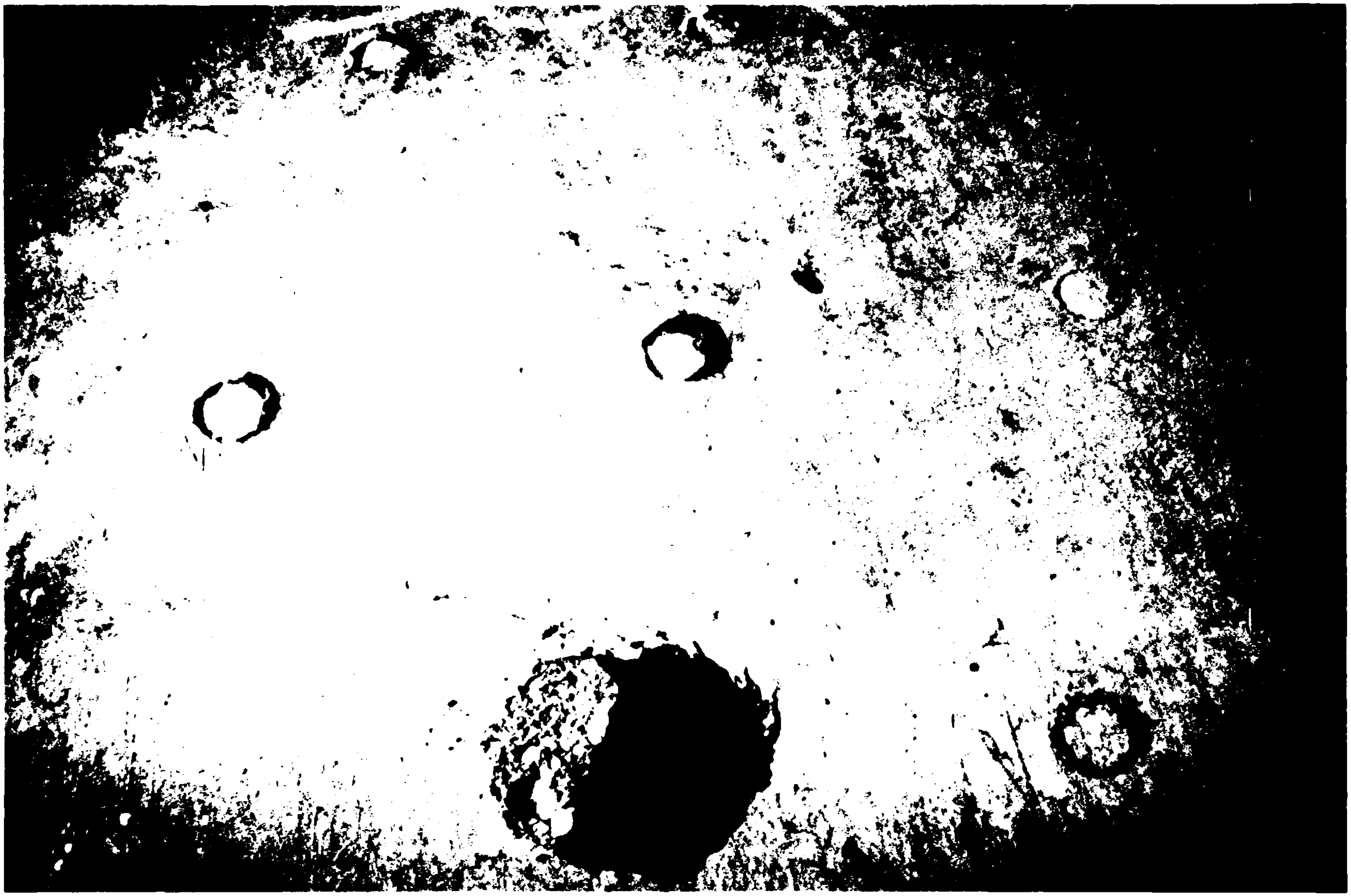

Photo 18. Punch through of PCC pavement resulting from cracking operation

Photo 19. Sweeping the pavement surface in preparation for asphalt concrete overlay

Photo 20. Applying asphaltic tack coat

Photo 21. Placing asphalt concrete overlay

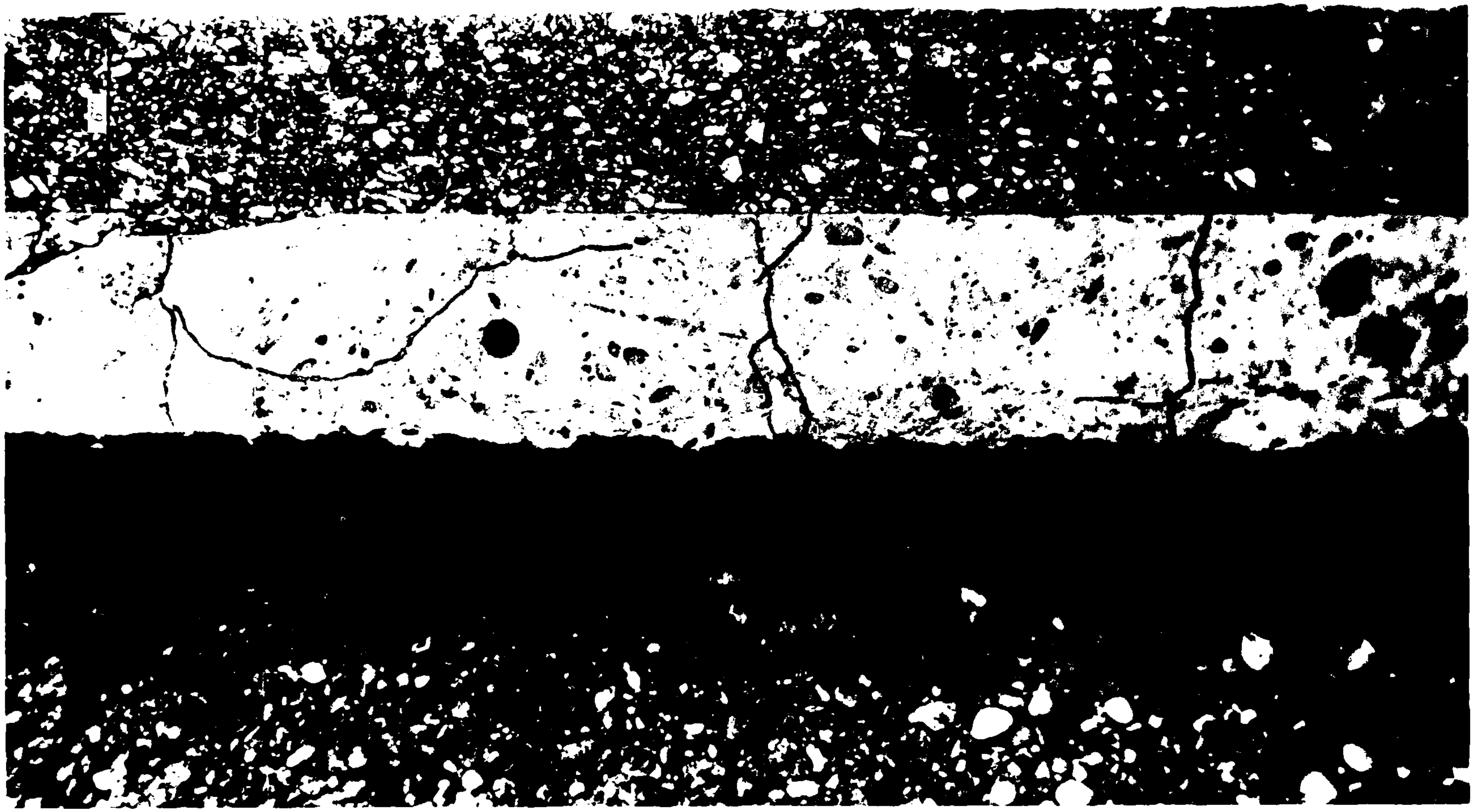

Photo 22. Cut-away section of a typical asphalt concrete overlay of cracked and seated pavement

Photo 23. Demonstration site prior to cracking and seating of pavement

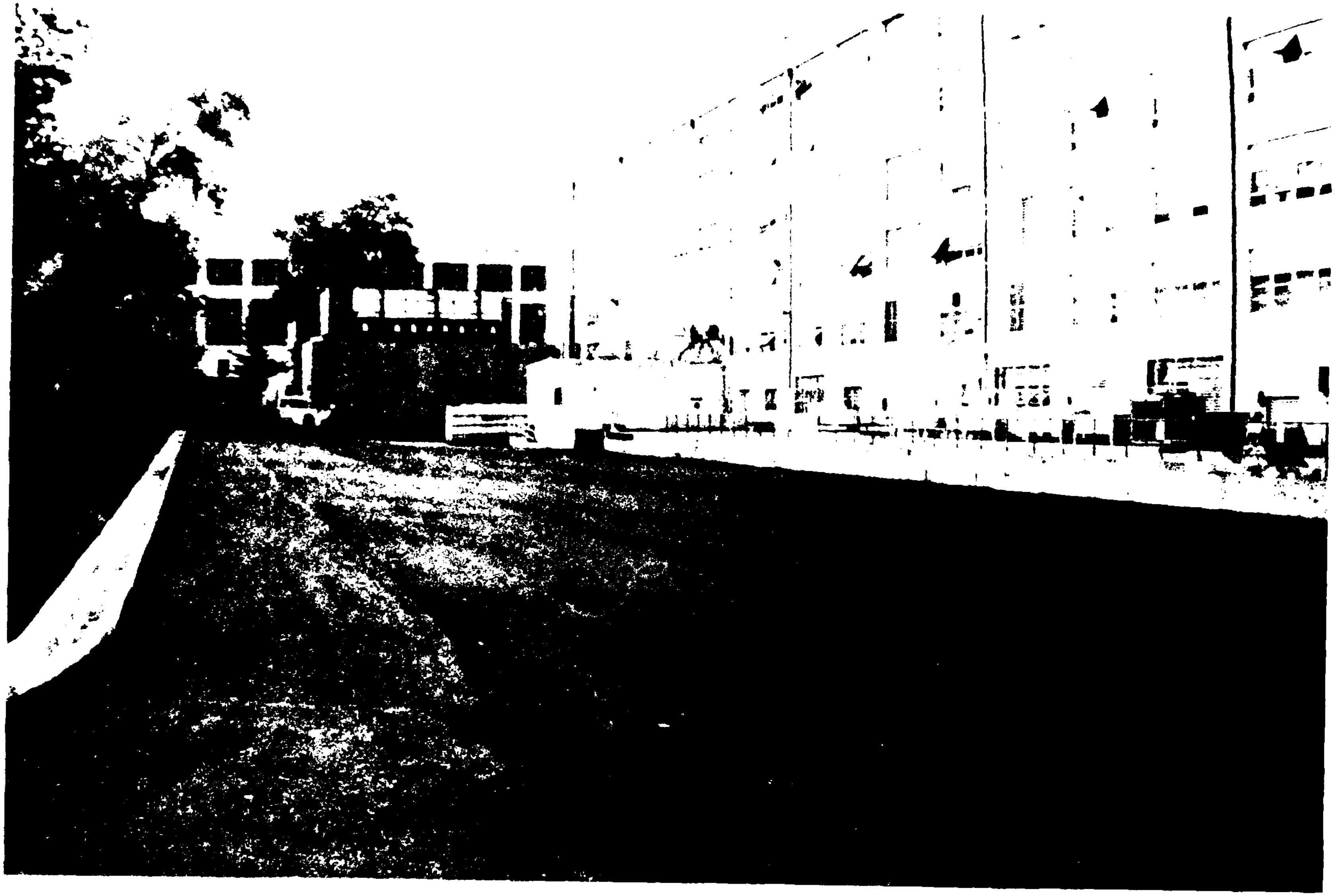

Photo 24. Demonstration site after asphalt concrete overlay

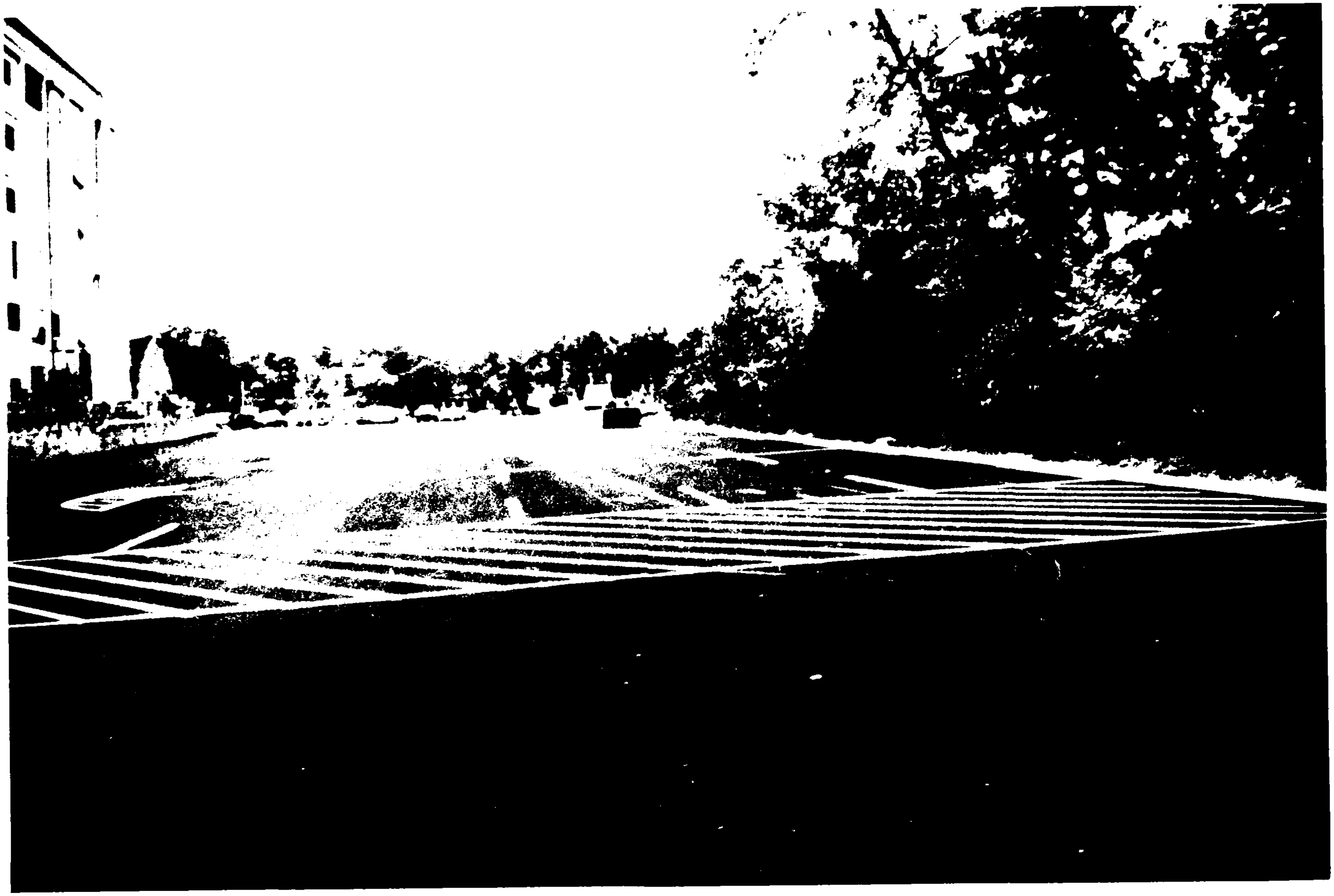

Photo 25. Completed demonstration site

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