Use of a Loaded-Wheel Testing Machine To Evaluate Rutting of Asphalt Mixes

JAMES S. LAI AND THAY-MING LEE

A loaded-wheel testing machine is used to evaluate the rutting characteristics of asphalt mixes. The 3- × 3- × 15-in. asphalt beam samples used for the test can be prepared by kneading compaction or by static compression. The rutting tests are normally conducted at an elevated temperature between 95°F and 105°F. The repeated loading on the beam sample is generated by a pressurized rubber hose placed lengthwise on top of the beam sample and a loaded wheel riding back and forth at 44 cycles/min along the rubber hose. The pressure in the hose is maintained at 100 psi, and the magnitude of the wheel load is 100 lb. The rut depth developed on the beam sample along the wheel path under the rubber hose is measured at different numbers of repetitions and is used for evaluating the rutting potential of the asphalt mixes. This repeated-load mechanism has several advantages over the conventional wheel-tracking mechanism. Asphalt mixes of the Georgia Department of Transportation standard Type B mix, Coarse B mix, base mix, and two other modified mixes using three different aggregate sources were tested by the proposed method to evaluate the effect of mix gradations and aggregate sources on rutting resistance. The results showed significantly different rutting resistance among the asphalt mixes tested.

Rutting on asphaltic pavement has become more serious as the wheel loads and tire pressure of truck traffic on highways have increased. Rutting reduces road serviceability and creates the problem of hydroplaning caused by the accumulation of water on the rutted wheel paths. Methods to eradicate rutting on asphaltic pavement usually involve asphalt concrete (AC) overlay. This rehabilitation process is costly and provides no assurance that the overlayed pavements will not rut again.

An asphaltic pavement can develop rutting because of inadequate structural capacity as a result of improper design, improper construction practices, or instability of the asphalt mix used in the pavement. Currently available mechanistic flexible pavement design and analysis procedures can be used to design a flexible pavement structure with adequate structural capacity to minimize rutting. But rutting still occurs because of lack of stability. Poor resistance to deformation of the asphalt mix itself must be mitigated by having a better asphalt mix design procedure through which asphalt mixes with better rutting resistance can be obtained.

Two commonly used methods for the design of asphalt mixes are the Marshall and the Hveem mix design methods. Although these two methods can probably screen out extremely unstable mixes, there is no assurance that an asphalt mix with properties satisfying the design criteria of either of these methods will not develop rutting under normal traffic conditions.

J. S. Lai, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332. T.-M. Lee, National Expressway Engineering Bureau, Taipei, Taiwan, Republic of China.

Recent studies by Lai (*1–3*) demonstrated the inability of the Marshall method to assess the rutting potential of asphalt mixes. Many testing methods have been proposed to improve prediction of the rutting potential of asphalt mixes. These include the triaxial repeated-load test and the creep test. Some of the test methods have achieved varying degrees of success in predicting the rutting potential of asphalt mixes.

In a recent study conducted by Lai (*1*) for the Georgia Department of Transportation (GaDOT), the loaded-wheel testing (LWT) machine was demonstrated to be capable of evaluating the rutting characteristics of AC. Results of the LWT method were more compatible with the rutting characteristics normally experienced in asphaltic pavements under vehicular loading than results achieved by the permanent deformation of the same asphalt mixes tested under the triaxial repeated-load test and the creep test. In the second study (*2*), the LWT machine was used to assess the rutting potential of GaDOT Type B asphalt mixes and six different modified mixes using aggregates from three different sources. The mixes used fillers with different gradations and particle shape and size distributions. One of the mixes also contained polymer modifier. Although all 21 of the asphalt mixes met the Marshall mix criteria, they exhibited significantly different rutting characteristics under the LWT machine. From these test results, certain modified mixes that have the potential to give better resistance to rutting were identified.

In the third study (*3*), the same test method was used to evaluate the rutting potential of six asphalt mixes for potential use in base course. The gradation of the mixes varied in the maximum aggregate size and the fine aggregate portion. Again, the results from the LWT showed significant difference in rutting resistance among the mixes, even though all the mixes satisfied Marshall mix criteria. The LWT machine and the testing procedure are described in the following section, and some rutting characteristics of asphalt mixes determined by this testing procedure are presented.

DESCRIPTION OF LOADED-WHEEL TESTING MACHINE

The original version of the LWT machine was developed by Benedict Slurry Seal, Inc., for evaluating certain properties of asphalt slurry seals. A similar machine has been used elsewhere to evaluate the rutting potential of AC (*4,5*). The original machine was modified (*1,2*) to make it more applicable for evaluating the rutting behavior of asphalt mixes under a laboratory environment.

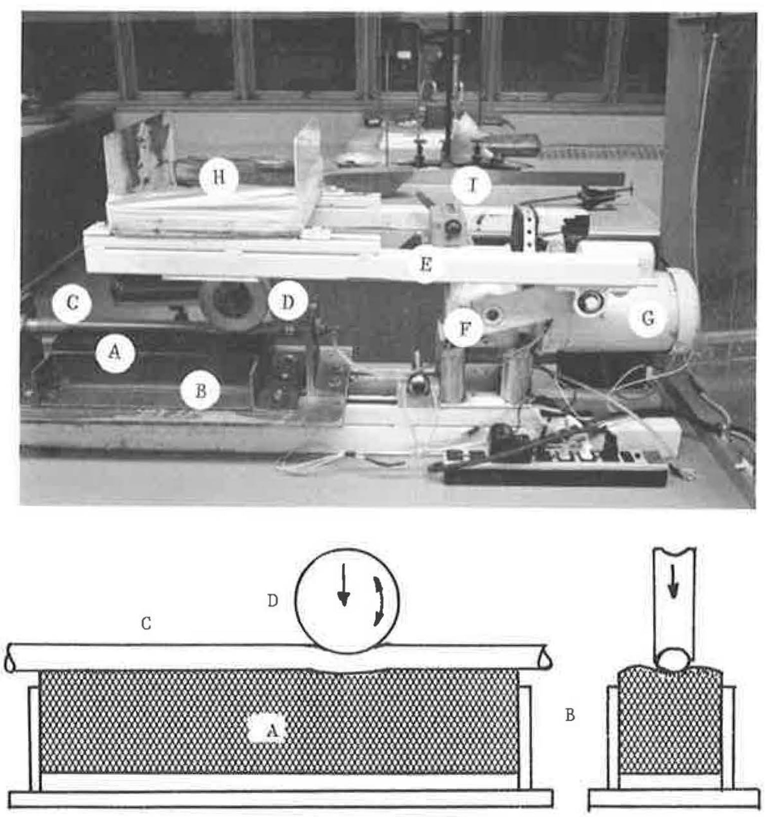
Figure 1 shows the main features of the modified LWT machine. The 3- × 3- × 15-in. beam sample (*A*) is placed in the sample-holding mold (*B*). The beam sample and the sample-holding mold are shown more clearly in Figure 2. The base of the sample-holding mold includes a removable 3- × 15- × ½-in. steel plate to simulate a rigid base-course condition. This steel plate can be replaced by an equally thick resilient rubber pad to simulate a flexible base. The sides and ends of the sample are partially confined by steel brackets. A pressurized rubber hose (*C*), also shown in Figure 2, is placed on top of the sample and is partially restrained at the ends. In addition to the loading wheel (*D*) shown in Figure 1, the components of the loading system consist of a ⅓-hp motor (*G*), 12-in. reciprocating-stroke arms (*E* and *F*), and the weight-holding box (*H*). The machine is equipped with dual counters, a resettable mechanical counter (*I*), and an electric counter activated by a photographic relay for recording the number of repetitions. The electric counter was installed on top of the environmental chamber lid, so that the number of cycles during the test can be read when the environmental chamber lid is closed. The entire testing machine is enclosed in this environmental chamber, which can maintain a constant temperature of up to 120°F throughout the test period. Details of the environmental chamber and the preheating box (for preheating the test samples) and other features of the LWT machine were described by Lai (*6*).

DESCRIPTION OF WHEEL-LOAD GENERATING SYSTEM

The original 1-in.-wide aluminum loading wheel had a 3-in. diameter and was fitted with a hard rubber tire. The tire would exert nonuniform contact pressure on the surface of an AC sample, particularly for the coarser mixes. It was decided that the hard rubber tire should be replaced with an inflatable tire, so the contact pressure could be more controllable.

At first, an approximately 1-in.-wide, off-the-shelf tire with tire pressure up to 120 psi was sought. No suitable tire could be found, so a loading wheel with the specified characteristics was developed in the laboratory.

The first version was an 8-in.-diameter aluminum wheel with a 1-in.-diameter high-pressure rubber hose wrapped around the rim. The hose could be pressurized and maintained at a controlled pressure up to 100 psi through an air-pressure system and a pressure regulator. This wheel assembly was fitted on the LWT machine, along with other necessary modifications to make the system compatible. Several preliminary



A: Beam Sample
B: Sample Holding Mold
C: Pressurized Rubber Hose
D: Loading Wheel
E & F: Reciprocating Arms
G: 1/3 hp Motor
H: Weight Holding Box
I: Restable Counter

FIGURE 1 Modified loaded-wheel testing machine.

rutting tests were performed on 3- × 3- × 15-in. asphalt beam samples. The wheel assemblage itself performed satisfactorily, with pressure in the hose kept relatively constant, but several problems were observed during the tests. The reciprocating action of the loaded wheel, which occurred at the end of each stroke, caused the rubber hose to generate excessive skidding against the rough surface of the sample near the ends of the stroke. The skidding caused excessive wear of the rubber hose and, more importantly, excessive rutting on the asphalt samples near the ends of the beam. Furthermore, because of the excessive ruts developed there, the wheel had the tendency to push near these regions, instead of just rolling along the wheel path. Shoving became evident along these regions and slowly progressed toward the center. For these reasons, this version of the wheel system was abandoned.

To overcome these problems, a rather novel concept of generating moving-wheel load was conceived. This loading system consisted of a flexible linear tube made of a high-pressure rubber hose, and a 3-in.-diameter aluminum wheel (see Figures 1 and 2). The rubber hose was pressurized to the prescribed pressure and placed on top of the AC specimen. The hose was stationary, loosely held in position on both ends by end clamps to maintain the longitudinal alignment along the center of the beam. The concave shape of the rim would keep the aluminum wheel on top of the rubber hose. The wheel was attached to the reciprocating arm of the machine. During the rutting test, the loaded aluminum wheel rode along

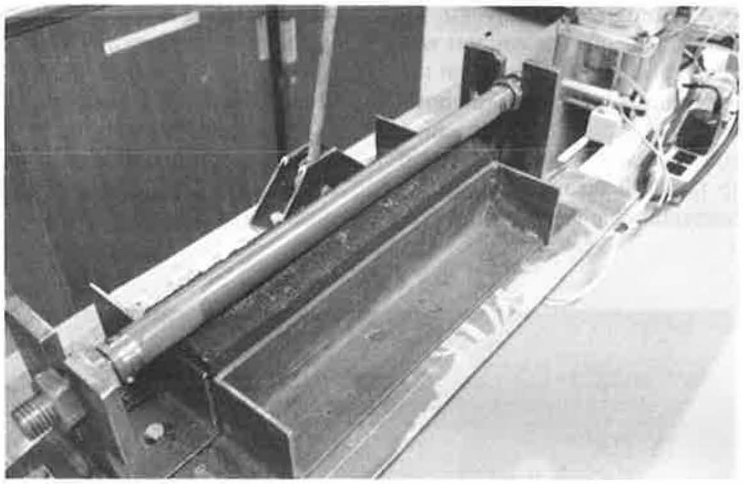


FIGURE 2 Linear-tube loading system.

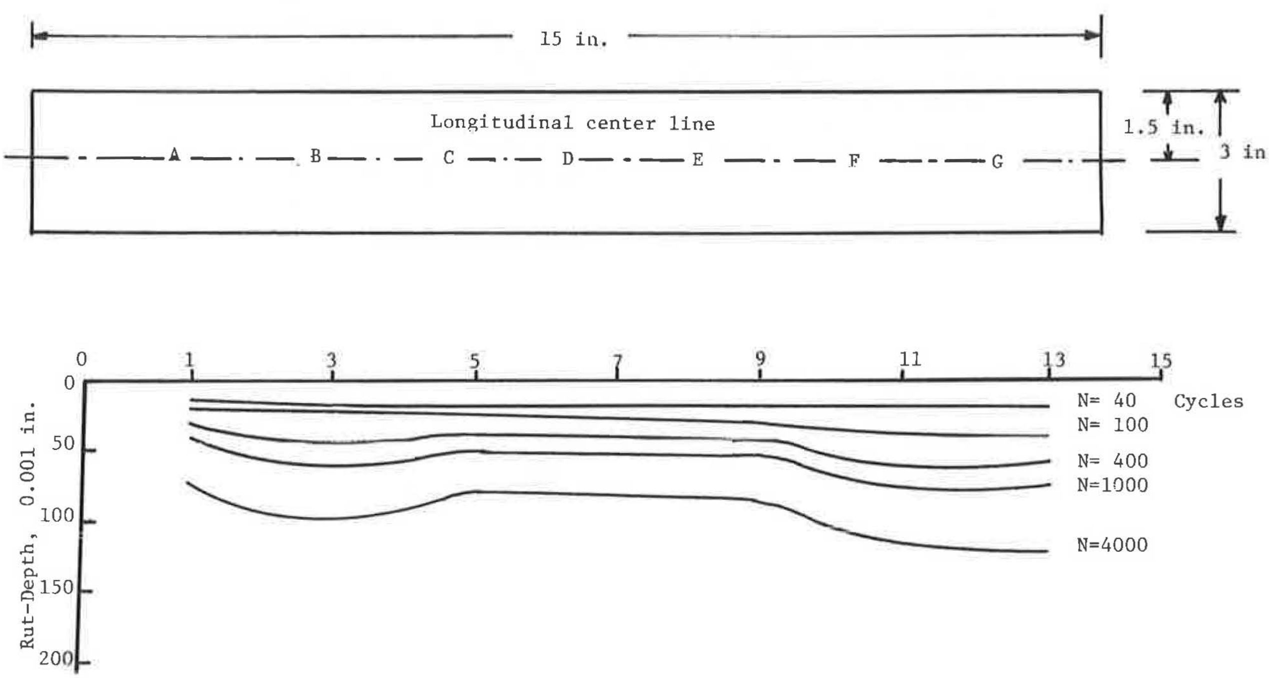


FIGURE 3 Rutting profile along the longitudinal centerline.

the pressurized rubber hose; at the point of contact, it generated pressure on the surface of the beam sample.

The linear-tube concept was tested, and the performance was satisfactory. The excessive rutting at both ends of the asphalt beam sample was substantially reduced. The magnitude of rutting at the end regions was still greater than that at the middle region (see Figure 3), probably because the total duration of loading was longer at the end regions than at the middle region because of the wheel's reverse movement at the end of the reciprocating action.

Because of the novelty of the linear-tube loading concept, some questions still needed to be answered. One concerned the nature of the contact pressure exerted on the test specimen. The other involved the effect of the stiffness of the rubber hose on the rutting of beam samples.

In order to evaluate the effect of the stiffness of the rubber hose, the imprints of the contact area between the rubber hose and the asphalt beam sample were measured for the two types of rubber hose, one relatively stiff and one relatively flexible, under 100-psi inflated pressure and at 100-lb weights. The imprints are shown in Figure 4. The stiffer rubber hose generated a more elongated and narrower contact area, whereas the more flexible hose generated a shorter and wider contact area. This information alone implied that the use of the stiffer hose may generate a greater rutting on the beam sample than the less-stiff hose would. A series of rutting tests was performed on the same asphalt mix using these two rubber hoses. The results (presented in Table 1) indicated that the flexible hose generated a slightly greater rutting on beam samples than the stiffer hose did. No direct measurement of the contact pressure between the rubber hose and the asphalt beam surface was taken.

ASPHALT BEAM SAMPLE PREPARATION PROCEDURE

In the previous studies (*1–3*), the 3- × 3- × 15-in. asphalt beam samples used for the rutting test were fabricated using a kneading compaction machine. The typical procedure was as follows. A Marshall mix design for an asphalt mix was followed; 50-blow compaction per side was used for preparing the samples. The optimum asphalt content for the mix was determined on the basis of air voids in the mix at approximately 4.5 percent. On the basis of the bulk density of the mix at the optimum asphalt content from the Marshall mix design and the known volume of the 3- × 3- × 15-in. beam mold, the weight of the aggregate samples for one-third beam

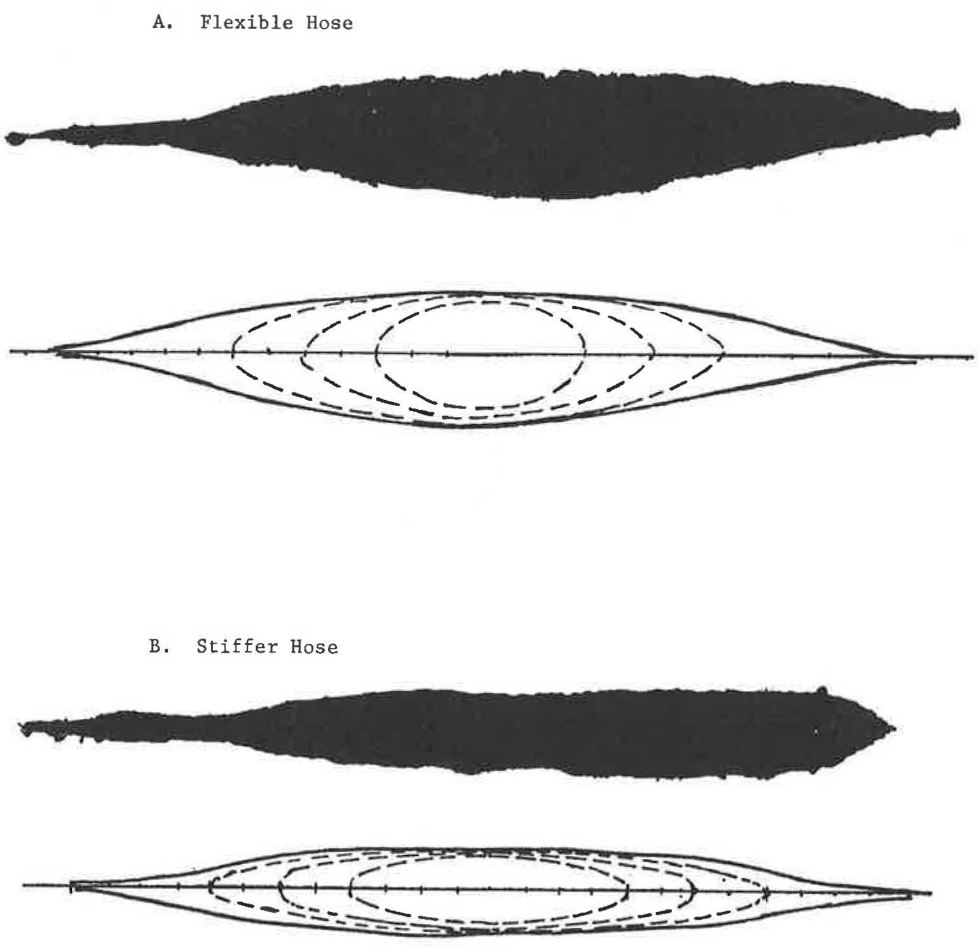


FIGURE 4 Contact imprints of the rubber hoses with asphalt beam sample at 100-lb load and 100-psi pressure.

TABLE 1 RUT DEPTHS USING FLEXIBLE AND STIFFER HOSES

	Flexible Hose		Stiffer Hose	
Number of Cycles	Test 1 (in.)	Test 2 (in.)	Test 3 (in.)	Test 4 (in.)
500	0.106	0.087	0.080	0.086
1,000	0.126	0.106	0.103	0.101
8,000	0.189	0.210	0.177	0.193

sample volume was calculated and batched. The heated aggregate sample was mixed with the predetermined amount of asphaltic cement, and the mix was placed in the heated beam mold. The 3- × 1-in. loading foot of the kneading compactor was activated to compress the asphalt mix placed in the mold. The asphalt mix was compacted in three lifts. After the third batch of the mix was in the mold and was compacted to approximately the required height, a heated 3- × 15-in.-thick plate was placed on top of the beam and high pressure was applied to compress the mix in the mold to the final required height, flush with the 3-in.-high mold. After the beam sample was allowed to cool, it was removed from the mold. The bulk density was determined

A simplified procedure to fabricate the beam samples by static compression using a universal testing machine was successfully developed (*6*). The potential advantages of using a static compression procedure are a simpler and shorter procedure and more readily available equipment. Because only about 50,000 lb of static compressive load are needed for fabricating 3- × 3- × 15-in. beam samples and most testing laboratories are equipped with a universal testing machine with a larger capacity (usually 100,000 to 200,000 lb), larger AC beam samples can be made. The static compression procedure is presently being used by GaDOT for fabricating asphalt beam samples for the rutting tests.

In the course of this investigation, some mixes (e.g., the base mix described in the next section) used a maximum aggregate size of 1½ in. This size appeared to be too large in relation to the beam size. For aggregate of this size, a large-beam cross section would be preferred.

RUTTING TEST PROCEDURE AND RESULTS

The rutting tests were conducted at temperatures ranging from 95°F to 105°F. In the previous studies (*1–3*), the testing machine was placed in an environmental room with the temperature controlled to the prescribed testing temperature. To make the testing machine more portable, an environmental chamber attached to the testing machine and a sample-preheating box were designed and constructed (*6*). The beam samples could be preconditioned in the preheating box for about 6 hr and then transferred to the testing machine for testing.

The following procedures were used for the rutting test. The preheated beam sample was placed in the sample-holding device. The initial sample surface elevation was measured using the rutting-profile measuring device (see Figure 5). Then the rubber hose was placed on top of the beam sample and the ends of the hose were loosely clamped down. The hose was pressurized to the preset pressure level of up to 100 psi. The loading assembly, including the aluminum wheel, was lowered so that the wheel rested on the rubber hose; appropriate weights were placed in the weight-holding box. The environmental chamber lid was then closed, and the testing machine was turned on. The reciprocating action of the machine caused the loaded aluminum wheel to move back and forth along the rubber hose, generating repeated loading on the beam sample. When the repeated loading reached the pre-

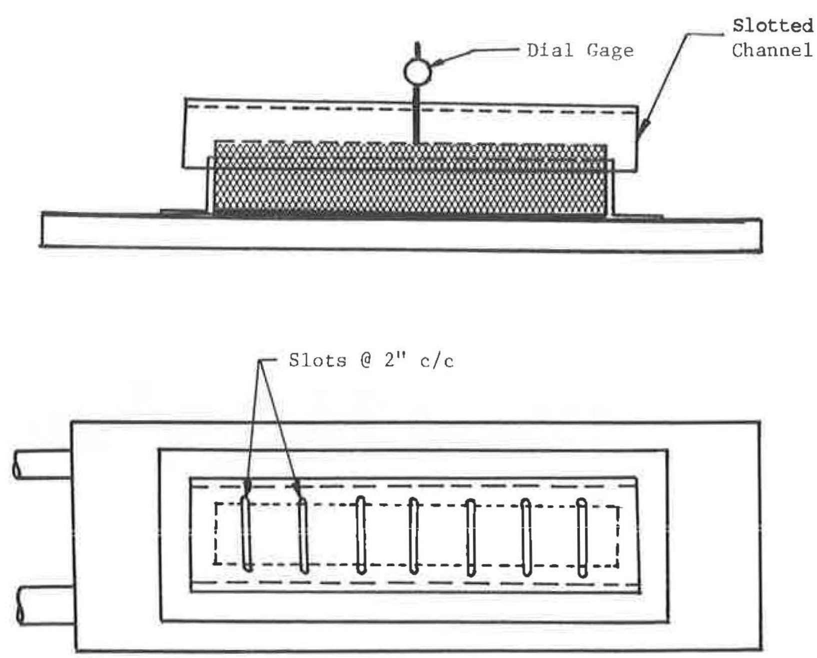


FIGURE 5 Rutting-profile measuring device.

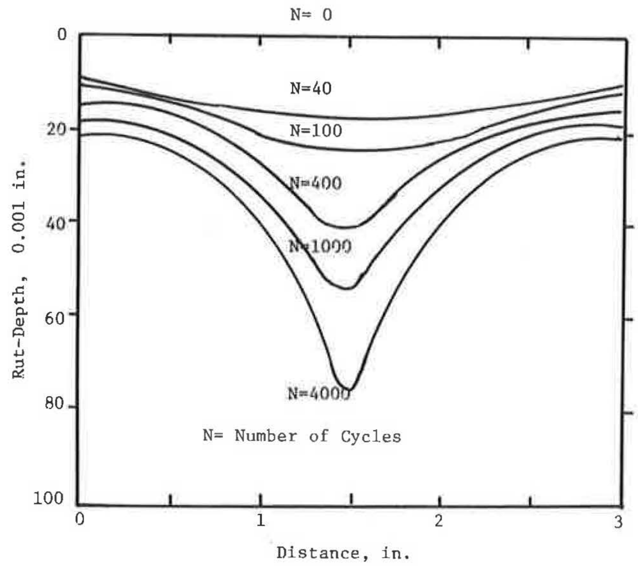


FIGURE 6 Typical transverse rutting profiles.

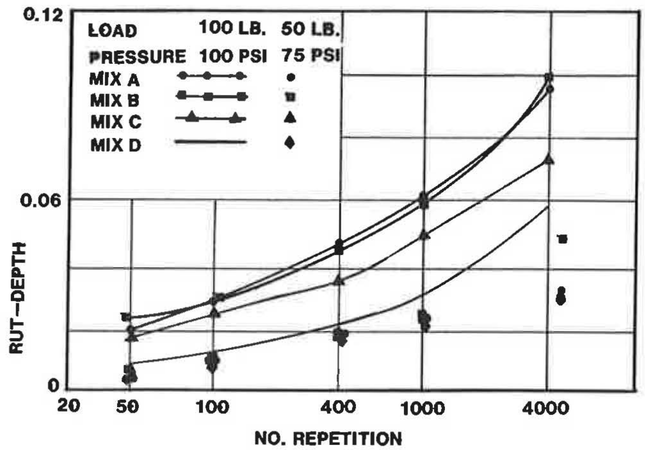


FIGURE 7 Loaded-wheel test results, rut depth versus load application.

scribed number of repetitions, the machine was stopped, the environmental chamber lid was lifted, the weights were removed, the loading wheel was propped up, and the rubber hose was removed. The rut depths on the beam sample at three reference locations along the wheel path (directly underneath the rubber hose) were measured. If it was necessary to continue the test, the rubber hose was put back on top of the beam sample, the wheel was lowered, and the weights were put back in the weight-holding box. The chamber cover was lowered, and the machine was restarted.

In the initial investigation (*1*), transverse rutting profiles were taken at seven reference positions (*A* to *G*) along the centerline of the beam samples. Figure 6 shows the typical transverse rutting profiles at different cycle numbers, and Figure 3 shows the typical longitudinal centerline rutting profile. The longitudinal profiles show uneven rutting, with the heaviest rut developed at the rear end of the beam (closest to the pivot of the reciprocal arm). Excessive rutting at the end regions does not represent the normal rutting characteristics of the asphalt mix under repeated moving wheel loads. Rutting at the middle region (Reference Positions *C*, *D*, and *E* in Figure 6) was usually quite uniform. On the basis of these findings, the results of subsequent rutting tests were represented by the averaged value of the rut depths measured at these three positions, provided that the three readings were consistent.

In the initial investigation (*1*), four types of asphalt mixes were selected. These mixes had been used by GaDOT in four separate paving projects, and the pavements had shown varying degrees of rutting. In order to determine the best combinations of pressure and wheel-load magnitude, which would yield the most usable test results, two levels of pressure (75 and 100 psi) and three levels of loading (50, 75, and 100 lb) were used. The combination of 100-lb load and 100-psi pressure produced significant differences in rutting among the four mixes (see Figure 7); at 50-lb wheel load and 75-psi pressure, however, the effects of mix types on rutting became almost indistinguishable.

EFFECT OF AGGREGATE GRADATION ON RUTTING OF ASPHALT MIXES

Segregation of AC paving mixtures has been an annoying problem in asphalt paving construction. These problems have become more noticeable since the advent of drum-mix plants with large-capacity storage silos. Other factors, such as placement procedures and coarse-mixture gradations, also affect the degree of segregation. One method of minimizing segregation is to reduce the largest size of aggregate particles normally used in a particular mixture. Although this approach may minimize the segregation problem, changing the size of coarse aggregate used could affect the properties of the asphalt mixes produced. Among the asphalt mix properties that could be affected by the change and have significant effect on the performance of asphalt pavements is the rutting resistance.

GaDOT initiated a research project to evaluate the effects that varying the maximum nominal-aggregate size and the fine-aggregate portion of asphalt mix gradations have on the rutting resistance of the asphalt mixes. Three aggregate sources commonly used for asphalt mixes in the Atlanta area were selected. Five different gradations, including the standard gradation for the Type B binder course, base course, Coarse B mix, and two modified gradations for each aggregate source, were prepared. The gradations were identified as follows:

Type	*Designation*	*Maximum Aggregate Size (in.)*	*Percent Passing No. 8 Sieve*
Standard Type B	B	1	38
Base mix	BA	1½	35
Coarse B mix	CB	1	33
Modified X mix	X	¾	30
Modified XX mix	XX	¾	38

All the mixes had 1 percent lime as a part of the filler. The coarse aggregate used in this study was 100 percent crushed. The fine aggregate used in all mixes was also 100 percent crushed, and no natural sand was used.

Marshall mix design (using 50 blows per side) was followed for the 15 mixes. Results of the Marshall mix design are presented in Table 2. The asphalt contents used for preparing the beam samples for each mix were based on the Marshall mix design results at about 4.5 percent air voids. The actual air voids content in the corresponding Marshall mixes for the 15 mixes varied between 4.5 and 4.7 percent.

On the basis of unit weights and the asphalt content at 4.5 percent air voids (determined from the Marshall mix design), three 3- × 3- × 15-in. beam samples were prepared for each mix. Following the procedure described in the previous section, rutting tests using the LWT machine were performed. The following test conditions were used:

Temperature	105°F
Load	100 lb
Hose pressure	100 psi
Frequency	44 cycles/min

During the test, rutting profiles of the beam samples along the wheel path were measured initially, at 200, 500, and 1,000 cycles, and at every 1,000-cycle increment up to 8,000 cycles. Figure 8 shows the results of rut-depth growth versus number of load repetitions for the five gradations. The rut depths developed at 2,000- and 8,000-load repetitions for all the mixes are presented in Table 2. Additional test results and analyses of the results were described by Lai (*3*). Some of the more significant results from this study are presented in the following section.

COMPARISON OF MODIFIED X AND MODIFIED XX MIXES

Both the modified X and modified XX mixes have ¾-in. maximum aggregate size, which is smaller than the top aggregate size of the three other mixes (B, BA, and CB) commonly used for a binder course. The difference between the X mixes and the XX mixes is the percentage of fines. The X mixes have 30 percent passing No. 8 sieve; the XX mixes have 38 percent passing No. 8 sieve. These two percentages represent the extremes of the fines among the five mixes. The amount of fines between X and XX mixes has a significant effect on the rutting resistance of the mix. Table 3 presents the results of the rut depths measured at $N = 8{,}000$ cycles for these two mixes among the three aggregate sources.

These results clearly indicate that the X mixes, which contain 30 percent fines, can resist rutting much better than the XX mixes, which contain 38 percent fines. The results are consistent with what would normally be expected for asphalt mixes containing aggregates with a top size of ¾ in.

When the Marshall stability and flow values of the mixes are analyzed, as presented in Table 3, a different picture emerges. The stability values of the XX mixes are consistently higher than those of the X mixes. The flow values of these mixes are not significantly different. A comparison of the rut depth and the Marshall stability value of the five mixes from the same aggregate source (Figure 9) shows the advantage of using the LWT method to assess the rutting potential of asphalt mixes.

COMPARISON OF DIFFERENT AGGREGATE SOURCES

The purpose of this analysis was to determine whether aggregates from different sources affect the rutting characteristics

TABLE 2 MARSHALL MIX DESIGN AND RUTTING TEST RESULTS FOR DIFFERENT ASPHALT MIXES

Agg. Source & Mix Type	Marshall Mix Design Results					Rutting Test Results	
	Stab.	Flow	Air Voids	Unit Wt.	Opt. AC	Rut-Depth, in.	
	lbs.	0.01"	%	pcf	%	N=2000	N=8000
D-BA	2140	11.6	4.6	156.5	4.5	0.118	0.182
D-B	2130	10.0	4.5	153.0	4.7	0.133	0.229
D-CB	1880	10.7	4.5	155.2	4.8	0.152	0.222
D-X	1810	12.2	4.5	153.5	5.2	0.138	0.218
D-XX	2120	11.0	4.3	155.4	5.1	0.147	0.294
K-BA	3000	10.2	4.7	153.4	4.8	0.100	0.184
K-B	3170	12.7	4.6	153.3	5.0	0.127	0.208
K-CB	2810	11.0	4.6	153.0	4.9	0.136	0.193
K-X	2880	11.6	4.6	152.5	5.3	0.097	0.163
K-XX	3010	11.8	4.6	152.3	5.3	0.128	0.217
L-BA	2970	10.8	4.6	145.9	4.8	0.124	0.218
L-B	2930	10.4	4.6	144.6	5.3	0.113	0.184
L-CB	2740	12.0	4.6	145.2	5.1	0.139	0.211
L-X	2580	10.0	4.5	144.5	5.5	0.109	0.162
L-XX	2710	9.6	4.6	144.2	5.3	0.137	0.220

Aggregate Sources: D=Dalton, GA
K=Kennesaw, GA
L=Lithia Springs, GA

TABLE 3 COMPARISON OF X MIX AND XX MIX PROPERTIES BY AGGREGATE SOURCE

	Mix X	Mix XX	Difference
Top aggregate size (in.)	¾	¾	–
Percent passing No. 8 sieve (%)	30	38	–
Rut depth at N = 8,000 (0.001 in.)			
D	218	290	76
K	163	217	54
L	162	220	58
AC content (%)			
D	5.2	5.1	–
K	5.3	5.3	–
L	5.5	5.3	–
Stability (lb)			
D	1,810	2,120	–
K	2,280	3,010	–
L	2,580	2,710	–
Flow (0.01 in.)			
D	12.2	11	–
K	11	11.8	–
L	10	9.6	–

NOTE: D (Dalton Springs), K (Kennesaw), and L (Lithia Springs) are aggregate sources.

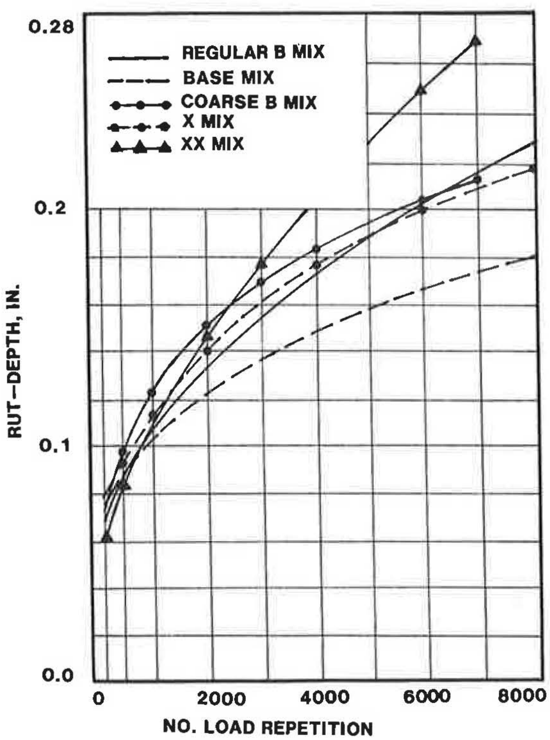


FIGURE 8 Rut depth versus number of load repetitions.

of asphalt mixes. Using the results presented in Table 2, the averaged rut depth values of the five mixes from the same aggregate source at N = 8,000 were calculated, as follows:

	Rut Depth at N = 8,000 (0.001 in.)	*Asphalt Content (%)*	*Marshall Stability (lb)*	*Marshall Flow (0.01 in.)*
Dalton	229	4.86	2,016	11.1
Kennesaw	193	5.06	2,974	11.3
Lithia Springs	199	5.2	2,786	10.6

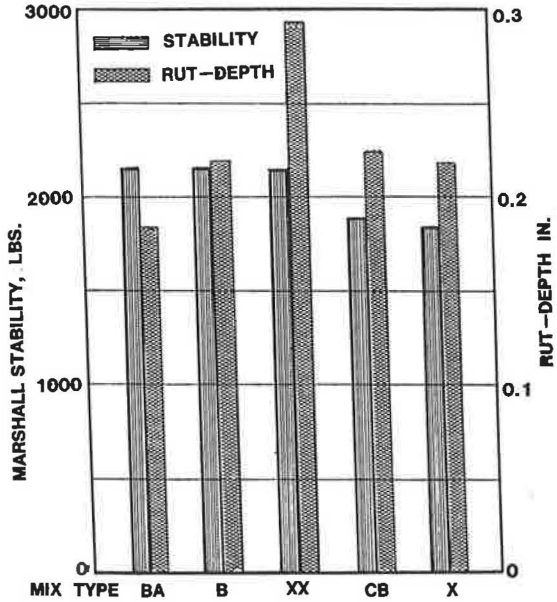


FIGURE 9 Comparison between Marshall stability value and rut depth of asphalt mixes.

The mixes using aggregates from Dalton showed significantly greater rutting than the mixes using the other two aggregates. The average rutting between mixes using aggregates from Kennesaw and mixes using aggregates from Lithia Springs was not significantly different. The averaged Marshall stability of the mixes using Dalton aggregate was lower than that of the mixes using the other two types of aggregates. These effects can be explained by the particle shape and the surface texture of the aggregates. The aggregate from Dalton is limestone type, and the particles of the coarse aggregates are more elongated and flaky, whereas the aggregates from Kennesaw and Lithia Springs are granite, the particles are more cubical, and the surface textures are rougher than the limestone from Dalton.

CONCLUSION

The modified LWT machine described in this paper has been used in several studies to evaluate the rutting resistance of asphalt mixes. The studies have shown that the LWT machine is relatively simple to operate in a laboratory environment and that the test can be used to assess the rutting characteristics of asphalt mixes.

ACKNOWLEDGMENT

This work was performed for GaDOT in cooperation with the U.S. Department of Transportation, FHWA, Office of Materials and Research.

REFERENCES

1. J. S. Lai. *Development of a Simplified Test Method to Predict Rutting Characteristics of Asphalt Mixes*. Research Project 8502,

Final Report, Georgia Department of Transportation, Atlanta, 1986.
2. J. S. Lai. *Evaluation of Rutting Characteristics of Asphalt Mixes Using Loaded-Wheel Tester.* Research Project 8609, Final Report, Georgia Department of Transportation, Atlanta, 1986.
3. J. S. Lai. *Evaluation of the Effect of Gradation of Aggregate on Rutting Characteristics of Asphalt Mixes.* Research Project 8706, Final Report, Georgia Department of Transportation, Atlanta, 1988.
4. M. Livneh and J. Greenstein. Influence of Aggregate Shape on Engineering Properties of Asphaltic Paving Mixtures. *Highway Research Record 404*, HRB, National Research Council, Washington, D.C., 1972, pp. 42–56.
5. J. Uzan. An Evaluation Scheme for Conventional Requirements of Design and Construction Quality for Asphalt Concrete. *Proc., Association of Asphalt Paving Technologists*, Vol. 51, 1982, pp. 129–148.
6. J. S. Lai. *Development of a Laboratory Rutting Resistance Testing Method for Asphalt Mixes.* Research Project 8717, Final Report, Georgia Department of Transportation, Atlanta, 1989.

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Department of Transportation of Georgia or the FHWA. This report does not constitute a standard, specification, or regulation.

Publication of this paper sponsored by Committee on Characteristics of Bituminous Paving Mixtures To Meet Structural Requirements.