A STUDY OF

CONSTRUCTION EQUIPMENT AND INITIAL PAVEMENT ROUGHNESS

AS MEASURED WITH A PROFILOGRAPH

Research Report 49-2

Development of a Construction Control Profilograph
Research Project 1-8-63-49

Conducted by
Highway Design Division, Research Section
The Texas Highway Department

In Cooperation With The
U. S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

August 1968

A C K N O W L E D G M E N T

The research reported in this paper was conducted under the supervision of Mr. Robert L. Lewis, Research Engineer and under the general supervision of Mr. T. S. Huff, Chief Engineer of Highway Design.

Mr. J. C. Roberts, District Engineer of District 8 (Abilene) conceived the idea for this study and acknowledgment is given to Mr. G. J. Smith and Mr. W. O. Crawford of District 8 for the supervision and consultation rendered.

Acknowledgment is also given to the personnel of the Allen Construction Company for the help received in performing the various tests.

This study was conducted by personnel from District 8 and the Research Section of the Highway Design Division.

TABLE OF CONTENTS, Continued

LIST OF FIGURES

A B S T R A C T

This is an interim report concerned with the development of a profilograph for measuring construction roughness. The profilograph presently under study was designed and fabricated by the Rainhart Company of Austin, Texas. Particular attention was given to the cost, ruggedness, simplicity of operation and maintenance during its design in order that similar instruments could be made available for use by the various Districts in Texas.

This report is a study dealing with the reasons for roughness in asphaltic concrete paving. The primary test site had the advantages of the following features:

(1) The surface of the flexible base had been planed with an CMI Autograde using electronically controlled grade apparatus and was very smooth and true to cross-section.

(2) Two asphaltic concrete mats were placed using bituminous pavers with electronically controlled screeds.

The roughness was determined with the Rainhart profilograph and consisted of obtaining a profile over the areas in which the rollers parked, the paver paused, and various paver speeds were used.

This study could find no significant roughness in the area where rollers paused; however, surface variation was present near the area in which the paver paused for a change of trucks. Increased roughness was experienced as the paver speed increased.

The pavement materials and temperature of the mix were not considered in this study. The type of rollers and roller operation could be considered as constants since the same equipment and operators were used throughout.

I. INTRODUCTION

There are many theories which have been advanced denoting reasons for initial roughness in pavement surfaces. Several causes for roughness can actually be seen during construction and traced to construction practices. Other theories have only been postulated in the past because equipment to accurately measure roughness has not been available.

The undesirable effects of initial or construction roughness in the pavement surface are not fully defined, since long term studies have not been directed to this end. However, it is thought that initial roughness can be compounded in certain cases by the impact loads occurring in repeated applications of traffic. In the test sections of this study, roughness caused by construction procedures results in small movement in the wheels of a vehicle. In general, this movement is absorbed by the vehicle spring and shock absorber system and is not noticed by the passenger. But this roughness can be noted through the steering wheel by the driver. Also, there are cases in which initial roughness is objectionable to passengers--particularly at bridge approaches.

It is interesting to note that a wide range of initial roughness is present in Texas. Research personnel attempting to relate AASHO Road Test results to Texas conditions experienced difficulty because the initial serviceability index, as measured with the CHLOE profilometer, did not duplicate initial serviceability as found at the AASHO Road Test.[1] Indeed, a wide range of initial serviceability indices were found. The Texas study found that certain newly constructed pavement surfaces have a high initial serviceability index number and several years of traffic could be expected from these surfaces before the serviceability index number approached the initial serviceability index of those roadways found with the lower initial values.

Objective

The objective of this study is to note causes of initial roughness in asphaltic concrete construction procedures. Hypotheses were formed as to which construction equipment and procedures result in roughness. The locations of these procedures were marked on roadway test sections, and the roughness of those locations was measured with a profilograph and noted on the output chart.

II. DESCRIPTION OF TEST SITES

Two test sections were established in District 8 (Abilene). These two locations were different in that one was an urban section and the other rural. These sections were both overlaid with approximately 1-1/4 to 1-1/2 inch layer of asphaltic concrete; however, the overlay placed on the urban section was over an old well established street and the surfacing of the rural section was over a newly constructed portion of interstate highway. The same contractor (Allen Construction Company, San Antonio, Texas) used the same equipment on both jobs.

The first test site was located on Treadaway Street (loop 243, 33-8-7) in the City of Abilene, Texas. Several city streets intersect Treadaway Street in a transverse manner. These transverse streets were originally constructed with a dip at each curb line for drainage.

No intermediate leveling or "blade-on" mix was used on this street during the overlay process. A machine laid course of approximately 1-1/2 inches of Texas Specification Type C hot mix asphaltic concrete was placed during the testing period.

The second test site was located on IH 20(I 20-2(71)225) (6-2-35) approximately eight miles West of Roscoe, Texas. This newly constructed section of interstate highway was composed of a base material of limestone origin and two surface layers of Texas Specification Type B and Type D asphaltic concrete. During the finishing of the base, approximately 1/4 inch of the surface of the base was planed with an electronically controlled planer (a CMI Autograde). The resulting surface was very smooth with a constant transverse slope. The Type B hot mix was used over the base material and the final surface was the Type D asphaltic concrete (1-1/4 inches). Both asphaltic concrete types were placed with the same electronically controlled laydown machine. The test section was in rural surroundings and was relatively straight and level. The only unusual vertical alignment was the approaches to an overpass near the final portion of the test section.

The asphaltic concrete was mixed at temperatures ranging from 290° F to 315° F. The breakdown rolling temperature was around 170° F to 210° F.

III. CONSTRUCTION EQUIPMENT

The contractor's equipment was relatively new and in good working order. Even though duplicate equipment was present on the job,(i.e. two of the same type rollers, pavers, etc.) the same equipment was used on both test sections.

Bituminous Paver

The paver used was a PF 180 Blaw-Knox (see Figures 1 and 2). The tires on the rear axle were the large pneumatic type and the tires on the two axles under the hopper were hard rubber. The laydown machine was equipped with an electronically controlled screed. The "stringline" was actually a structural member supported by several manually adjusted shoes (see Figure 1). Differential movement experienced by the structural "stringline" activated the electric sensor shown in Figure 3 and from there corrections were made by a hydraulic and mechanical linkage to the screed. The tampers operated at a vibration rate of 1,500 r.p.m. and move 1/64" below the screed plate.

Rollers

The breakdown roller was a ten ton, three wheeled roller as shown in Figure 4. This roller was operated directly be-

FIGURE 1

OBLIQUE VIEW OF BLAW-KNOX PAVER

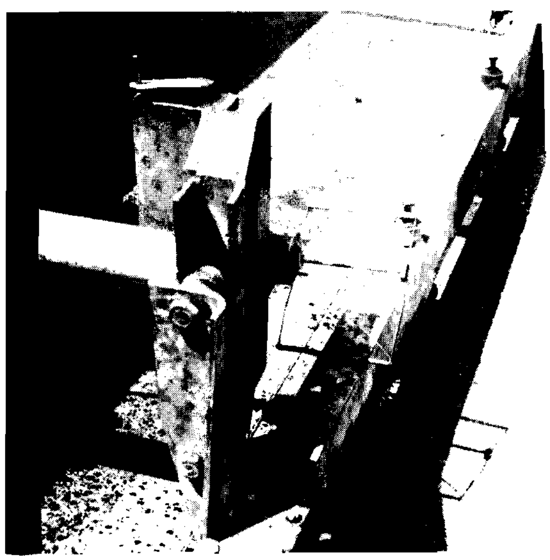


FIGURE 2

REAR VIEW OF BLAW-KNOX PAVER

FIGURE 3

SENSOR ON THE AUTOMATIC SCREED LEVELING DEVICE

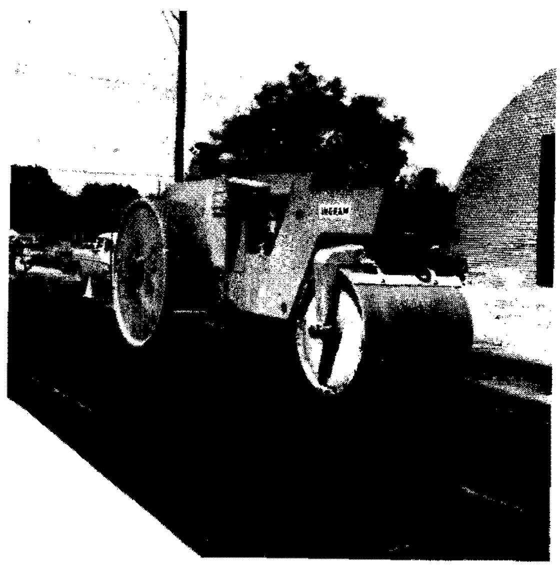


FIGURE 4

BREAKDOWN ROLLER

hind the laydown machine and as close to the placement operations as possible. As usual, the material was allowed a short cooling period before compaction in order that the mix would not stick to the steel roller wheels.

The second roller was an 8 to 12 ton steel wheel tandem roller (see Figure 5). This roller operated behind the breakdown roller and "ironed out" minor irregularities left by the first roller.

The last roller was a 25 ton pneumatic roller (see Figure 6). The pneumatic roller provided further densification of the mat and appeared to knead the mat, forming a more homogeneous surface.

<u>Haul Trucks</u>

The haul truck consisted of a fleet of diesel powered, 12 cubic yard, tandem axle vehicles. These trucks were of the bob-tail variety and were equipped with a specially constructed hydraulic dumping gate (see Figure 7).

All of the equipment used on this construction project appeared in excellent operating condition. No time was lost because of equipment break down during the testing period.

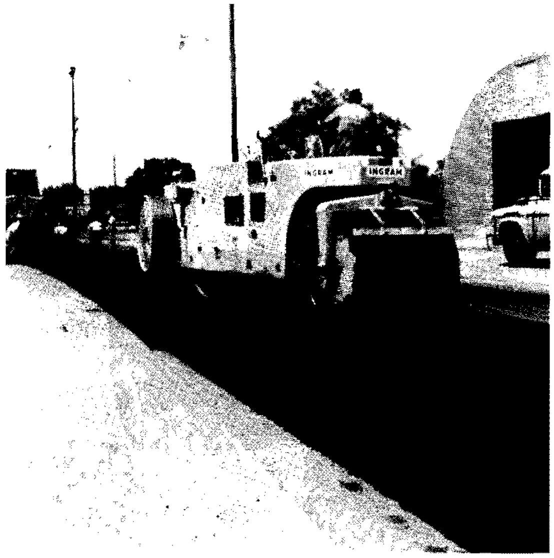


FIGURE 5

TANDEM ROLLER

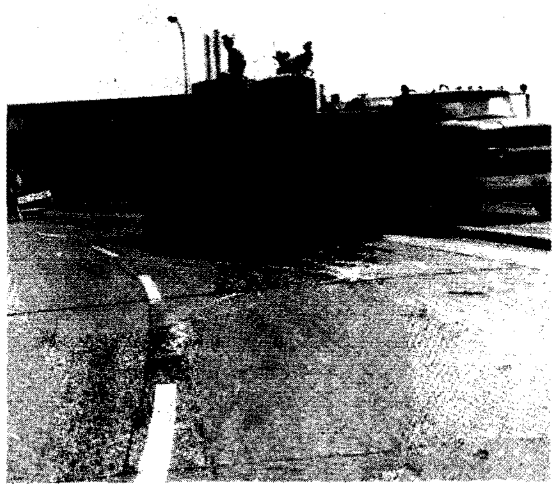


FIGURE 6

PNEUMATIC ROLLER

FIGURE 7

HAUL TRUCK EQUIPPED WITH SPECIAL DUMPING GATE

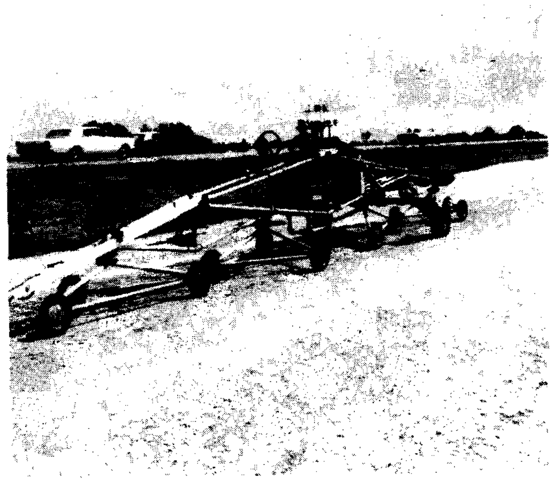


FIGURE 8

CONSTRUCTION CONTROL PROFILOGRAPH

IV. PROFILE MEASURING EQUIPMENT

The equipment which was used to measure surface roughness is a profilograph developed at the Rainhart Company in Austin, Texas[2] (see Figure 8). The profilograph is approximately 25 feet in length and 52 inches in width. Twelve small, equally spaced averaging wheels are utilized to allow a recorder to be positioned at a relatively constant height above the roadway surface. The recorder emits paper at a rate proportional to the speed at which the instrument is manually pushed. An extension from the recording wheel is attached with a ball point pen stylus which scribes the resulting profile (to the selected horizontal and vertical scale) on the paper being emitted. Mechanical counters are also utilized to digitize accumulative peak heights.

The twelve averaging wheels are arranged in four sets of tripods. Each tripod contains three wheels so fixed as to provide self-contained stability. Each wheel tracks in an individual path when recording. Two outrigger wheels are attached on each side for roading as a trailer when they are lowered by means of a mechanical jack.

V. METHOD OF STUDY

Hypotheses were formed as to which equipment and construction procedure contributes to initial surface roughness. It was postulated that the following procedures causes roughness:

(1) Laydown machine pauses for the discharge of material into the machine hopper from haul trucks.

(2) Rollers parked on the freshly placed asphaltic concrete mat.

(3) Areas which are hand raked.

(4) Fast paver machine speeds.

(5) Unusual or unnecessary movement of the haul truck while the truck is in contact with the laydown machine during the unloading process.

One additional postulation was made - roughness is reflected through the new mat from the overlaid surface.

Method of Marking Construction Roughness

It was desired to physically mark locations on the pavement surface at areas where roughness was expected. To accomplish this location marking, small symbols were cut from thin cardboard. These cardboard symbols were nailed into the fresh asphaltic concrete mat at the selected locations.

Reasoning suggested that thin cardboard would not cause roughness and could be pulled from the surface at the completion of the study. The cardboard was cut into various symbols in order that certain symbols would denote different causes of roughness.

<u>Laydown Machine Pauses</u>. A square cardboard symbol was nailed to the new surface near the screed at the rear of the paver at each location which the laydown machine halted. In almost every case the laydown machine did not pause unless the haul truck had finish unloading. Triangular symbols were used where the laydown machine pause exceeded one minute.

<u>Parked Rollers</u>. The rollers were numbered in consecutive order with the smallest number being near the laydown machine. The three wheel breakdown roller was labeled Roller #1, the tandem was labeled Roller #2 and the pneumatic was labeled Roller #3. A small rectangular cardboard symbol was nailed to the surface near the roller wheel at each location on the pavement at which a roller parked. A 1, 2 or 3 was written on the cardboard to denote each roller as described above.

Raked Areas. It was planned to mark extensively hand raked areas with a circular symbol; however, almost no raking was done. Areas at the beginning and end of the job were raked, but it was thought that these areas would not constitute a reliable test.

Variation in Paver Speed. At the suggestion of Mr. J. C. Roberts, District Engineer of District 8, and with the help of Allen Construction Company personnel, the speed of the laydown machine was varied as the material was placed. Speeds of 22.3, 39, 50 and 70 feet per minute were selected for study and material was placed for approximately 800 feet at each speed. Locations of each speed study section were noted by station number and by distance from the beginning of the job.

The Truck - Paver Combination. A small thickness of asphaltic material was noted on the paver contact rollers shown in Figure 9. This thickness was noted on approximately one half of the circumference of each roller. In order to determine the effect of this small bumping between haul truck and laydown machine, a short section was placed with the material on the rollers. The rollers were then cleaned and another section placed. Both sections were noted by station number and by distance from a known location.

FIGURE 9

PAVER CONTACT ROLLERS

AND SPRING ASSEMBLY

FIGURE 10

PROFILOGRAPH RECORDING WHEEL NEAR AN EVENT SYMBOL

Roughness Reflected from Below

Profiles were obtained before and after overlay placement on all section studied to determine the effect of the roughness of the older surface on that of the new mat. The urban street was selected for study because the drainage dips indicate large surface variation at the street intersection locations. The before (Type B) and after (Type D) profiles on IH 20 are not shown because the newly constructed Type B asphaltic concrete revealed little roughness.

Measurement of Construction Roughness

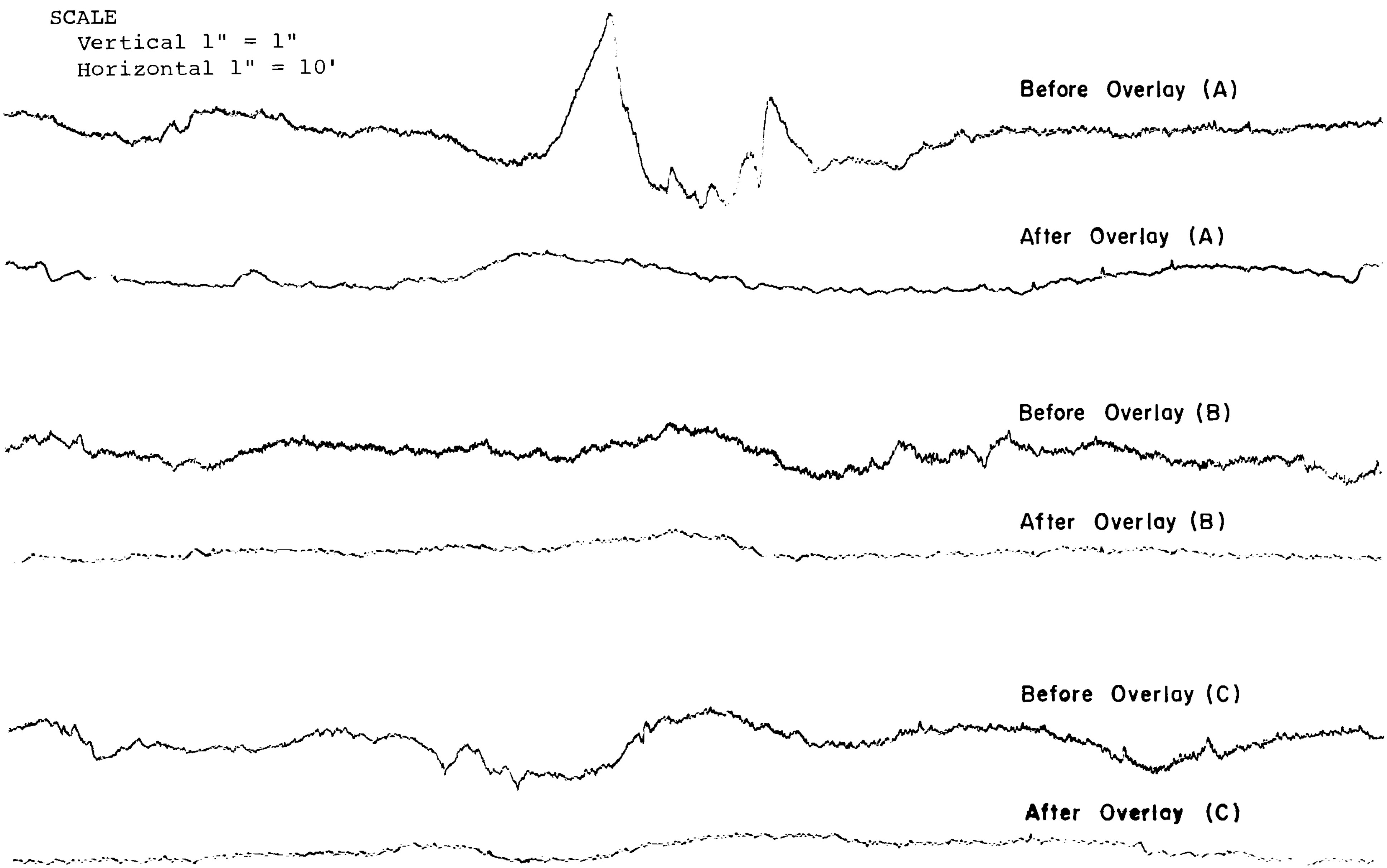
The profilograph was pushed over the surface of the roadway in order to obtain a graphical profile of the entire test section. The before profile was, more or less, a continuous run from beginning to end. However, the after profile consisted of halting the profilograph at each cardboard symbol nailed to the roadway and recording directly on the graph the symbol information.

VI. PRESENTATION OF RESULTS

The results of each test have been reported in this study in terms of a scaled profile of the vertical irregularities and horizontal lengths found by the profilograph. The horizontal scale is one inch equals ten feet and the vertical scale is true, or one inch equals one inch, for all profiles shown herein. On each profile, the construction operations proceeded from right to left.

Roughness Reflected from Below

The first test section selected was the city street or urban section. The street was originally constructed with small dips transverse to the section length. These dips occurred at the gutter line of the intersecting streets and are used for drainage. Figure 10 indicates before and after profiles of three sections of this street which show that roughness is reflected through the new mat from the original surface. All three sections indicated in Figure 10 were at intersecting streets. The thickness of the new surface was approximately 1-1/2 inches and was placed with the electronic screed control in operation.



ROUGHNESS REFLECTED FROM BELOW

FIGURE 11

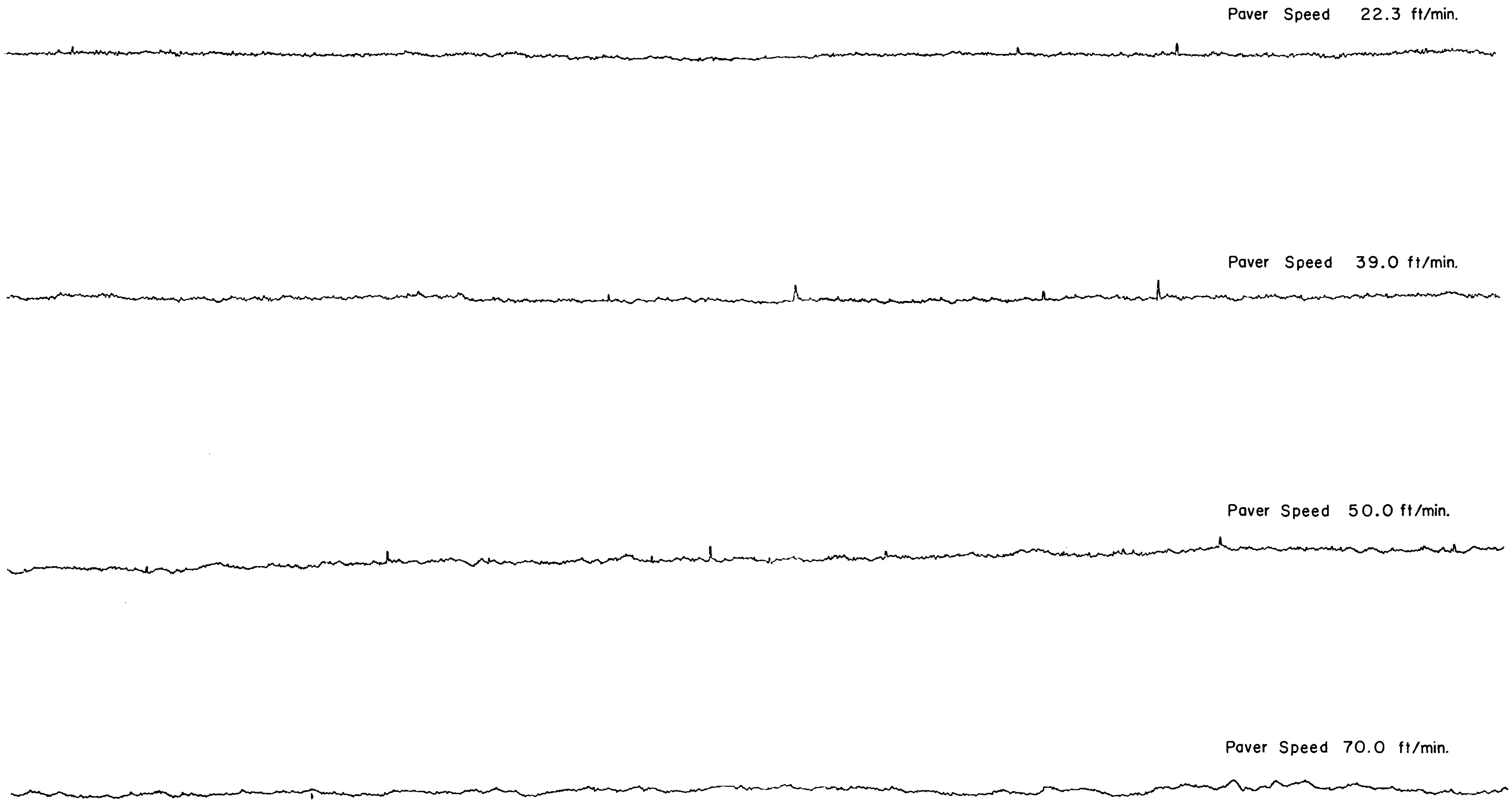
The Paver Speed

Figure 11 reveals four roadway profiles. Each profile was obtained on a section over which asphaltic material had been placed with the laydown machine operating at different speeds. The speeds were 22.3, 39, 50 and 70 feet per minute and the related profiles are indicated in consecutive order from top to bottom.

Due to limitations of the size of the paper in this report, only short lengths can be indicated herein; however, the profiles shown in Figure 11 are indicative of the total length tested. The second or rural section of IH 20 was used in this study.

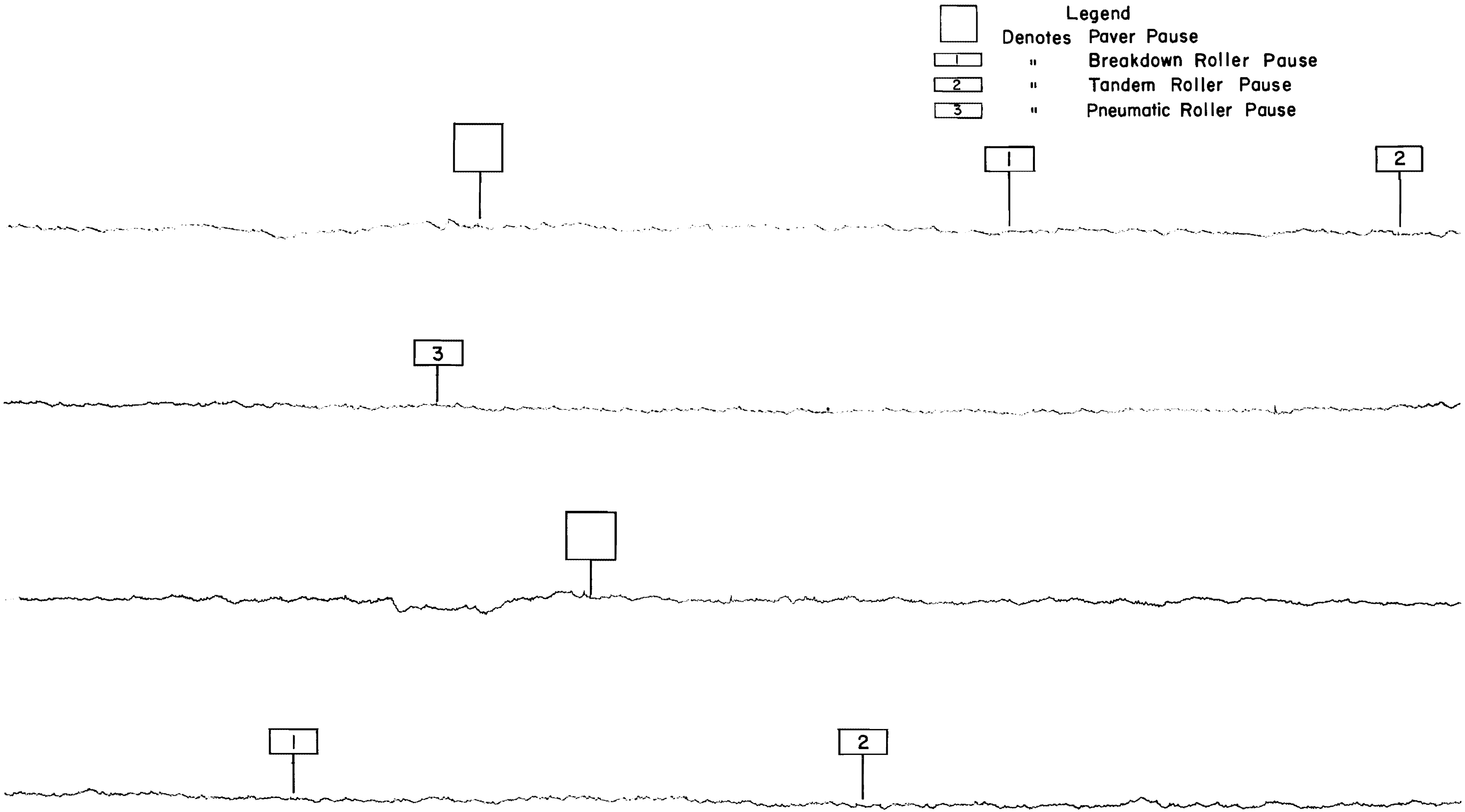
The Parked Roller and Paver Pauses

Figure 12 contains profiles obtained on IH 20 at a paving machine speed of 50 feet per minute. The square symbols indicate locations at which the laydown machine paused. The rectangular symbols indicate points at which a roller was parked. The numbers within the rectangular symbols indicate the roller type, the "2" being the tandem roller and the "3" the pneumatic roller. Care was taken to obtain a profile over the area in which the roller was actually parked. Attention is called to the small irregu-



PROFILES AT VARIOUS PAVER SPEEDS

FIGURE 12



PROFILES INDICATING LOCATIONS OF PAVER AND ROLLER PAUSES

FIGURE 13

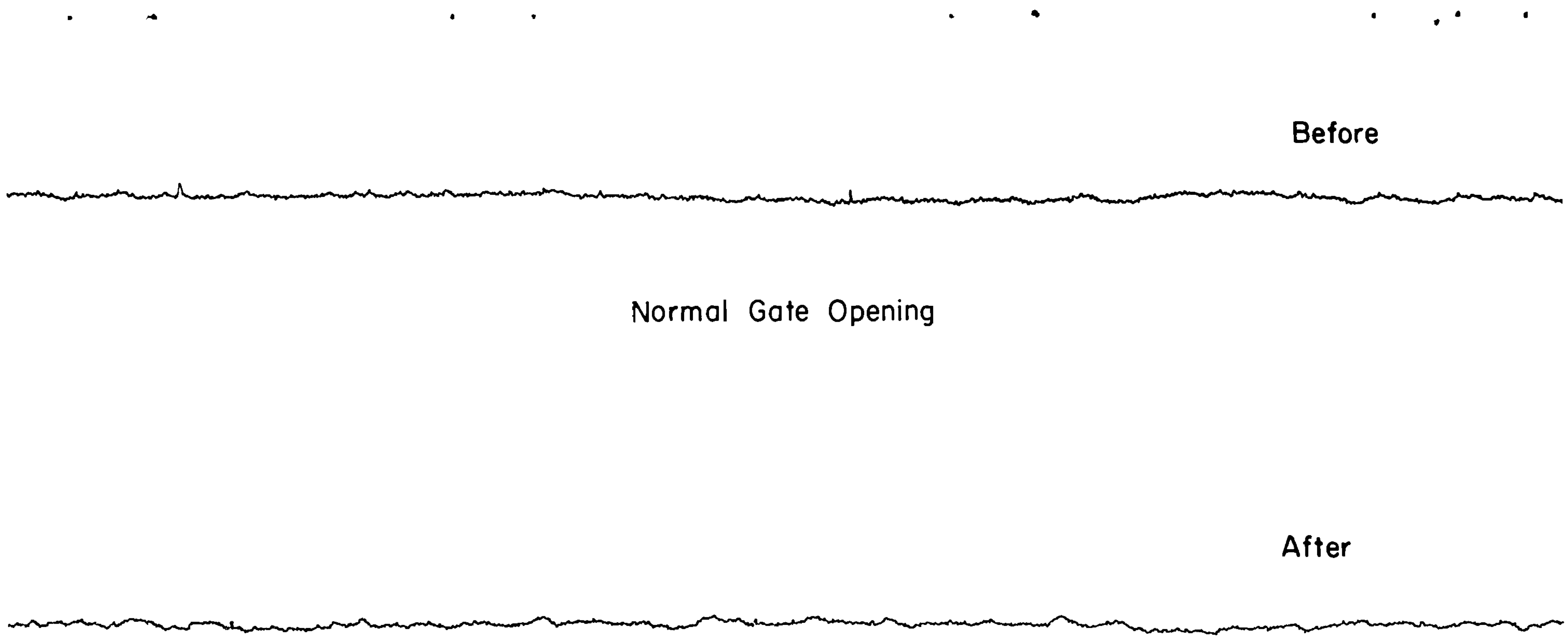
larities noted in the profile (approximately two inches) to the left of the square symbols. This could be considered the area just _after_ the machine starts operating after pausing for another load from the haul truck. In general, the profile indicates a small depression or sag within this length. The paver length is approximately 19 feet or 1.9 inches on the output chart.

Opening the Gates

During the operations in which the laydown machine speed was varied, it was noted that the gates between the hopper and the transverse augers required adjustment. That is, faster speeds required that more material be furnished to the auger spreaders. This was accomplished by opening a gate at the rear of the hopper. In this study it was decided to open the gate wider than normally required at 50 feet per minute to determine if the increased material which the augers were required to handle affected the roughness. Figure 13 indicates a before and after profile of this study.

The Paver and the Haul Truck

As previously stated a small amount of material was noted clinging to approximately one half the circumference



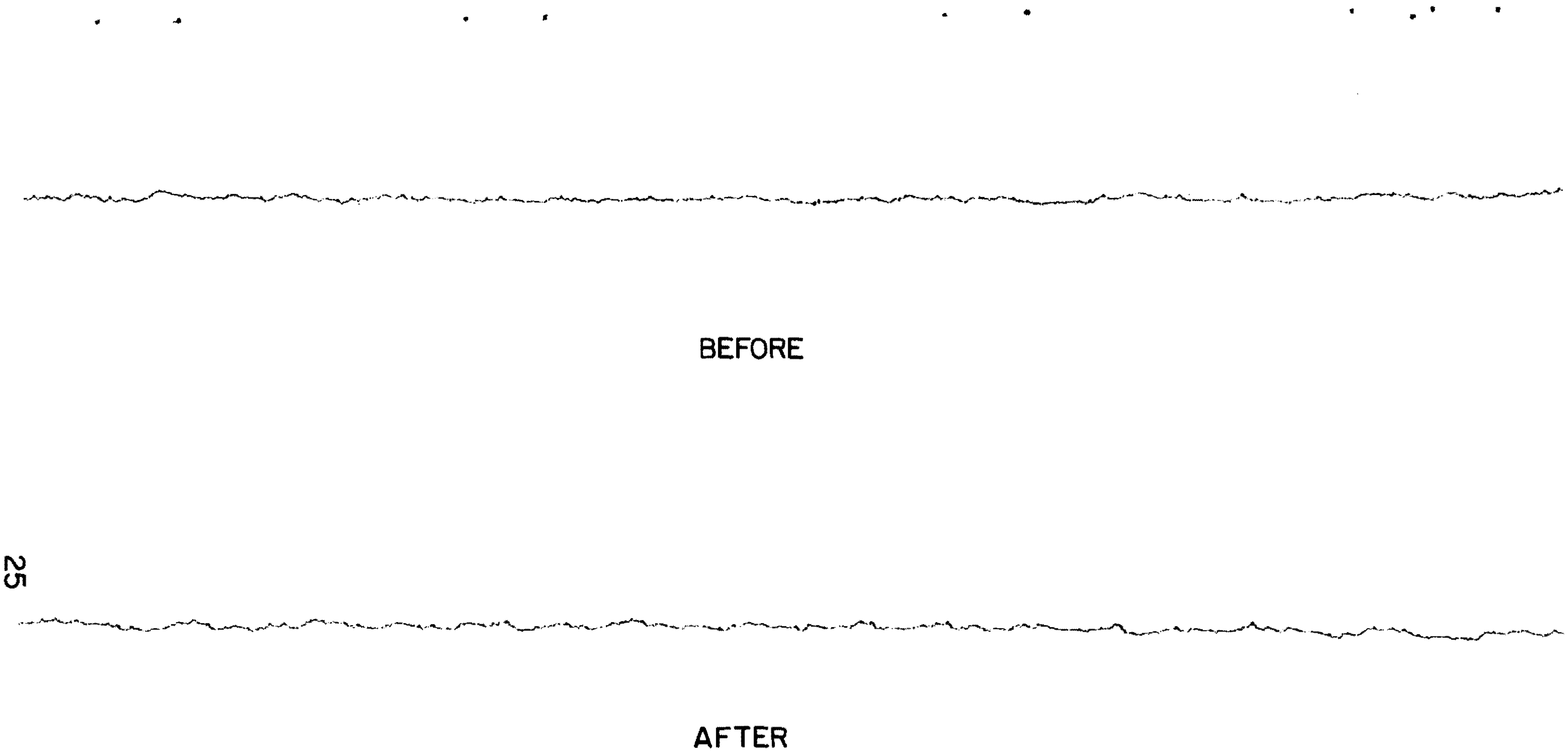
Excessive Gate Opening

SCALE
VERTICAL 1" = 1"
HORIZONTAL 1" = 10'

PROFILES INDICATING VARIATION IN GATE OPENING

FIGURE 14

of the small contact rollers between the truck and the lay-down machine. The thickness of this "cake" was about one-half inch and was found on the rollers of both sides. The upper profile in Figure 14 shows the profile obtained before cleaning the small contact rollers and the lower profile indicates a profile obtained after these rollers were cleaned.



SCALE
VERTICAL 1" = 1"
HORIZONTAL 1" = 10'

PROFILE INDICATING BEFORE AND AFTER CLEANING PAVER CONTACT ROLLERS

FIGURE 15

VII. DISCUSSION OF RESULTS

Of the initial roughness studied, it is obvious that the greatest contributor is that which is reflected from below. In many cases, this type of roughness cannot be due to construction procedures or equipment since sufficient thickness of asphaltic material is necessary or "blade on" applications must have been applied previously. Figure 10 indicates the extent that the 1-1/2 inch overlay reduces the original profile fluctuations.

The Parked Roller

The parked roller has been the cause of great concern for many years. Speculation as to where to park or even if a roller should stand idle on a fresh mat has been given considerable thought throughout many years of highway construction. This study indicates no appreciable difference in the roughness area of the parked roller as compared to the roughness of the surrounding area. In other words, the parked rollers which were studied, do not cause initial roughness of any significance. Small indentations were visually observed in the surface at each of the locations where the flat wheel rollers paused, but these depressions appear to be "ironed out" after all rolling was completed.

Construction methods used to control roughness should not be confused with those used to control strength. A good example of this statement is the requirement that a roller be so aligned that the drive roll is operated toward the laydown machine. This is done in order that the uncompacted material is "tucked" under the drive wheel on the initial roller pass forming a more homogeneous mat. If this were not done, the steering roll would be in the lead and the fresh mix would be shoved slightly. In some cases when the steering roller is in the lead, small vertical cracks occur at close longitudinal intervals. Of course, loss of strength is experienced in this case.

Variation in Gate Opening

It was postulated that some roughness occurs if the augers and screed are required to handle excessive material; i.e. the asphaltic concrete would be forced into the area where the augers operate and due to excessive head and the force of the augers, a larger amount of material would be forced to the screed. This larger amount of material was obtained by opening the gate wider and allowing extra material into the auger area. Visual observations of this appear to be "ironed out" after all rolling was completed.

Construction methods used to control roughness should not be confused with those used to control strength. A good example of this statement is the requirement that a roller be so aligned that the drive roll is operated toward the laydown machine. This is done in order that the uncompacted material is "tucked" under the drive wheel on the initial roller pass forming a more homogeneous mat. If this were not done, the steering roll would be in the lead and the fresh mix would be shoved slightly. In some cases when the steering roller is in the lead, small vertical cracks occur at close longitudinal intervals. Of course, loss of strength is experienced in this case.

Variation in Gate Opening

It was postulated that some roughness occurs if the augers and screed are required to handle excessive material; i.e. the asphaltic concrete would be forced into the area where the augers operate and due to excessive head and the force of the augers, a larger amount of material would be forced to the screed. This larger amount of material was obtained by opening the gate wider and allowing extra material into the auger area. Visual observations of this operation indicated that large amounts of material were not present with the wider gate openings used in this study and the augers appeared to handle the material in an adequate manner. A check of Figure 13 indicates no excessive roughness between the "before" and "after" profiles of this study. Small roughness does occur on both profiles but variation in roughness was not detected.

The Paver and the Haul Truck

Engineers, inspectors and contractors have given much thought to roughness caused by the haul truck jolting the laydown machine. There are many reasons for these considerations:

(1) Small ridges are formed at the rear of the laydown machine as the truck backs into the machine to unload.

(2) The front wheels of the truck are often turned at an angle, as the paving machine pushes the truck, which causes the paving machine operator to take corrective measures.

(3) Material sluffs in large quantities from the truck into the laydown machine hopper. (It was noted on this job that a small ridge is also formed at the rear of the paving machine when the sluffed material empties into the hopper.)

(4) Mud flaps hang at the rear of the haul truck and these flaps are between the paver and the rear wheels of the truck. When the paver begins to push the haul truck, the mud flaps are forced vertically. It has been postulated that the truck bumps the laydown machine as mud flaps roll free and the small void caused by the thickness of the mud flaps allows the truck to bump the machine. Various corrective measures have been initiated to cure these problems. The mud flaps have been pinned up before unloading. Manufacturers have incorporated an additional machine which operates immediately prior to the laydown machine acting as a buffer between the truck and the laydown machine. This equipment, sometimes termed a "reloader", is in use in this state.

The study conducted as shown in Figure 14 indicates no significant roughness due to the build up on the contact rollers. In fact, the profile after cleaning the rollers seems to be rougher than the profile before cleaning. It should be noted that these rollers operate on a spring-type arrangement. This spring consists of a short length of pipe which has been sawed longitudinally at the diameter as shown in Figure 9. Visual observations of this attachment reveal that it was working properly. The spring was apparently absorbing the small variations or bumps which occurred. The device appeared adequate for the equipment which was used on this job.

The Paver Speed

The variation in laydown machine speed did reveal that roughness can be associated with the paving machine speed (see Figure 11). When the laydown machine was operated at 22.3 feet per minute the chart indicated only small variations in profile. The roughness seems to increase as the speed of a laydown machine increases. The profile at 70 feet per minute indicates much more roughness than that at 22.3 feet per minute. It is possible that a different roughness effect would have been noted in this study if another mix design or a different mix temperature had been used. However, the effect of machine speed is present.

Visual observations of the surface reveal that the higher speeds resulted in an open texture. It is believed that the screed slightly pulled the hot asphaltic concrete as the mat was placed. In comparison, the mat placed at 22.3 feet per minute revealed a small close-textured surface in which no pulling was apparent. It should be noted that the roughness in all four cases is minor and hardly noticeable when driving over the freshly laid mat. The difference in roughness is observed by the driver of the vehicle if he is aware of the test section as he drives over it. Large movement of the vehicle body is not present and the roughness appears only through vibration in the steering wheel and by listening to the tire impact on the pavement surface.

Paver Pauses

Figure 12 does indicate significant roughness in the area where the paver pauses for a change of haul trucks. The empty truck has just completed unloading and moves away to allow the next full truck to unload. After finding the variation in the profile at this point, the unloading operation was observed closely. It is postulated that the truck initially unloaded a large amount of material into the paving machine hopper and that the front of the paver settled under this load. It is theorized further that the paver began corrections for this variation when forward movement was again initiated. In any event, the major profile variation on the rural IH 20 job is present in this area.

Three Months Later

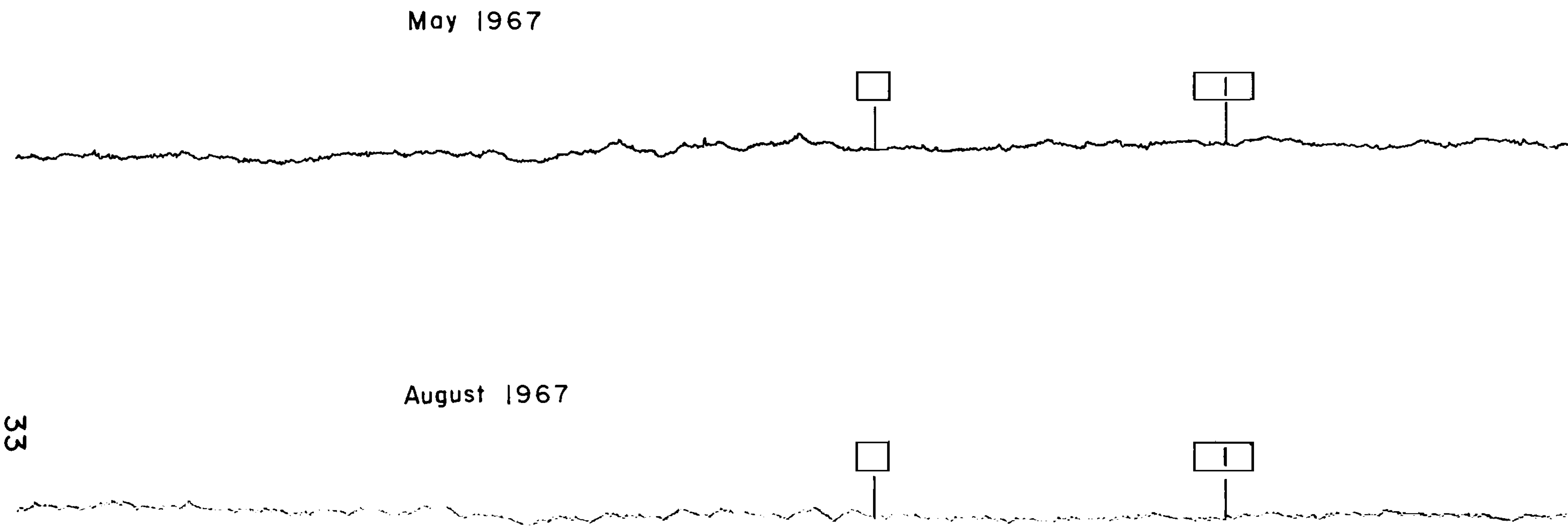
In an effort to study the change in surface profile with age, the entire section on IH 20 (I 20-2(71)225) was rerun after a period of 80 days. Since traffic was allowed on the completed pavement soon after the asphaltic material was placed, it is estimated that 160,000 vehicle passages accrued over this lane in this time span.

Comparisons of both profiles indicated that almost no change had occurred during this period. Each test site was easily located. The site at which paver speed tests were conducted was noted on the chart without the aid of station numbers as the profile was obtained. It did appear that certain sharply defined small peaks were beginning to be flattened by the traffic as indicated in Figure 15, but it must be assumed that the profilograph was not pushed over exactly the same path during the later testing.

This test does point out that periodic testing is possible with the Rainhart profilograph. It would be interesting to find the exact locations in which roughness does occur as the pavement ages and also to determine which areas occur first. The graphic chart would in itself constitute a permanent record.

Observations

Opportunity was present for study personnel to observe the pavement surface as it was placed. One interesting



SCALE
VERTICAL 1"=1"
HORIZONTAL 1" = 10'

VARIATION IN PROFILE AFTER 80 DAYS
(160,000 Vehicles)

FIGURE 16

fact occurred when riding the roller with the operator. The roughness present in the roadway can be "felt" while riding on the roller. Only the larger bumps or roughness can be noted on the three wheel breakdown roller and the major portion of the roughness noted while riding this roller occurred at the areas in which the laydown machine paused. These areas were easily discernable because of the small square cardboard symbols nailed to the surface. Much more roughness was noted while riding the pneumatic roller. This roller appears to pick up almost every minor variation in the pavement surface. The pavement surface was observed while riding this roller in that variations in texture were observed by light reflectance from the sun. This reflectance revealed two interesting facts: (1) variations in texture are easily seen and (2) these variations appear to be erratic. Areas are found in which the surface appeared to be closed textured and between these closed areas are sporadic areas of open or pulled texture. An area was found in which approximately two thirds of the width contained no fluctuations in texture. The remaining third of the pavement revealed sporadic fluctuations in texture. The pneumatic roller appeared to ride smoothly over the area in which no fluctuations in texture were found, and rode much rougher over the outer third in which texture variance was found. There are two observations which can be developed from these facts: (1) the contractor and inspector have available one of the best construction control roughness meters available and (2) these minor fluctuations in texture must result from the laydown machine pulling the surface as it is placed. These pulled areas when compacted by the pneumatic roller are lower in elevation than the areas which are not pulled. This means that minor roughness can be associated with fluctuations in texture due to pulling from the screed. This is apparent from the variation in laydown machine operating speed as previously described. It must be noted that this roughness type is minor and variations between upper and lower peaks found by the profilograph are around 1/8 to 1/16 inch in depth.

It can be stated that the rural test section on IH 20 is one of the smoothest roadways which has been tested since this research project began. This section was selected because the CMI Autograde was used on the surface of the base and it was felt the roughness reflected from below would be at a minimum allowing confidence in the other studies reported herein. This postulation proved to be true. The profile of the lower Type B surface was very smooth. Electronic gadetry is helping the highway industry but there is still room for improvement as pointed out with the roughness associated with increased paver machine speeds.

Review of Manufacturers Recommendations

In reviewing the Operation and Maintenance Manual of paving machines, it was realized that many highway construction personnel are not aware of the valuable information contained in these publications. Therefore, it was decided to review several items dealing with initial roughness and suggested procedures to correct undesirable surface roughness:

(1) Some machines are equipped with cables to lift the screed for roading purposes. During the paving operation these cables must be detached or slack to insure that the cables are not partially stressed in order that the screed rests upon the mat being placed. Failure to do so could result in a wavy mat.

(2) Pavers contain burners for heating the screed. Care must be exercised in the use of this apparatus. Overheating of the screed will warp the screed base plate and

continued use results in an uneven surface. If the heated screed is allowed to rest on the mat for prolonged periods when the machine is not in motion, the screed tends to settle causing a low area in the surface. If the screed cools between truck changes, tearing of the surface may result upon resumption of paving.

(3) Manufacturers suggest the material level be maintained about the center of the augers. This is done in order that the augers operate continuously. Sporadic operation of the augers and fluctuation in material height (head) result in an uneven mat. (Observations in this report indicate the height may be above the center of the augers, but constant elevation should be maintained.)

(4) The tamper near the screed is generally arranged in two halves. The tamping cycle is arranged so that when one is up the other is down. If these tampers are "out of phase", the excessive vibration causes a loose wavy mat. Manufacturers indicate that the tamper bar should have a clean sharp beveled face of uniform dimension. If the bar section has been worn out of shape, dragging of the mix results.

(5) When tamper and screed extensions are used, misalignment of either will result in an open or rough mat within the extension area.

(6) Braking of the tracks or wheels is sometimes used for steering. Improper use of the brakes could affect the surface finish.

(7) The paver should be moved forward to make contact with the truck. If untimely truck movement occurs, ripples will be ironed into the mat.

(8) Suggested air pressures for the tires of a paver are generally given in the operations manual. If the paver appears to bounce the pressure may be varied for correction. Also, tire pressure should be equal on both sides of the paver.

VIII. CONCLUSIONS

The following has been concluded from this study:

(1) Significant initial roughness was caused from excessive laydown machine speeds (with the mix design, types of rollers, rolling practice, asphalt temperature, and paver used on this study).

(2) Significant initial roughness was caused by fluctuations in amounts of material present in the laydown machine hopper.

(3) It can be postulated that initial roughness can be caused by variations in surface texture because of pulling of material by the screed.

(4) Significant roughness was not found on this job because of parked rollers. It should be noted that the mat depth was 1-1/4 inches. The parked roller effect at greater mat thicknesses, different mix designs, and asphalt temperatures is still unknown.

(5) Significant roughness was not found on this job because of accumulated cakes on the contact rollers of the laydown machine.

(6) Significant roughness was not found on this job due to excessive material being handled by the augers.

(7) Significant amounts of initial roughness are due to roughness being reflected from below.

(8) The rollers themselves can be used to advantage to detect roughness. An experienced inspector should be able to detect excessive roughness by periodically riding on the pneumatic roller.

BIBLIOGRAPHY

(1) Scrivner, F. H. and Moore, W. M., "A Tentative Flexible Pavement Design Formula and Its Research Background", Research Report 32-7, Research Study 2-8-62-32, Texas Transportation Institute, February 1966.

(2) Hankins, K. D., "Construction Control Profilograph Principles", Research Report 49-1, Research Study 1-8-63-49, Texas Highway Department, January 1967.