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16. Abstract

The addition of a rubber-tire roller was required on two projects on maintenance schedules and on two construction projects in 1988. The rubber-tire roller was used as an addition to the conventional rollers on one-half of each project. The rubber-tire roller was required to have a minimum of 80 psi ground contact pressure (GCP). Used in the intermediate roller position, it applied three passes to the pavement. On two of the projects, the addition of the rubber-tire roller improved the pavement properties compared to those on the conventionally rolled section. On one project, the conventionally rolled section had better pavement properties, and on one project there was no differences.

The results of this study and one conducted in 1987 indicate that the addition of a rubber-tire roller improved the pavement properties on more than half of projects tested. Based on this rate of improvement, it is recommended that a rubber-tire roller operating in the intermediate roller position with a minimum GCP of 80 psi and applying three passes be required on all modified mixes; i.e., those in which the optimum asphalt content is based on a 75-blow Marshall compactive effort.

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FINAL REPORT

EVALUATION OF THE USE OF RUBBER-TIRE ROLLERS ON ASPHALT CONCRETE

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(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

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ABSTRACT

The addition of a rubber-tire roller was required on two projects on maintenance schedules and on two construction projects in 1988. The rubber-tire roller was used as an addition to the conventional rollers on one-half of each project. The rubber-tire roller was required to have a minimum of 80 psi ground contact pressure (GCP). Used in the intermediate roller position, it applied three passes to the pavement. On two of the projects, the addition of the rubber-tire roller improved the pavement properties compared to those on the conventionally rolled section. On one project, the conventionally rolled section had better pavement properties, and on one project there was no differences.

The results of this study and one conducted in 1987 indicate that the addition of a rubber-tire roller improved the pavement properties on more than half of projects tested. Based on this rate of improvement, it is recommended that a rubber-tire roller operating in the intermediate roller position with a minimum GCP of 80 psi and applying three passes be required on all modified mixes; i.e., those in which the optimum asphalt content is based on a 75-blow Marshall compactive effort.

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INTRODUCTION

At the request of the VDOT's Flexible Pavement Task Force, the Research Council undertook a study in 1987 to determine the effectiveness of rubber-tire rollers in the compaction of asphalt concrete. The final report of the study, entitled "Investigation of Improved Compaction by Rubber-Tire Rollers" (1), was approved by the FHWA on January 22, 1988.

This study concluded that although some benefits were found with the use of the rubber-tire roller, they were not sufficient to make a rubber-tire roller a general requirement. However, at the spring 1988 Bituminous Research Advisory Committee meeting, the presentation of the study elicited much discussion concerning the benefits that were found in those sections that used a rubber-tire roller. As an outcome of this discussion, Mr. W. E. Winfrey suggested that several projects be selected in the 1988 construction season on which a rubber-tire roller would be required.

PURPOSE

The purpose of this study is to evaluate the use of rubber-tire rollers under typical operational conditions. It was the responsibility of the Research Council to coordinate the projects, to establish guidelines for evaluating the rollers, to interact with the districts in gathering the data, and to analyze the data and prepare a report.

STUDY

Two construction projects and two maintenance schedules were selected on which the use of a rubber-tire roller was required. The projects tested were:

1. 2-M-88, Rte. 460 WBL, Bedford Co. - S-5 Modified - 2.9 mi
2. 1-B-88, Rte. 460 E & WBL, Buchanan Co. - S-10 - 5.6 mi
3. 0275-007-101, C-502, N & SBL, Augusta Co. - S-10 - 1.7 mi
4. 6019-083-106, C-504, SBL, Russell Co. - S-5 - 1.4 mi

One of the questions that arose from the study undertaken in 1987 was whether the roller used was heavy enough to produce the beneficial effects often attributed to the use of a rubber-tire roller. The roller used on four of the five projects last year was a Dynapac CP15. This is a 15-ton Roller with 7.50 x 15 six-ply tires. The manufacturer's literature on this roller stated that with a 2,000-lb wheel load (a total weight of 18,000 lbs) and a tire inflation pressure of 50 psi, a 50 psi ground contact pressure (GCP) would be obtained. This level of GCP may not have been sufficiently high to provide additional compaction over the normal compaction train.

The 1988 study initially considered a minimum roller size of 12 to 15 tons with minimum GCP of 70 psi. Mr. Myron Geller, a renowned compaction consultant, advised that a GCP of at least 90 psi be required in an attempt to more closely approach the tire pressures of the trucks that will be using the roadway. A Bituminous Research Advisory Committee subcommittee of Mr. A. D. Barnhart, J. G. G. McGee, and A. D. Newman discussed the minimum requirements needed to provide meaningful results and decided that a minimum GCP of 80 psi was a reasonable requirement. The guidelines for the evaluation of the rollers is in the Appendix.

FIELD TESTING

The field testing followed the same procedure used in the previous study. The first half of the project used the contractor's normal equipment and normal rolling pattern and was designated as the conventional section. Conventional rolling consisted of vibratory breakdown rolling and tandem finish rolling. After rolling, ten nuclear readings were taken transversely across the pavement at 1 ft intervals beginning adjacent to the longitudinal joint. This series of measurements was made every .1 mi in the longitudinal direction. Four-inch cores were taken from the same section with a minimum of two taken adjacent to the longitudinal joint and at least four spaced at random transverse locations.

The second half of the project included the use of the rubber-tire roller as an intermediate roller making three passes and was designated the test section. The normal roller pattern used on the conventional section was not changed. The same nuclear and coring sequence was followed for the test sections.

RESULTS

Table 1 shows averages and standard deviations for nuclear densities, air voids, permeability, resilient modulus, and indirect tensile strength. These properties will be discussed one by one.

Table 1

Test Results

Project		Nuclear Den. pcf		Air Voids %		Permeability		M_R ksi		Indirect Ten psi	
		Conv.	Test	Conv.	Test	Conv.	Test	Conv.	Test	Conv.	Test
Rte. 460 M	$\bar{X}$	142.2	144.0	12.7	9.3	56	47	59	72	57.0	80.9
	σ	2.95	3.32	1.38	0.75	-	-	12	18	9.1	22.0
Rte. 460 C	$\bar{X}$	136.2	138.9	11.3	8.9	87	67	47	56	68.5	74.3
	σ	3.45	2.84	2.39	1.32	-	-	29	16	17.6	15.3
Rte. 275	$\bar{X}$	139.1	135.5	9.3	13.1	43	164	70	49	78.8	59.5
	σ	4.32	2.31	0.72	2.44	-	-	7	17	6.7	13.1
Rte. 19	$\bar{X}$	140.2	138.5	10.4	10.6	-	-	68	63	87.8	80.5
	σ	1.90	1.60	3.37	1.92	-	-	23	8	19.3	12.7

M = Maintenance
C = Construction

Nuclear Densities

On the four projects, the average nuclear density for the rubber-tire test section is slightly higher than the conventional section on two but slightly lower on the other two. The standard deviations of the nuclear density are lower for the test sections on three of the four projects, indicating a more uniform density across the pavement which reinforces the belief that rubber-tire rollers overcome bridging that cannot be overcome by steel-wheel rollers. The first nuclear density in each testing sequence is adjacent to the longitudinal joint, and averaging these first readings on each section provided an indication of the average joint density. The results from the 1987 study showed densities on the average 2.6 pcf higher for the rubber-tire roller section. The results this year were just the opposite: three of the four projects had densities on the average of 1.7 pcf lower on the rubber-tire roller section. Because of the variability encountered in the measurements, this difference is not statistically significant.

Air Voids

The average air void results pretty much reflected the results of the average nuclear density: the rubber-tire test sections had lower air voids on two projects, higher on one, and on one project there was no difference. The results of the standard deviations of air voids on the test sections again generally showed a slight improvement over those of the conventional sections. For the joint air voids, the rubber-tire roller reduced the air voids on the two Rte. 460 projects and increased the air voids on Rte. 275. On Rte. 19, there was no difference between the air voids of the test sections using the rubber-tire rollers and the conventional rollers.

Permeability

The use of rubber-tire rollers has been reported to reduce the permeability of pavements compared to those rolled with steel-wheel rollers. Permeability results were obtained on only three projects, and on all three, the results reflect those of the air voids, i.e., lower permeabilities for the rubber-tire roller sections for the Rte. 460 projects and higher permeabilities on Rte. 275.

Resilient Modulus

As in the 1987 study, the variabilities for the resilient modulus (M_R) test are sufficiently high to mask any differences in average that may exist between test and conventional sections. However, the trend of the M_R averages reflects the air void results in which the rubber-tire roller produced higher M_R results than the conventional rollers on both Rte. 460 projects, lower results on Rte. 275, and no difference on Rte. 19.

Indirect Tensile Strength

The trends for the averages of the indirect tensile strengths are much the same as the earlier tests indicated, the rubber-tire roller produced higher strengths on the Rte. 460 (M) project, lower strengths on Rte. 275, and little difference on Rte. 460 (C) and Rte. 19.

Summary of Results

Both the maintenance schedule and construction project on Rte. 460 appeared to benefit from the use of the rubber-tire roller in improved density, lower air voids, lower air void permeability, lower permeability, and high strengths. The Rte. 275 project, on the other hand, seemed to suffer as a result of the use of the rubber-tire roller. Why the densities were lower and air voids higher on the rubber-tire roller section of this project is not clear. The results on the fourth project, Rte. 19, were the same for the section on which the steel wheel roller was used and the section on which the rubber-tire roller was used.

One additional comment is warranted: on one of the sections that benefited from the use of the rubber-tire roller, Rte. 460 Buchanan Co., the rubber-tire roller used had a GCP of only about 65 psi and thus did not meet the guideline of 80 psi GCP.

CONCLUSIONS

Conclusions from the testing are as follows:

1. The use of the rubber-tire roller tends to reduce the variability of the air voids and the nuclear density, and thus it provides somewhat more uniform density than does the conventional rollers. This indicates that the rubber-tire roller overcomes bridging that cannot be overcome by steel-wheel rollers.

2. The use of the rubber-tire roller tended to improve the mix and pavement properties on two projects, did not affect the properties on another project, and negatively affected the properties on the fourth project.

3. The trends in terms of improved joint density, pavement permeability, and strength are related by project as indicated above.

RECOMMENDATIONS

The conclusions of the two studies indicate that the use of a rubber-tire roller improves pavement properties on more than half of the projects studied. However, it is the author's opinion that the benefits are not sufficient to warrant the use of rubber-tire rollers on all asphalt paving.

Modified mixes in Virginia use a higher compactive effort in mix design on which the optimum asphalt content is chosen. This results in a lower asphalt content than would be chosen with a standard 50-blow compactive effort. This lower asphalt content likewise requires a higher or more efficient compactive effort in the field to reduce the air voids to an acceptable level. One method of attempting to increase the compactive effort would be to use a rubber-tire roller as an intermediate roller.

Thus, it is recommended that for modified mixes, three passes of a rubber-tire roller operating in the intermediate roller position with a minimum GCP of 80 psi be required beginning January 1, 1990.

ACKNOWLEDGMENTS

Special appreciation goes to David Lee, Assistant Materials Engineer in Salem. David was the project coordinator; supervised all the testing and data gathering; and reported on the construction operations. Without his able assistance, this project could not have been accomplished. The task force consisting of A. D. Barnhart, A. D. Newman, and J. G. G. McGee is also thanked for its input in selecting projects and developing guidelines to be used. As always, the districts and contractors involved in this program were very helpful.

REFERENCE

1. Hughes, C. S. 1987. Investigation of Improved Compaction by Rubber-Tire Rollers. VTRC Report No. 88-R7. Charlottesville, Va.: Virginia Transportation Research Council.

APPENDIX

Guidelines for Evaluating Rubber-Tire Roller

This testing is to be accomplished on both the control section, that is, the section with only conventional rollers and on the test section, that is, the one with the rubber-tire roller in the intermediate roller position. This testing is in addition to whatever testing that is needed for project acceptance and only applies to the surface course.

The purpose of this testing is to:

1. Determine if the longitudinal joint is more densely compacted by using a rubber-tire roller.

2. Determine if the density is more uniform across the pavement with the use of the rubber-tire roller.

3. Determine whether the use of the rubber-tire roller reduces the average air voids in the pavement.

In order to make these determinations, the following paving and testing sequences are necessary.

1. The passing lane is to be paved first and the traffic lane paved second. This will allow the necessary testing to be restricted to only the traffic lane. This testing will take place after the completion of rolling but before the lane is opened to traffic.

2. At 0.1 mile intervals, nuclear testing across the pavement is to be conducted.

    a. The first nuclear reading is taken with the nuclear gauge entirely in the traffic lane and the edge of the gauge directly adjacent to the longitudinal joint.

    b. The gauge will be moved transversely approximately one foot and another reading taken.

    c. This procedure is to be repeated until 10 readings have been taken in the transverse direction.

    d. The 10th and last reading should be near (within one foot) of the unsupported edge on the shoulder side of the road.

3. A minimum of 6 cores from the control section and 6 cores from the test section will be taken. At least two of the six cores shall be taken as close to the longitudinal joint as practical (within one foot), but not straddling the joint. The other cores shall be taken randomly longitudinally and transversely to adequately cover each section. The cores will be taken to the District Materials Laboratory for the determination of air voids and for subsequent testing to be done at the Research Council.

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4. Approximately 80 pounds of mix (2 bags) will be taken from each section to be sent to the Research Council.