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PROGRESS REPORT OF COMMITTEE ON SALVAGING OLD PAVEMENTS BY RESURFACING

N. F. Schafer, *Chairman*

Commissioner, Indiana State Highway Commission

SOME PRACTICES USED BY OHIO IN THE SALVAGING OF OLD PAVEMENTS

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Salvaging of old pavements is the most important contribution of the highway industry to todays traffic needs. Ohio is fortunate in having many miles of all types of pavements of varying ages which provide a continuous test project for the development of methods and equipment for resurfacing and widening practices. Owing to the many comparatively recent developments in design and construction methods, this discussion is limited to widening with non-rigid bases of the macadam and bituminous concrete types and resurfacing with bituminous concrete.

It is very important that salvaging of a pavement be done at the proper time to avoid unnecessary costs. One of the most important items in salvage construction is to place the pavement in readiness for the salvage work to follow. In the case of old concrete pavements with rocking or broken slabs this may consist of undersealing or adding an insulation course to the surface. Economical procedure has proved it more practical to add extra leveling material as separate courses over areas of partial failure rather than to remove and replace the old pavement. Most salvage projects now include widening. Placing of widening courses of macadam or bituminous concrete or a combination of the two general types without the use of forms has increased production, decreased labor and improved the stability of the widening. Placing of widening with self propelled strike off units has improved results and increased production. Use of the same composition bituminous concrete mix in narrow base widening courses as used in leveling and some top courses has improved the density and stability of the course, and at the same time improved the contractor's operations. Asphalt of lower penetration is now being used on high traffic routes to provide increased stability. The open minded approach to salvage construction permitting the development of equipment and methods has resulted in improvements in equipment, methods and the finished product.

With an eye to the future, Ohio is today taking active steps to meet our present traffic demands.

It is our prerogative to speculate as to the probable demands of traffic 25 years in the future but it is purely a guess based on our

experiences of the past 25 years. Present day demands, however, are not speculative, they are real and a challenge to our immediate efforts.

Experience shows that the average citizen, while mildly interested in probabilities of the future has a very decided interest in what is happening today which affects his destiny or comforts now. And so it is with salvaging old pavements in Ohio. Recent studies indicate that nearly two thirds of Ohio's state highway mileage is in need of improvement to bring the system to a standard desired for present day traffic. The state system now consists of 18,420 miles, with approximately 2300 miles inside municipalities and thus the immediate problem is of sizeable proportions.

Ohio's highway system has been built on a "pay as you go" basis, resulting in a more gradual development than those state systems that were built rapidly under the bond issue method of financing. This method of building a system of highways has many good features and some not so desirable. It has the good feature of today's traffic paying its own way without mortgaging the future. It has the advantage of the growing system incorporating new ideas and new developments as it gradually builds. It has the disadvantage of not providing a complete system as quickly as some users desire. This gradual development is reflected in a variety of types and widths of pavement as well as materials which met accepted standards and traffic requirements when built. We have thus been fortunate from the standpoint of development of methods and practice in salvaging construction in having a wide variety of pavement as to type, width and age on which to practice.

Probably the most important factor to be considered in the salvaging of any pavement is performance of that operation at exactly the proper time. Resurfacing should be performed on a straight economic basis allowing maintenance costs to govern the necessity for the more extensive salvaging operation. If the resurfacing is dealyed beyond a certain point the cost rises rapidly. It is well to err on the side of safety and resurface too soon rather than too late. War time traffic demands with the consequent easing of load limitations during that period developed the need for salvaging much more rapidly for some pavements than would have been necessary under ordinary conditions. War time restrictions on the use of steel for pavement reinforcement, dowel and tie bars, has resulted in development of conditions which require resurfacing of some pavements at a comparatively early period in their life. Lack of sufficient funds to perform the necessary work always at the proper time has resulted in development of conditions requiring more extensive treatment than should have been necessary had the resurfacing been done at an earlier period.

Deficiencies on many roads are due primarily to inadequate widths and riding qualities. Other sections of pavement are in partial failure due to increasing traffic demands. Many sections of Ohio have topography such that the lines and grades of the original construction are not obsolete. The problem thus resolves itself into one of salvaging the existing road by widening and improving riding qualities, with correction of the occasional failures which have shown up with the passage of time. These activities are coordinated with new construction where salvaging of the existing pavement cannot logically be integrated with the ultimate design.

Ohio is fortunate in having a wide variety of paving materials at hand and for that reason, as was true in the original construction, we employ all of these materials in widening and resurfacing. In order not to attempt to cover too much territory in this discussion, I am limiting the subject to widening with nonrigid bases and resurfacing with bituminous concrete mixtures. I am doing this for several reasons; first, due to the fact that rigid type widening and resurfacing methods have been rather thoroughly covered in past discussions and the methods are generally accepted; second, resurfacing with lighter surface treatments and road mix types, which in a general way fall in the category of routine maintenance, also have their methods and limitations on a well defined basis and therefore will not be dwelt on here; third, widening with nonrigid bases and resurfacing with bituminous concrete involves design features and methods of construction which have been developing rapidly in recent years and therefore are deserving of more detailed attention at this time.

Ohio has been engaged in rather extensive operations involving these types on an increasing basis for the past 12 years. This

discussion is therefore essentially limited to bituminous concrete along with other materials which may be used as a base or sub-base where widening is involved for that material. This construction has many advantages which have been responsible for its adoption on an increasing basis in Ohio. The principal advantages may be roughly grouped as follows:

(1) It is not necessary to close the road to traffic.
(2) The new pavement is ready for use soon after the compaction is completed.
(3) It may be adapted to use with any type of existing pavement both for resurfacing and widening.
(4) It is possible to complete an extensive mileage in an ordinary construction season.
(5) Improvements in equipment and construction procedures have made it possible to reduce labor costs while, at the same time, improving riding qualities.

Spreading of bituminous concrete is accomplished with self powered pavers capable of spreading to line and grade without the use of side forms. Ordinarily the widening and resurfacing is performed with traffic maintained. On two-lane pavements we require that one-way traffic be maintained with the length of such one-way zones being kept to a minimum. It is required that watchmen be used to direct traffic where one-way traffic may be necessary. Ordinarily less confusion to traffic results if the paver is operated toward the plant, making it unnecessary for the trucks hauling paving material to use the one-way traffic lane.

Prime, or tack coats as we have designated when used over old pavements, are ordinarily required for grout filled brick and portland cement concrete surfaces. They may also be provided for old dried out and badly cracked bituminous surfaces. Asphalt emulsion (MS-1) is generally used for the tack coat applied at a rate of 0.10 gal. per sq. yd. followed by the immediate application of a sand cover of from 2 to 5 lb. per sq. yd. in order that the bituminous material will not be picked up by traffic.

Resurfacing of any pavement regardless of type, involves first of all making it ready to receive the new surfacing material. In the case of old concrete pavement which may have developed pumping and rocking slabs, it is desirable to reduce any movement to a minimum before any new surfacing material is placed. This is generally accomplished by having the maintenance forces do an undersealing job immediately in advance of the resurfacing work. This practice is an interesting subject and one on which we could dwell for some time; however, in this approach it is necessary that we limit our discussion to a few observations. The method involves forcing a relatively hard, hot asphalt under the slab, thereby sealing the joints or cracks from underneath, and at the same time replacing the pumped out subgrade material. The asphalt is pumped under the slab through holes which have been drilled adjacent to the pumping joint or crack. We have found that it is important to effectively plug the hole through which the asphalt has been pumped to avoid having the process reversed later and the asphalt forced through the resurfacing material, which may happen if higher penetration asphalt is used.

Pavement failures which are obviously due to subgrade conditions and which may not be strengthened sufficiently by the resurfacing alone may be corrected by removing the defective areas along with 12 in. to 18 in. of the subgrade material and replacing with selected sub-base material. If this material is of the open, free draining classification, it may be necessary to provide drainage in addition to the blanket material.

Delay in resurfacing to the extent that pavement slabs are so badly broken that they may not be restored to slab action has resulted in a method of treatment which has been used with success in Ohio. It is considered that the old pavement is of some benefit providing it may be placed in actual contact with the subgrade. This is accomplished by further breaking the slabs with a pavement breaker, cracking the rocking slabs and at the same time seating them on the subgrade. The broken area is then treated by one of two general methods. One, which has been used with success is to sweep all the loose material from the broken area and to add a prime coat. The area is then leveled up and strengthened by courses of bituminous concrete extra leveling material applied in not to exceed 3-in. compacted layers.

Another method which has been used with success is for an insulation course to be laid over the old broken pavement followed by a bituminous concrete base or leveling course

and the regular surface courses as used for the remainder of the project. The insulation course used may be either of the granulated slag or screening or coarse graded type depending upon conditions, and depths to be laid. The coarse graded insulation course referred to consists of aggregate as used for water bound macadam filled with screenings. Granular sub-base courses as used under new pavements in recent years have also been used over the broken slabs preliminary to placing the bituminous concrete courses.

It is important for the success of either of these methods that the broken pavement actually be rammed into the subgrade with a drop hammer effect.

In some instances where slabs are broken and pumping they are covered with an insulation course of the screening or granulated slag type, 2 in. to 6 in., in depth followed by the bituminous concrete courses. This method has been effective in providing an absorptive blanket which acts as a blotter for subgrade moisture and is also effective in eliminating transmission of cracks from the old pavement to the new surface.

During the war period a combination of resurfacing methods was used on one project with success. The old concrete pavement was pumping badly and had developed many broken slab sections under extremely heavy truck traffic. A 2-in. road mix surface was placed the first season which sealed many of the less serious pumping joints and cracks. However, as was expected, some of the more critical pumping sections soon pumped through the road mix surface course; however they were easier to maintain than they had been before. The following season a 3-in. bituminous concrete extra leveling course was placed over the areas where pumping continued to show through before a 2½-in. bituminous concrete was placed over the entire project. This project has held up for several seasons without any indication of pumping being transmitted through the bituminous concrete surfacing.

It has been determined by experience that it is generally more economical and satisfactory to correct minor failures of the old pavement by increasing the thickness of the resurfacing material over these areas than by resorting to removal of the old pavement. In proceeding in this manner, where traffic is maintained, it is necessary to observe special precautions to avoid having the failures in the old pavement transmitted through the new surfacing material. If the old pavement moves materially under the action of traffic, it is necessary to place enough material in the initial operation to provide a mat of sufficient thickness to carry traffic over the broken areas. Where the original pavement is in advanced stages of breakage, our plans usually provide for an extra leveling course to be laid from 1 to 3 in. thick over those areas. This extra course is laid in advance of the regular leveling material in order that the successive leveling and top courses will provide proper riding transitions to the extra depth material. The desirability of proceeding in this manner, that is, by laying extra depth material, is dependent upon the effect the minor profile change will have on the adjoining facilities. In the case of urban improvements where curbed sections are usually involved, it may not be possible or practical to proceed in this manner.

In covering obviously weakened pavement areas another method which has proved to give satisfactory protection from the action of traffic until sufficient mat thickness is placed, is for the additional leveling material to be placed along with the regular leveling course before traffic is permitted to use it. This may be done by placing the additional leveling course and compacting and then without waiting for the material to cool to place the regular leveling over the same area. This method has the advantage of having the extra depth material compacted to the maximum density in successive courses and at the same time assuring the maximum beam strength from the leveling material acting as a single course.

As previously stated Ohio's resurfacing experience covers all types of old pavement and some of the practices vary with the different types. In our first experience with bituminous resurfacing we used a 2-in. average thickness over the old pavement. Experience revealed that with this thickness, particularly over old concrete, grout filled or monolithic brick where joints and cracks predominated, the joints and cracks would soon be carried through the resurfacing mat. We have accordingly increased the thickness of resurfacing generally to a minimum of 2½ in., with 1¼ in. each for top and leveling when laying the coarser graded top. This coarser graded top

mixture, the same as used in the leveling course, is ordinarily used on rural projects where it is not necessary to do much hand raking. When laying the Type B or C finer graded top mixture, we have specified some with 1-in. top thickness after all leveling has been done with the coarser graded leveling mixtures.

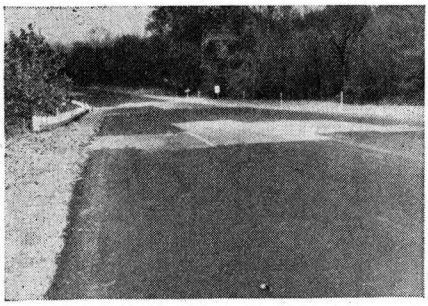


Figure 1. Extra leveling material has been laid as a separate operation in advance of the regular leveling to follow.

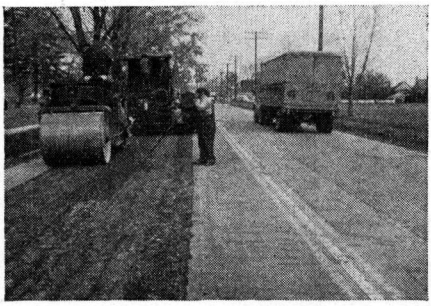


Figure 2. Laying Extra Leveling Material in a Separate Operation where Crown Correction is Necessary.

Each project is carefully analyzed for requirement for leveling material. In addition to the minimum top which is made up of a top course and more or less regular thickness leveling course, usually extra leveling material is designated at the rate of so many cubic yards per mile if the requirements are more or less uniform throughout the project. This uniform requirement may be due to crown correction or more or less uniformly rough conditions through out the project. Some projects have apparent weaknesses in certain areas which are treated with an extra leveling course as previously described.

When extra thickness mats are specified for certain areas this material is laid as a separate operation in advance of any other bituminous material. Occasionally sufficient extra leveling material is provided so that a separate course may be laid throughout the project with the regular paver. Separation of the leveling courses and laying in two operations provides more smoothing up action and may be desirable where the old pavement is especially rough or where crown correction is to be made throughout the project. Separation of the courses permits more uniform compaction in low areas where extra depth material would be placed in a regular leveling operation. The

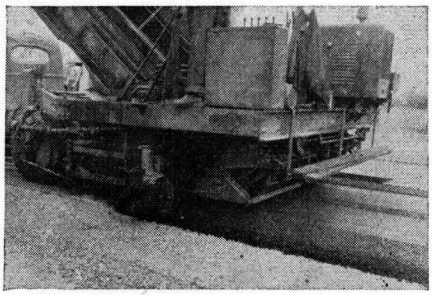


Figure 3. Indicating Level Attached to End of Screed Assembly of Paver to Permit Accurate Crown Control.

paver should be equipped with an indicating level attached to the screed assembly to permit accurate crown control where the old pavement is irregular.

Extra leveling material may be desired in a separate operation, particularly in a municipal section, where the old surface may have a uniformly rough condition. This is true of old brick surfaces where the filler is usually low or almost entirely gone. The finer graded B or C gradation may be specified under these circumstances. This permits feathering out and results in a maximum density material in immediate contact with the old pavement where it is especially desirable. Some sand asphalt mixtures have been used as a preliminary leveling course. In the use of separate finer graded courses, it is considered that it will not be objectionable if a plane of weakness is created between that course and the regular leveling course which follows, as it will then prevent transmission of cracking from the old pavement through to the new surfacing. It is in

effect doing a maintenance operation immediately in advance of the resurfacing to follow. The placing of preliminary leveling courses

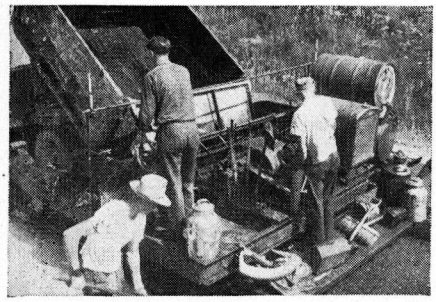


Figure 4. Indicating Level Attached to Screed Assembly to Permit Accurate Crown Control.

Figure 5. "Uniformly Rough" Surface Where a Fine Graded Extra Leveling Course is Desirable.

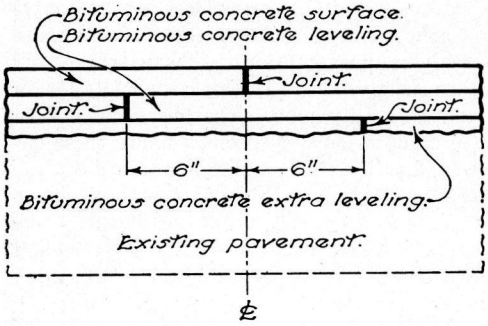


Figure 6. Method of Lapping Longitudinal Joints—Bituminous Concrete Construction.

permits a more uniform thickness and thus a more uniform density and texture of the regular surface course.

Normally the surfacing material is placed in single-lane widths with the requirement that the longitudinal joints in the courses be offset 6 in. from the one immediately below. This requirement is to avoid the possibility of a plane of weakness being established through the successive courses. The longitudinal surface joint is designated to be located on the

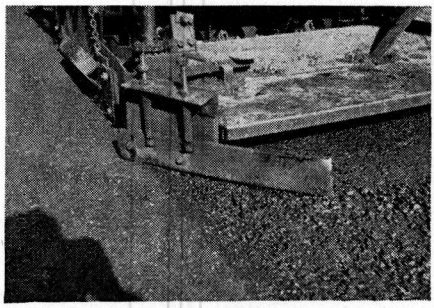


Figure 7. Automatic Raking Device Attached to Paver Which Pulls Coarse Aggregate Away from Longitudinal Joint. Held in Close Contact with Portion Previously Laid with Spring Assemgly.

Figure 8. Laying With Two Pavers Resulting in a Hot Joint—No Raking Necessary at Joint. Accurate operation of paver is necessary for the success of this method. This equipment has also been used without hand raking when laying against previously compacted material.

center line of a two-lane pavement in order that it will coincide and be hidden to a great extent by center line marking. In placing the adjoining course of material the paver is operated so that the bituminous concrete will lap over the edge of the previously placed course 2 to 3 in. The raker then pushes the coarser material away from the joint over on the newly laid material ahead of the rolling operation,

leaving an excess of fines at the joint to form a dense well bonded joint after rolling.

Some contractors have used a sort of automatic raking device attached to the paver which is held in contact with the previously laid material with a spring arrangement and which pulls the excess coarse aggregate away from the joint. The device proves satisfactory in performing at least a portion of the work of the rakers. We require, if necessary to obtain a dense joint, that it be heated with torches, or that a bead of asphalt cement be poured along the bottom of the joint just prior to placing the adjoining material. When air temperatures are low, it may be necessary to

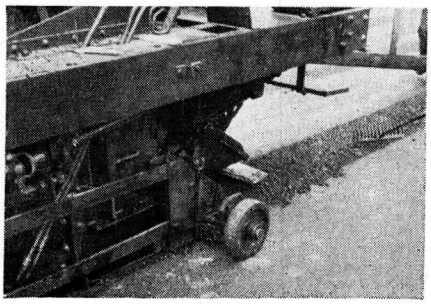


Figure 9. Paver Equipped with Dolly Control Attached to Screed Assembly for Laying Material in Proper Relation to that Already in Place. Raker pushes coarse aggregate away from longitudinal joint leaving excess of fines to provide a dense joint.

perform both of these operations in order to obtain a good dense joint. It is well to err on the safe side and have an excess of fines or asphalt cement or both at the joint to assure a good dense joint.

We have found it possible to make an acceptable joint without any hand raking. This has been done with one type of paver only when extreme care has been exercised in laying the courses to a true line. The screed laps the first course laid from 1 to 2 in., depending upon how much the edge has become rounded under traffic action. Rolling is then done without any hand raking at the joint.

Where sufficient width is available to maintain traffic and where plant output will justify, some contractors have operated two pavers adjoining which makes it possible to lay against hot material and thus essentially eliminate the joint.

We have recently completed a survey of the efficiency of longitudinal joints in bituminous concrete construction by coring many projects in which different methods and equipment were used. It was interesting to note that several projects, which were cored where no hand raking was done at the joint, had more uniformly dense joints than projects on which

Figure 10. Shoe Attached to Screed Assembly of Paver Which Permits Accurate Control in Relation to Previously Laid Material.

Figure 11. Rolling Longitudinal Joint.

hand raking was used to make the joints. The survey also revealed that the density of the full machine made joint more nearly approached that of adjoining material than did joints made by hand raking methods.

Several special dolly or screed attachments have been developed which travel on the previously placed adjoining material to assure that the paver is laying in proper relation to

the other lane. These attachments prove very beneficial in assuring that the proper amount of material is deposited to make a good joint.

Rolling requirements are such that at least two rollers are required at all times. One of these must be a 10-ton three-wheel finishing roller while the other must be an 8-12-ton tandem roller. As many additional rollers must be used as necessary to provide at least one roller for each 30-ton of material laid per hour or each 500 sq. yd. of material placed per hour when the depth of course is such that 30 tons of material is spread over an area of more than 500 sq. yd.

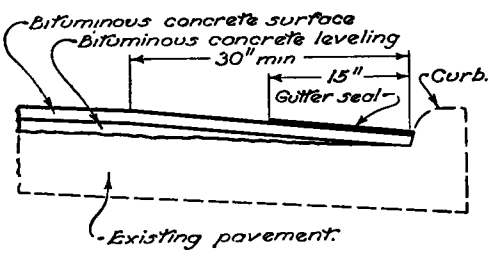


Figure 12. Resurfacing at Gutter Line to Curb Height. Gutter seal consists of the same asphalt cement as used in the mix.

We have recently added the requirement that one of the rollers must be a three-wheel roller. We also stipulate that we may require the tandem roller to weigh at least 10 tons. This has been done the past season. We have emphasized more and more that all courses shall be rolled when the material is at the proper rolling temperature and that rolling shall be completed while the material is at a temperature at which proper compaction can be secured. The three-wheel roller is kept immediately back of the paver, operating with one rear wheel mostly over the previously placed portion which thus has the front wheel crowding material against the joint to provide the maximum density joint. The rolling then proceeds across the newly laid material with checking and straight edging being done along with rolling to assure a proper riding surface.

We require that the leveling material be placed to full width prior to placing of any surface course. This is done to assure the proper crown section and to avoid the possibility of low longitudinal joints. We require that surface courses be placed on the leveling course within 10 days between May 15 and October 15 of the calendar year and within 3 days when placed between October 15 and May 15 of the succeeding year. The three-day requirement may also be invoked between May 15 and October 15 if conditions such as cracking or disintegration of the leveling course under traffic action or other factors reducing the bond between the courses make it desirable to do so. This is especially the case where there is a tendency for cracks in the pavement below to be carried through the successive courses under the action of traffic.

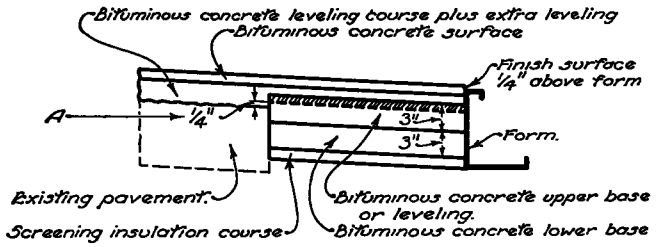
We have dealt primarily with practices in laying bituminous resurfacing in two or more courses. However, in some instances where the condition of the old pavement is such that it is necessary only to add material to protect the old surfacing or eliminate a slippery condition, we have placed single course surfaces with success. These have varied from 1 in. to 1½ in. in thickness. This practice, however, should be confined to pavement surfaces not requiring any leveling or crown correction and those which do not have joints or cracks which will be objectionable when transmitted through the thin resurfacing.

Many of the resurfacing projects are urban where numerous manhole and catch basin castings are involved. We require that all such castings in the main traveled area be adjusted to the new grade after the leveling course material is in place. This is required in order: (1) that the casting be adjusted to the proper finished grade which is possible only when the variable depth leveling courses have been placed, (2) that subsequent placing of the uniform surface course will cover the joints in the lower courses and provide a uniform surface. Several test installations have been made using adjusting rings to set the casting to the new grade. The depths of these rings are determined after all leveling material has been placed and for that reason it is necessary to have variable depths at hand in order that delay may be avoided.

Construction adjoining curbed sections creates a problem, particularly where it is desirable to minimize gutter reduction depths. Where the curb height does not permit extending full depth leveling and surface courses to face of curb the leveling course is decreased in

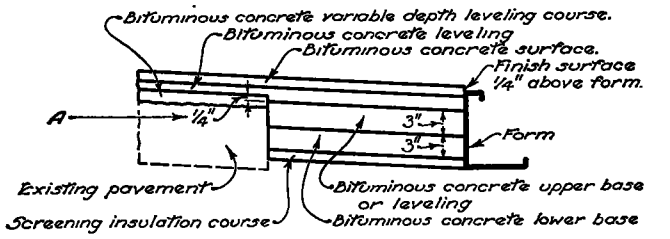
a minimum distance of 30 in. to a zero depth at the curb face. The surface course is then carried full depth to the curb face. After the surface course is placed and compacted it is required that the gutter be sealed with the same bituminous material as contained in the mixture. Only enough material is applied to coat the surface for 15 in. from the curb or 24 in. wide for a "V" gutter.

(1) a $1\frac{1}{4}$-in. insulation course of granulated slag, slag or limestone screenings, (2) two 3-in. bituminous concrete base courses, and (3) a 2-in. leveling and wearing course. The use of such forms necessitated quite a lot of hand labor in setting the forms and bracing to withstand rolling thrust. War conditions, causing a shortage of steel as well as labor, led to the development of an alternate practice which



A:—Where the 3 inch leveling or upper base in the widening area would finish more than 1/4 inch above the edge of the existing pavement, that portion below the dashed line shall be placed and compacted in a separate operation. The hatched portion shall be placed simultaneously with the full width leveling course

Figure 13. Widening with Forms—Two-Course Construction



A:—If the upper base widening course is placed before the variable depth leveling course, the variable depth leveling course shall be finished 1/4 inch above the upper base widening course.

Figure 14. Widening with Forms—Three-Course Construction

Many of our resurfacing projects of recent years include widening. This widening may vary with each project, but generally consists of widening 16, 18 and 20 ft. pavements to 22 or 24 ft. widths. If the widening is 2 ft. in width, it probably will be confined to one side. It may also be confined to one side for greater widths depending upon existing shoulders and structures.

Originally our bituminous concrete widening required the use of steel side forms to allow for: has proven so successful that it has been used for all widening during the past two years.

In the 1944 construction season several plans provided an alternate to the use of steel side forms. Briefly, the contractor was permitted to dispense with forms if the base courses were extended beyond the neat line a distance equal to the depth of the courses. Thus if a 24-in. widening was to be built, the insulation course and first 3-in. bituminous base course was built 30 in. wide, the second 3-

in. base course 27 in. wide and the leveling and surface course extended 24 in. beyond the old

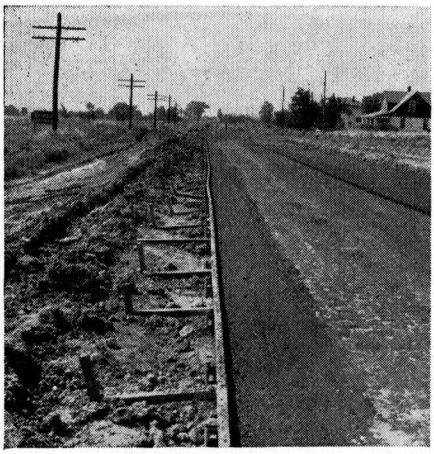


Figure 15. Forms which were required for widening prior to 1944 necessitated a considerable amount of labor in setting and bracing.

manner, not as an alternate but as the design, allowing payment for the material used in the stepped construction. This method of construction has many advantages. First, it permits the placing of the widening to follow the excavation very closely, which is a distinct advantage where the subgrade may become too wet to lay upon when operations are delayed as in setting forms, second, it results in less inconvenience to traffic as open trench may be kept to a minimum, and third, it stands up better under service than widening which was placed using forms.

There has been a tendency for some widening sections to become distorted under the action of traffic and show a break through the surface at the junction of the original pavement and widening sections. Widening which has been placed without the use of side forms does not show this tendency for displacement under the action of traffic or cracking in the surface course. This may be partly due to a

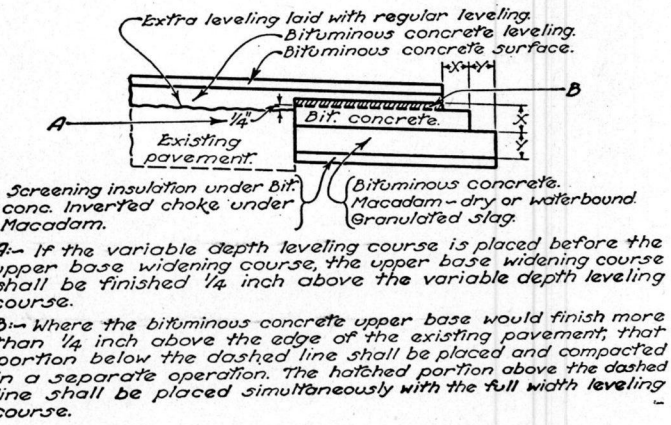


Figure 16. Widening Without Forms—Two-Course Construction

pavement. When this alternate method was first permitted, the contractor was required to furnish the additional material beyond the neat line in lieu of the use of forms. In every instance where this construction was permitted, the contractor furnished the additional material and dispensed with the use of forms even though he might have had sufficient forms on hand for the project.

Widening without the use of forms proved so successful on the test projects that since 1945 all of the widening has been shown in that

tendency towards increasing the depth of surface courses in recent years which offers greater resistance to shear at the critical line between the old and the new base. However, it is felt that construction without the use of side forms is responsible to a great extent for this improved result. When forms with the necessary bracing are used they provide temporary edge support which is removed or interrupted at least with their removal. On the other hand when the widening is compacted in place without the use of forms it attains its full sup-

port immediately from that material on which it ultimately must depend. The advantage of the stepped design in edge construction has been recognized for many years and this too provides more stability than the other type of construction where forms are used.

Excavation for widening is generally accomplished by one of two methods: (1) specially designed trencher, (2) motor grader. The trencher is a unit mounted on a truck chassis which may be set to excavate to a constant depth below the old pavement from which it is operated It leaves a uniform shoulder with vertical edge, not requiring further cleaning by hand, which is especially advantageous where widening is being placed without the use of side forms. If a motor grader is used to advantage a short section of mould board is attached to the end of the regular mould board. The short section is of such length that it excavates the widening trench to the proper dimensions. The opposite end of the mould board of the motor grader extends over the pavement and is equipped with a shoe to control the depth of cut. Some loose material is left in the widening trench by this latter method and must be removed by hand.

It is apparent that for any method of excavation which depends upon the old pavement for grade, it is desirable to have it to as good a grade as practicable before proceeding with the excavation. In some cases where the old pavement has been so rough that a preliminary leveling course was provided in addition to the regular leveling course, this course has been laid prior to excavating for widening. This provides an adjusted grade from which the trenching operations may be controlled. When this practice is followed it is necessary that care be observed to avoid laying any leveling material which may be lost in the trenching operation. It is also necessary that excavated material be kept off the surface of the leveling material in order that bond to the regular leveling course will not be reduced.

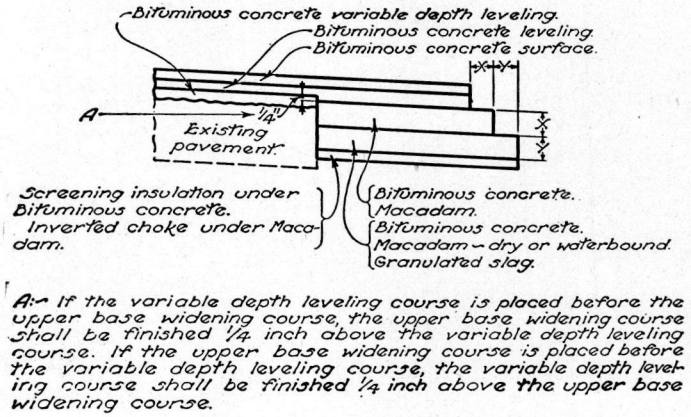


Figure 17. Widening Without Forms—Three-Course Construction

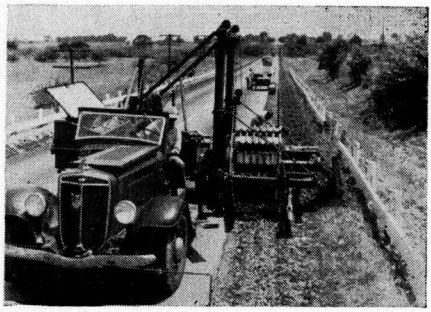


Figure 18. Excavating for Widening with Trencher Unit.

The problem of excavating for the widening is simplified to a great extent when the old pavement to be widened is of a rigid construction. This permits operation of the excavator immediately against the edge of the old pavement without much possibility that it will be disturbed in the process. When the old pavement is of macadam construction the edges are not so well defined and care must be exer-

cised in excavating to a neat line without disturbing the old pavement.

The availability of local materials suitable for sub-base and base construction has resulted in an increasing use of these materials rather than full depth bituminous concrete construction. Granulated slag has been used with

Figure 19. Rear View of Trencher Unit. Shoulder material is scarified in advance of trenching to speed up operation.

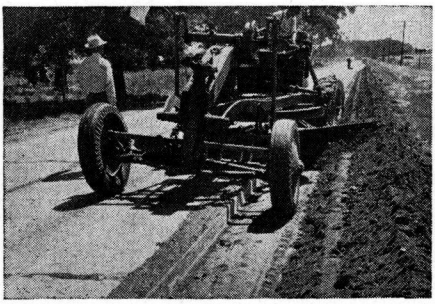


Figure 20. Excavating for Widening with Motor Grader Having Auxiliary Mould Board Attached to the Regular Mould Board.

satisfactory results as a first base widening course where this material is available in the northeastern Ohio district. Where crushed slag or limestone is available it is our practice to use 4- to 5-in. courses of coarse graded insulation or base courses constructed essentially the same as water bound macadam except that the actual water binding operation is omitted. Waterbound macadam courses are also used for widening, either as first courses under a bituminous concrete or as first and second courses under the surface courses. The dry macadam type has proved satisfactory where it has been used as a first base course and is being used on an increasing basis in multiple base construction. This type of construction has an advantage over the waterbound type in

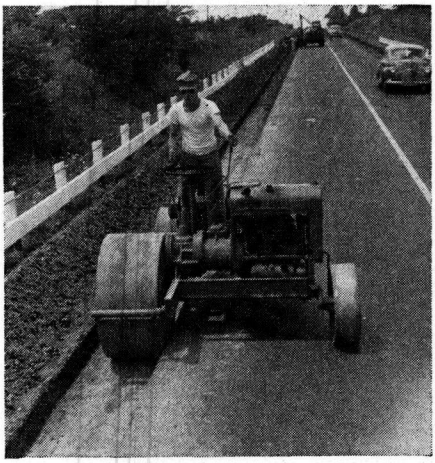


Figure 21. Compaction of Subgrade to Maximum Density Prior to Placing Base is Important.

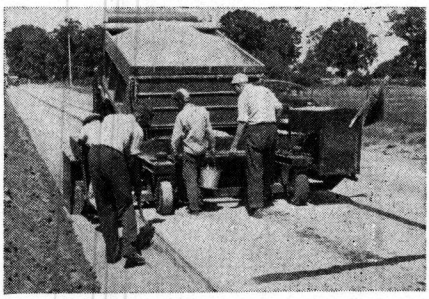


Figure 22. Placing Inverted Choke of Screenings Preliminary to Placing Coarse Aggregate for Dry Macadam. Using Self Propelled Box with Belt Conveyor Built by Contractor.

permitting construction to move along at a faster pace, which is especially advantageous in early and late season construction.

Granulated slag, waterbound and dry bound macadam bases and sub-bases are being constructed without side forms when approved spreading and leveling machines are used. The stepped-in edge construction as described for bituminous concrete is also used for these base courses.

Mechanical, self-propelled spreading and leveling devices are being used generally to spread the aggregates. These machines reduce the labor to a minimum and speed up construction operations. Several contractors developed equipment having a screw type conveyor to carry the material from the hopper to the strike off which proved satisfactory for finer graded materials. Belt conveyor type

Figure 23. Spreading Coarse Aggregate with Self-Propelled Unit Equipped with Belt Conveyor Built by Contractor.

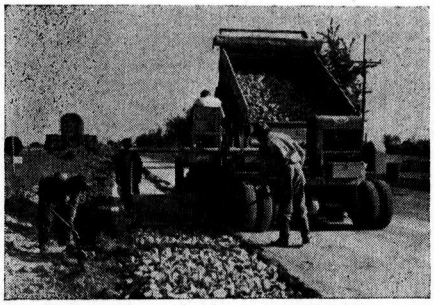


Figure 24. Spreading Coarse Aggregate with a Self Propelled Unit Equipped with Belt Conveyor. This unit was recently placed on the market.

has proven the most practical for the coarser graded material. Recently several manufacturers have recognized the demand for this type of equipment and have improved the various devices developed by contractors and placed them on the market for general use.

Where bituminous concrete base widening courses are placed the edge of the old pavement is sealed with bituminous material applied from a spray nozzle in not less than two applications.

Bituminous concrete base courses may be placed in widening courses by hand methods or suitable spreading devices. In keeping with the necessity for reducing labor to a minimum and at the same time attaining high pro-

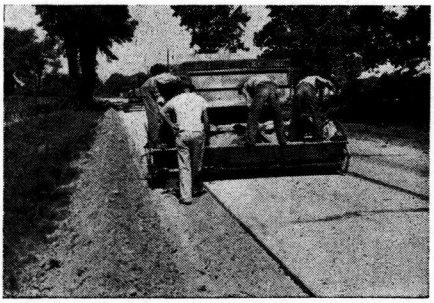


Figure 25. Applying Screenings

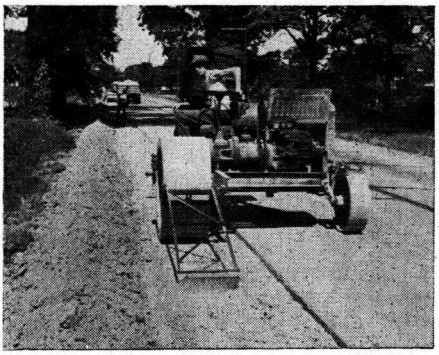


Figure 26. Rolling and Sweeping in Screenings Using a Trench Roller Unit.

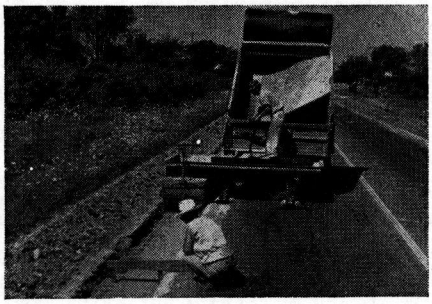


Figure 27. Placing Fine Graded Insulation Course Preliminary to Bituminous Concrete Widening.

duction, it has been the practice to spread the bituminous concrete mechanically. The same general equipment of the self-propelled screw conveyor type used for other base courses is being used with satisfactory results for bitu-

minous concrete base construction. This equipment spreads the material without the segregation which often results when other methods are used.

Compaction of base material in widening trenches, inaccessible to standard rolling equipment, is accomplished with trench rollers.

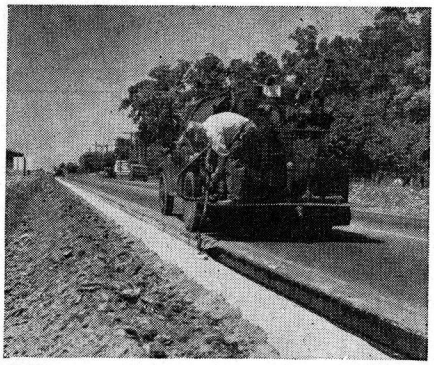


Figure 28. Sealing Edge of Old Pavement Preliminary to Placing Bituminous Concrete Base Widening.

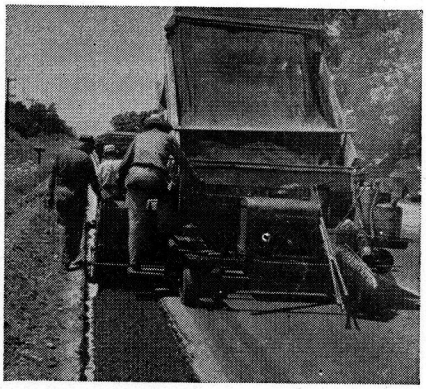


Figure 29. Spreading Bituminous Concrete Base Widening with Self-Propelled Unit.

These rollers have minimum 10-in. width rolls for the main compression rolls with a minimum requirement of 300 lb. per in. width and a maximum of 365 lb. per in. width. Where conditions permit, it has been found that "breaking down" of the base material first with a standard roller and then completing the compaction with the trench roller works to advantage. Requirements for compaction of bituminous concrete widening with trench rollers specify that the roller shall not operate in excess of $1\frac{1}{2}$ mile per hour at a rate not to exceed 0.8 tons per hour per inch width of compaction roll. We require that the finished base course be $\frac{1}{4}$ in. above the edge of the old pavement to guard against possible bridging.

In the construction of narrow widening sections in recent years, we have permitted the use of the same bituminous concrete mix for

Figure 30. Rolling Base Widening with Trench Roller Unit—Type A Asphaltic Concrete.

Figure 31. Standard rollers may be used in conjunction with trench roller units Type A asphaltic concrete.

the widening as is used in the leveling or binder course. This same mixture is also generally used for the surface course on sections constructed outside municipalities. In this mixture, known as Type A composition, the coarse aggregate passes the 1-in. screen.

Use of the same base mixture as is used in the leveling course is an especial advantage in narrow widening. Our asphaltic concrete base mixture permits 10 to 20 percent of material retained on the 1-in. screen and passing the 2-in. This material tended to segregate

in placing and in the narrow base widening sections it caused difficulty in securing density immediately adjacent to the pavement being widened. This often led to further movement under traffic and frost action and caused cracking and separation to be carried through to the surfacing material.

Use of the same composition mix in leveling and base courses has a distinct advantage from the contractor's standpoint in that he may change quickly from leveling operations to base and back again or carry them on concurrently. This enables the contractor to

Figure 32. Spreading Granular Shoulder Material with Self Propelled Unit After Resurfacing is Completed.

Figure 33. Full Width Spreader Finisher Unit Travelling on Forms.

keep widening trenches filled as they are opened and thus avoid later possible delay.

Prior to 1945 it was the policy to use 85–100 penetration asphalt for the asphaltic concrete of the type laid with pavers. However, some displacement was experienced under traffic action on some of the more heavily travelled routes and in urban sections at traffic lights, and as a result we are using a 70-80 penetra-

TABLE 1
COMPOSITION OF ASPHALTIC CONCRETE MIXTURES

Base

Passing Sieve	Retained on Sieve	Percent	
		Minimum	Maximum
2 Inch	1 inch	10	35
1 Inch	½ Inch	10	45
½ Inch	No. 4	5	40
No. 4	No. 6	0	5
No. 6	No. 50	10	40
No. 50	No. 200	2	17
No. 200		0	3
Bitumen		4	8
Total Retained on No. 6		60	75

Type "A"
Narrow base, leveling or surface rural

Passing Sieve	Retained on Sieve	Percent	
		Minimum	Maximum
1 Inch	¾ Inch	0	5
¾ Inch	½ Inch	5	20
½ Inch	⅜ Inch	7	30
⅜ Inch	No. 4	10	35
No. 4	No. 6	0	10
No. 6	No. 50	20	45
No. 50	No. 200	3	15
No. 200		0	5
Bitumen		5	9.5
Total Retained on No. 6		50	60

Type "B"
Surface

Passing Sieve	Retained on Sieve	Percent	
		Minimum	Maximum
¾ Inch	½ Inch	0	6
½ Inch	⅜ Inch	10	35
⅜ Inch	No. 4	10	35
No. 4	No. 6	0	10
No. 6	No. 50	20	45
No. 50	No. 200	3	15
No. 200		0	5
Bitumen		5	9.5
Total Retained on No. 6		45	60

Type "C"
Surface urban

Passing Sieve	Retained on Sieve	Percent	
		Minimum	Maximum
½ Inch	⅜ Inch	0	7
⅜ Inch	No. 4	25	45
No. 4	No. 6	0	15
No. 6	No. 50	20	45
No. 50	No. 200	3	15
No. 200		0	5
Bitumen		6	10
Total Retained on No. 6		40	55

Conversion Table

Coarse Aggregate	Slag	Stone or Gravel
Pounds per cu. yd	3550	3800

tion asphalt except on the light traffic routes. Normally the resurfacing of an old established road necessitates the addition of material to the shoulders to affect a transition from the new surfacing to the existing shoulder. Where a narrow aggregate section exists on the shoulder this transition is accomplished by adding granular material. Several types of mechanical spreading boxes have been used in placing this material.

Figure 34. Old Concrete Pavement Which has Disintegrated Badly at Joints and Cracks Even Though it Has Been Kept Sealed Ready for Resurfacing. (Before)

Figure 35. After Resurfacing—Restored to Many More Years of Service. (After)

Where widening is done the excavated material from the widening section is usually used to widen the shoulder. Our design trend on many projects in recent years has been to widen the scope of the salvage construction to include shoulder widening and seeding.

This discussion has dealt primarily with various widening practices and laying of bituminous concrete with paver units. We also have another type of bituminous concrete which is generally known as a higher type. The mix for this type requires a closer graded aggregate using 60–70 or 70–80 penetration asphalt. Ordinarily this type is used where a finishing machine travelling on forms is required. This requires that the material be shoveled in front of the screed from a dump board or spread with a spreader unit. It is obvious that this type requires considerably more labor than the other and for that reason has been used on a decreasing basis in recent years. Some projects may justify the accurate crown control possible with a finishing machine travelling on forms. However, with the improved practices and equipment used in laying with the paver type construction the necessity for the additional expense of the other type of construction becomes less and less justifiable.

Figure 36. Many sections of streets on the highway system have become distorted and retard drainage. (Before)

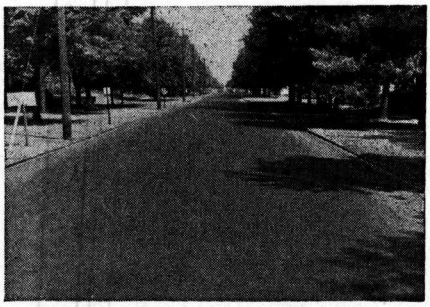


Figure 37. Resurfacing has restored the crown and gutter grade to many years of added service. (After)

Originally the bituminous concrete type laid with the paver unit was set up with much more open requirements for aggregate than the other type. This was done to permit the

use of some local aggregates not meeting all the soundness requirements. These requirements have been modified over a period of years as experience revealed undesirable results with some aggregate combinations. We have experienced stripping with some limestone and gravel aggregate mixes. In areas where this has occurred we are now requiring the use of asphalt meeting "no strip" tests.

In the past 12 years which cover the period of salvage work under discussion, Ohio has salvaged an increasing mileage. In recent years this program has varied from 350 to 500 miles per year. Bituminous concrete for this mileage has varied from 850,000 to 1,000,000 tons per year. In that period we have witnessed practically a 100 to 300 percent increase in construction costs for other types of construction. It speaks well for the highway industry—the highway engineer—the contractor—and the equipment producer, that in this particular branch of highway construction the costs have increased only about 30 percent. New developments and practices have to a great extent offset rising material and labor costs. We, as engineers, have been receptive to new ideas and developments in the salvage type construction which accounts for these improvements. We should likewise have an open mind on all our highway work in order that we do not rule out progressive developments.

DEPARTMENT OF TRAFFIC AND OPERATIONS

WILBUR S. SMITH, *Chairman*

THE EFFECT ON DRIVER BEHAVIOR OF CENTER LINES ON TWO-LANE ROADS

A. TARAGIN, *Highway Engineer, Division of Highway Transport Research, Public Roads Administration*

SYNOPSIS

A driver behavior study revealed that motor vehicle speeds and transverse positions are substantially affected by the presence of pavement markings along the roadway center line. Observations were made on level, straight sections of rural two-lane pavements 18 to 24 ft. wide, with grass or gravel shoulders in average condition. The principal findings made in an analysis of operating data for 18,235 vehicles, recorded at 12 locations in 7 States, are summarized as follows:

1. For each of the pavement widths studied the typical vehicle path is farther to the right on pavements with a center-line marking than it is on similar pavements without center-line markings. The differences observed vary from less than 0.5 ft. to nearly 1.5 ft., depending on pavement width, vehicle type, the presence of other traffic and similar factors.
2. In all cases, vehicles are driven closer to their proper position on the roadway and encroach on the left lane less frequently when they have the center-line marking for a guide.
3. On an 18-ft. pavement without a center-line marking 56 percent of the vehicles encroach on the left lane. This proportion is only 12 percent on the same width pavement with a center-line marking. On wider pavements, the corresponding percentages are lower but in all cases the encroaching action is less frequent on pavements having a center-line marking.
4. The average lateral clearance between the sides of meeting vehicles on 24-ft. pavements is greater by about 2 ft. on sections with center-line marking than it is on similar width pavements without marking.
5. Comparison of the speeds of vehicles on pavements with and without center-line markings shows that generally higher speeds exist on pavements with markings. The over-all difference in average speed amounted to approximately 4 mi. per hr.