# Comparative Evaluation of Laboratory Compaction Devices Based on Their Ability to Produce Mixtures with Engineering Properties Similar to Those Produced in the Field

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**A major objective of the Asphalt Aggregate Mixture Analysis System (AAMAS), sponsored by the National Cooperative Highway Research Program (NCHRP), is to ensure that laboratory-molded mixtures will be fabricated in a manner that will adequately simulate field conditions and, consequently, yield reliable engineering properties. This paper describes a field and laboratory study that evaluates the ability of five compaction devices to simulate field compaction. The compaction devices evaluated were selected on the basis of their availability, uniqueness in mechanical manipulation of the mixture, and potential for use by agencies responsible for asphalt mixture design. The devices evaluated are (a) the mobile steel wheel simulator, (b) the Texas gyratory compactor, (c) the California kneading compactor, (d) the Marshall impact hammer, and (e) the Arizona vibratory-kneading compactor. The ability of the five laboratory compaction devices to simulate field compaction is based on the similarity between engineering properties (resilient moduli, indirect tensile strengths and strains at failure, and tensile creep data) of laboratory-compacted samples and field cores. Five projects were selected for this study. Project locations were in Texas, Virginia, Wyoming, Colorado, and Michigan. The field compaction procedure used at the sites was the standard procedure used by the state highway departments responsible for the highways involved. Overall, the Texas gyratory compactor demonstrated the ability to produce mixtures with engineering properties nearest those determined from field cores. The California kneading compactor and the mobile steel wheel simulator ranked second and third, respectively, but with very little difference between the two. The Arizona vibratory-kneading compactor and the Marshall impact hammer ranked as least effective in terms of their ability to produce mixtures with engineering properties similar to those from field cores.**

The National Cooperative Highway Research Program (NCHRP) is sponsoring the development of an asphalt aggregate mixture analysis system (AAMAS) for the laboratory evaluation of asphaltic mixtures. A major objective of the study is to ensure that laboratory mixtures will be fabricated in a manner that adequately simulates field compaction and, consequently, will yield reliable engineering properties.

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Brent Rauhut Engineers, Inc. (BRE), is the prime contractor of the AAMAS project. Under this research program, BRE and their subcontractors are developing a design system based on performance-related criteria that will account for a wide range of distress mechanisms (e.g., fatigue cracking, thermal cracking, permanent deformation, moisture damage, age hardening). The evaluation system will also set standards for preparing, conditioning, and testing the test specimens and will specify criteria for mixture selection.

The Texas Transportation Institute (TTI), under the direction of BRE, was responsible for the implementation of an experimental program to evaluate the elements of laboratory sample preparation necessary to duplicate field conditions closely enough to yield realistic engineering properties of the asphalt concrete mixtures.

The specific objective of the research conducted by TTI was to evaluate a variety of laboratory compaction methods that are widely used and/or have the potential to mimic field compaction. The study was to select the compaction technique best able to achieve material and engineering properties (percent air voids, aggregate particle orientation, strength, stiffness, etc.) similar to those of the material placed in the field using standard compaction practices. Other factors whose effects were contemplated were compaction temperature, size of compaction mold, and maximum aggregate size (*1*). The compaction techniques selected for study and comparison were gyratory shear, kneading, impact, rolling wheel, and static load.

Field sites were selected by research team members for the study. Sites were selected so that a wide range of aggregate sizes and gradations would be represented, yet the ability and probability of maintaining close control of field variables were also a requirement.

Five compaction devices were selected for the study:

1. Texas gyratory shear compactor,
2. California kneading compactor,
3. Marshall impact compactor,
4. mobile steel wheel simulator, and
5. Arizona vibratory-kneading compactor.

These devices were selected because of the unique compaction techniques produced by each of them (e.g., gyratory action, kneading action, impact, simulated rolling wheel, and vibratory-kneading action, respectively (*2–8*).

One other compaction device was initially considered in this study, the Waterways Experiment Station (WES) gyratory compactor. The WES gyratory (*3*) was not made available for this study; however, it is the intent of AAMAS to evaluate this device as part of an extended program.

## RESEARCH APPROACH

The first step in the evaluation was to collect field cores and samples of asphalt, aggregate, and loose mix from the drum plants and to transport them in sealed containers from the field projects selected for this study to the laboratory. Specimens were manufactured by reheating the loose mix in the laboratory oven and then compacted at or near the same average air-void content that was produced in the field using a traditionally used field compaction method.

Compaction curves (compaction energy versus air void content) were developed for each material and for each compaction device in order to select the energy required for each device to produce the target air void content established by the field cores. Once laboratory samples were fabricated with each compaction device at the target air void content for each site, triplicate field cores and laboratory-prepared samples were tested for indirect tensile strength, indirect tensile creep, and diametral resilient modulus. Indirect tensile and resilient modulus testing was performed at 41°F, 77°F, and 104°F; creep compliance testing in the diametral mode was performed only at 77°F.

The laboratory compaction methods were prioritized on the basis of their ability to produce samples with engineering responses in close agreement with those measured from field cores.

The full-scale test matrix consisted of five field projects that will be discussed subsequently, five compaction devices, three test temperatures (41°F, 77°F, and 104°F, except for creep testing, which was performed only at 77°F), and three replicates per test cell. The mean and variance of the laboratory specimens compacted with the different devices were computed and compared with field core statistics to determine whether or not a significant difference existed between the field cores and the laboratory-fabricated samples for each engineering property.

All mixtures were prepared at Texas A&M University's Texas Transportation Institute. Indirect tensile testing and indirect tensile creep testing were performed at Texas A&M. Resilient modulus testing was performed at Texas A&M and the University of Texas at Austin.

### Selection of Field Projects

Field sites were selected partially on the basis of their potential for permitting the exercise of control over the variables influencing compaction (*1*). In other words, the first selection criterion was that the project must meet certain minimum standards ensuring that the variability of the following factors could be adequately controlled: compaction process, aggregate consistency and gradation consistency, base placement temperature, mixture placement temperature, consistency of the mixing plant, and air void content. Other variables that were considered in project selection included asphalt type and grade, aggregate size and type, and mix plant type.

Five field projects were selected. Each project possessed unique characteristics, which are discussed next.

#### *Colorado*

The site selected was a section of a two-lane rural highway, designated as State Route 9. The goal of this project was to extend pavement life by means of an overlay. The process began with a leveling course averaging 1.5 in. in thickness. On top of the leveling course, a nonwoven geotextile (Trevira) was placed. This was followed by the placement of two lifts, each 1.5 in. thick, of a dense-graded surface course mix. The surface course layer was evaluated in this study.

#### *Michigan*

This project was an overlay for a rural two-lane highway designated as State Route M21. To assure that cores were at least 1.5 in. high, the state and the contractor agreed to increase the mat thickness in the area of the test sections to 1.75 in.

#### *Texas*

The Texas project was located on Highway 21. This was a major reconstruction project converting an existing two-lane roadway into a four-lane divided highway. The thickness of the asphalt concrete lifts varies transversely across the roadway from 2 to 3 in.

#### *Virginia*

This was a reconstruction project of a two-lane highway designated as State Highway 621. It consisted of placing 4 in. of an asphalt concrete base on top of an untreated aggregate base course. An asphalt concrete binder and surface course were to be placed on top of the asphalt concrete base mix.

#### *Wyoming*

This project consisted of the overlay of a four-lane divided interstate highway, designated as IH-80, with a recycled mixture. Four inches of existing asphalt concrete pavement in the driving lane in each direction was removed by cold planing. This material was recycled back into the asphalt concrete mix in a combination of 40 percent reclaimed material and 60 percent new aggregate.

More detailed characteristics of these projects are depicted in Tables 1 and 2. These tables refer to the aggregate blends and asphalt types. Several other considerations should be noted: all mixtures were fabricated in drum mix plants and placed at temperatures ranging from 275°F to 310°F. The compaction trains used in the field projects included (a) vibratory rolling

TABLE 1 SUMMARY OF AGGREGATE BLENDS USED IN FIELD PROJECTS

| Aggregate Blend | Colorado | | Texas | | Michigan | | Virginia | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|
| Coarse | Pit run gravel | 30% | 3/4" crushed limestone | 35% | Pit run gravel | 39% | Trap rock #56 | 60% | RAP - | 40% |
| | | | | | | | | | Coarse gravel | 40% |
| | | | 3/8" crushed limestone | 33% | | | Trap rock #8 | 5% | | |
| Fine | Pit run | 70% | Limestone screenings | 15.1% | Concrete sand | 25% | Crushed fines #10 | 20% | Fine gravel | 20% |
| | | | Field sand | 16.9% | Blend sand | 16% | Natural sand | 15% | | |
| | | | | | 3CS sand | 20% | | | | |

TABLE 2 TYPE AND PERCENTAGE OF ASPHALT AND ADDITIVES USED AT JOB SITE

| Material | Colorado | | Michigan | | Texas | | Virginia | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|
| Asphalt | Sinclair AC-10 | 5.5% | Marathon (85-100) | 5.6% | Exxon AC-20 | 5.5% | Chevron AC-20 | 4.5% | Sinclair AC-20 | 2.75% |
| Additive | Pave bond | 0.4% | ----- | | ----- | | ACRA 1000 | 0.6% | Hydrated Lime | 1.00% |

for breakdown compaction followed by static rolling for finish compaction, (b) static rolling for breakdown compaction followed by pneumatic rolling for intermediate compaction and static rolling for finish compaction, and (c) pneumatic rolling for breakdown compaction followed by static rolling for finish compaction. All projects were constructed during the summer of 1988 so that the base placement temperature varied only from 90°F to 120°F.

### Material Handling and Specimen Preparation

The sampling of asphalt concrete mixtures for laboratory specimen preparation was performed in such a way as to ensure random selection of trucks and to prevent segregation of mixtures. Properly sealed containers were used to transport mixtures, and great care was taken to provide full mixture documentation and temperature histories.

The sampling of asphalt concrete cores from the roadway was performed in accordance with the following sequence:

1. Drill cores from pavement test section,
2. Allow cores to cool and dry,
3. Identify cores by test section and subset, and
4. Wrap cores with clear tape (for protection during transportation) and place them in bags with "zipper" tops (impermeable to air and water).

Figure 1 depicts the flowchart of the compaction study developed by BRE and implemented by TTI for specimen preparation.

Approximately 25 field cores were drilled from each project the day after rolling compaction. These cores were then collected and stored in the laboratory for testing. Nine of the 25 cores were tested for resilient modulus (three replicates), indirect tensile stress and strain at failure (three replicates), and indirect tensile creep (three replicates). Because material properties of these field cores were determined on sets of three replicate samples, it was necessary to arrange field cores in sets in a manner that would minimize the variance of air void content within a set, yet avoid any statistical difference between the mean of air voids in any set and the mean of air voids in the overall project. Laboratory-compacted samples were prepared at a void content approximately equal to the mean void content of all field cores from a selected project.

Table 3 presents air void content summaries for all field projects. The field section selected was that which used a compaction procedure prescribed by the state agency in which the project was located. The program for preparation and compaction of laboratory specimens was as follows:

1. Reheat the loose mix to the same compaction temperature as was used in the field, and
2. Determine compactive effort (*7,9,10*), by trial and error, for each compaction device required to produce the mean air void content derived from field cores for the project in question.

Table 4 presents a summary of the compactive efforts required for each compaction device and for each project to equal the mean air void content of field cores.

### Compaction Devices Used in the Study

#### *Marshall Hammer*

The Mechanical Marshall Hammer was used to prepare laboratory samples to simulate an impact-type compaction. All specimens were compacted in accordance with the procedure presented in "Resistance to Plastic Flow to Bituminous Mixtures Using the Marshall Apparatus" (AASHTO T245-82)

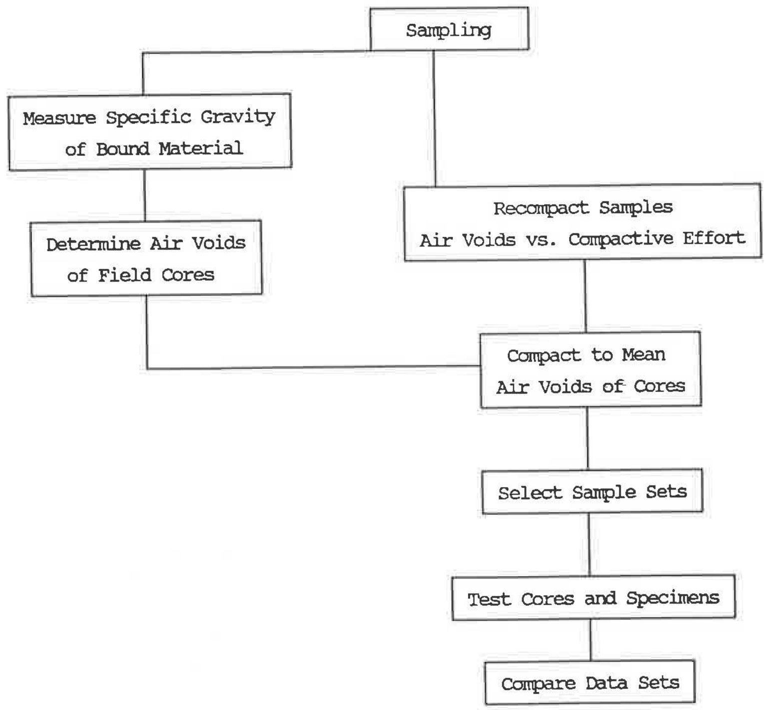


**FIGURE 1 Flowchart of compaction study.**

TABLE 3 SUMMARY OF AIR VOID INFORMATION FROM FIELD CORES

| Project | Statistical Data | Section (Compaction Train) | | |
|---|---|---|---|---|
| | | VB/SS | SP/SS | PB/SS |
| Colorado | Mean | 8.19 | | |
| | Standard Deviation | 0.936 | | |
| Michigan | Mean | | | 4.21 |
| | Standard Deviation | | | 0.63 |
| Texas | Mean | | 8.75 | |
| | Standard Deviation | | 0.966 | |
| Virginia | Mean | 5.85 | | |
| | Standard Deviation | 1.193 | | |
| Wyoming | Mean | 5.77 | | |
| | Standard Deviation | 0.688 | | |

Note: VB/SS = Vibratory roller for breakdown compaction followed by a static steel wheel roller for finish compaction.
SP/SS = Static roller for breakdown compaction followed by a pneumatic roller for intermediate compaction and a static steel wheel roller for finish compaction.
PB/SS = Pneumatic-rubber tired roller followed by a static steel wheel roller.

TABLE 4 SUMMARY OF COMPACTIVE EFFORTS REQUIRED TO COMPACT LABORATORY SAMPLES USING DIFFERENT COMPACTION DEVICES TO SIMULATE AIR VOIDS IN FIELD CORES

| | |
|---|---|
| 1. Marshall Hammer | (Blows per Face) |
| Colorado | 20 |
| Michigan | 23 |
| Texas | 18 |
| Virginia | 47 |
| Wyoming | 39 |
| 2. California Kneading Compactor | (Number of Tamps and Tamping Pressure) (psi) |
| Colorado | 20 (250) |
| Michigan | 25 (500) |
| Texas | 20 (250) |
| Virginia | 50 (500) |
| Wyoming | 20 (250) |
| 3. Texas Gyratory | (Gyration Pressure, Number of Gyrations and End Pressure - psi) |
| Colorado | 25-3-250 |
| Michigan | 50-3-500 |
| Texas | 25-3-0 |
| Virginia | 100-3-2500 |
| Wyoming | 50-3-250 |
| 4. Mobile Steel Wheel Simulator | (Number of Cycles or Coverages) |
| Colorado | 28 |
| Michigan | 16 |
| Texas | 15 |
| Virginia | 175 |
| Wyoming | 38 |

with the exception of mixing temperature and varying the number of blows. To produce laboratory specimens with varying air voids, the number of blows was varied from 10 to 100 on both faces of the asphalt concrete mix.

*California Kneading*

The Cox and Sons Kneading Compactor was used to simulate a kneading-type compaction in this study. All specimens were compacted in accordance with "Preparation of Test Specimens of Bituminous Mixtures by Means of California Kneading Compactor" (AASHTO T247-80) except that the "leveling off" load was not used. Kneading compaction methods apply forces to a portion of a free face of an otherwise confined asphalt concrete mix. Compacted forces are applied uniformly around the free face. The partial free face allows particles to move relative to each other, creating a kneading action that densifies the mix. For each of the asphalt concrete mixtures, the number of tamps was varied to compact a laboratory specimen at the same air void level measured on the field cores.

*Arizona Compactor*

The Arizona vibratory-kneading compactor was developed to densify laboratory asphaltic concrete specimens using low contact pressures. The diameter of the specimens compacted in Arizona has been varied from 2 in. to 17.5 in. Compaction is effected through the use of rapid impact loadings on a specimen that is rotating about an axis that is tilted to the direction of the load. The standard compactive effort was achieved with the following conditions:

1. Load frequency = 1,200 cpm,
2. Load due to eccentrics = 390 lb,
3. Tilt to load = 1 degree,
4. Duration of kneading load = 2.5 min, and
5. Duration of leveling load = 0.5 min.

Variations in compactive effort have been obtained by changing the mass of the eccentrics and the duration of kneading action. Because the exact force of compaction is not known, relative values of compactive effort are obtained as ratios of the products of force due to the rotation of the eccentrics, times the duration of the kneading action. The compaction ratios used for different specimen heights to yield the same density are obtained by varying the duration of kneading compaction time in proportion to height.

Bulk material was shipped to R. A. Jimenez at the University of Arizona for sample preparation using the Arizona compactor. Specimens were compacted to a height approximately equal to the lift thickness of each project. These specimens were labeled, properly wrapped and protected, and returned for testing.

*Texas Gyratory*

The Texas State Department of Highways Public Transportation Motorized Gyratory Shear Type Compactor was used to simulate gyratory compaction. Gyratory compaction methods apply normal forces to both top and bottom faces of the asphalt mix in a cylindrically confined mold. These normal forces are supplemented with a rocking or gyrating motion to work the mix into a denser configuration while it is totally confined. The angle of gyration for this device is fixed at 3 degrees.

All laboratory gyratory-compacted specimens were prepared in accordance with "Preparation of Test Specimens of Bituminous Mixtures by Means of Gyratory Shear Compactor" (ASTM D4013-81). The ASTM D4013 procedure had to be modified to reproduce the air void level measured from field cores. To determine the amount of compactive effort required to match an equivalent air void level of the field cores, many of the laboratory compaction variables had to be varied for each of the mixes. These variables were number of gyrations, gyration pressure, and end pressure.

Initially, the number of gyrations was to be reduced to define the compactive effort needed to simulate the air voids of the field cores. Unfortunately, three gyrations (the minimum that can be used with the Texas device) resulted in significantly lower air voids than in the field cores. Therefore, gyration and end pressures were varied for the minimum three gyrations to determine the compactive effort necessary to reproduce the average air void measured from the cores.

*Mobile Steel Wheel Simulator*

The mobile steel wheel simulator was used to simulate the rolling-type compaction of a static steel wheel. The rolling-type compaction applies a force to a portion of the free face of an otherwise confined asphalt concrete mix. Compactive forces are applied over the entire beam specimen using a curved foot to simulate the rolling pattern of a steel wheel roller. The partial free face allows the coarse aggregate to move relative to one another, allowing the particles to orient themselves in a manner similar to what occurs in the field. The specific steel wheel simulator used to compact laboratory specimens of each of the asphalt concrete mixtures was obtained from the Federal Highway Administration (FHWA) at the Turner-Fairbanks office. The piece of equipment used is relatively unsophisticated in comparison with the typical European-type compactors that simulate the rolling action of a steel wheel or rubber-tired roller.

The number of revolutions of the steel foot was varied to determine the compactive effort required to reproduce the average air void content measured from the cores.

**Testing Methods**

Once the compactive efforts were determined, a series of specimens was prepared with the same air void content ($\pm 0.5$ percent air voids) as the related field project. Sets of three samples per test, the means of which were not significantly (statistically) different from the overall mean air void content of the field cores, were prepared for testing.

Indirect tensile strength tests were performed by BRE in accordance with Test Method TEX-226-F of the Texas State Department of Highways and Public Transportation at 41°F, 77°F, and 104°F and at a loading rate of 2.0 in./min. This test was performed on mixes and field cores from three projects: Michigan, Texas, and Virginia. The repeated load indirect tensile test (resilient modulus) was performed in accordance with ASTM D4123-82 on samples from all five field projects. It was conducted by applying compressive loads of a haversine waveform (*11*). The resulting horizontal deformation of the specimen was measured and used to calculate the resilient modulus. The load applied to the specimens was determined on the basis of the indirect tensile strength (IDT) test results. Ten percent of the stress to failure in the IDT was the stress applied to the specimens to produce deformation in the elastic range without damaging the sample.

The indirect tensile creep was performed in the same way as the resilient modulus except that a static load, in lieu of a cyclic load, was continuously applied for 60 min and then removed. Deformation was measured during the loading and recovery periods (*12*). The creep test was performed on samples from all five projects.

**RESULTS**

To evaluate the average difference in means for each of the laboratory compaction devices from the field cores, an average absolute difference ($\Delta D$) for each of these properties was calculated. The absolute difference simply represents the average percent difference between the field cores and the laboratory specimens. This is mathematically represented by the following equation:

$$\Delta D = \frac{\sum_{i=1}^{n} \left( \frac{MP_c - MP_s}{MP_c} \right)}{n}$$

where

$MP_c$ = average material property measured on the field core, which becomes the target value;
$MP_s$ = average material property measured in the laboratory compact specimen; and
$n$ = number of data points for each compaction device.

Table 5 summarizes the results of this simple comparison. As shown, the Texas gyratory shear laboratory compaction device was found to simulate more closely, on the average, the engineering properties of the field cores. Less variation was noted for the indirect tensile strength and tensile strain at failure data, whereas the largest differences were found for creep compliance.

The mean squared error (MSE) was also used to compare the engineering properties of field- and laboratory-compacted specimens using the mean test value from field cores as a target value. All test results were sorted and analyzed on the basis of project, test, and temperature. Mixture properties evaluated using the SAS program included indirect tensile strength at 41°F, 77°F, and 104°F; resilient modulus at 41°F, 77°F, and 104°F; creep load strains at 77°F and 104°F for a loading time of 300 sec; and slopes of the creep curve at 77°F

TABLE 5 SUMMARY OF AVERAGE DIFFERENCES BETWEEN FIELD CORES AND LABORATORY-COMPACTED SPECIMENS

| Compaction Device | Creep Compliance at 77°F | Indirect Tensile Strength | Tensile Strain at Failure | Resilient Modulus |
|---|---|---|---|---|
| Arizona Compactor | 0.77 | 0.51 | 0.47 | 0.41 |
| Marshall Hammer | 0.80 | 0.35 | 0.45 | 0.55 |
| California Kneading | 0.59 | 0.21 | 0.27 | 0.42 |
| Steel Wheel Simulator | 0.51 | 0.31 | 0.11 | 0.26 |
| Texas Gyratory Shear Compactor | 0.44 | 0.14 | 0.16 | 0.37 |

Note: A zero difference indicates that the laboratory specimens had identical properties of the cores (no difference).

TABLE 6 MEAN SQUARED ERROR (MSE) COMPARISON OF COMPACTION DATA

| Laboratory Compaction Method | Average MSE Rankings by | | |
|---|---|---|---|
| | Project | Mixture Property | Temperature |
| Arizona Compactor | 5.0 | 4.8 | 4.7 |
| California Kneading | 2.0 | 2.0 | 2.0 |
| Marshall Hammer | 4.0 | 3.5 | 3.3 |
| Mobile Steel Wheel | 1.7 | 2.8 | 2.0 |
| Texas Gyratory | 2.0 | 1.5 | 1.3 |

and 104°F. This data analysis is summarized in Table 6 for the MSE comparison.

Although there is no single laboratory compaction method that always provided the best match with the results of the field compaction method, the Texas gyratory method was generally better than the other methods. The Texas gyratory method had the best average MSE ranking for the indirect tensile strength tests, the resilient modulus tests, and for the creep load strain at 300 sec. The Texas gyratory method also had the best average MSE ranking for the tests at 41°F and 104°F, and was second to the mobile steel wheel simulator for tests at 77°F.

The California kneading and mobile steel wheel methods generally finished second and third in the MSE rankings, with both occasionally ranking above the gyratory method. The results of the California kneading and mobile steel wheel methods are so close that it is difficult to select the "best" one in a comparison of the two methods. They virtually tied for the second-place ranking with respect to matching the test results from the field compaction method. The Marshall and Arizona methods generally finished fourth or fifth in the MSE rankings, with the Marshall hammer method ranking the higher of the two.

In addition to calculating mean squared error, each data set was evaluated to determine if two adjacent cells were significantly different or indifferent based on the mean and variation, using a confidence level of 95 percent. In all the comparisons made, the laboratory compaction methods that had the largest MSE values were those that were statistically significantly different from the results of the field compaction method. Thus, the internal structure and engineering or mechanical properties of the asphalt concrete mixture are dependent on the type of compaction device used.

For the compaction devices, three procedures were used to define which compaction device more closely simulates the engineering properties of field cores. Consistently, the Texas gyratory had the lower mean squared errors, more sample sets that were indifferent from the field cores, and a slightly lower absolute difference between the mean magnitudes. Considering these different comparisons, the following lists in descending order those compaction devices that better simulate the properties and characteristics of field cores in the laboratory.

1. Texas gyratory shear,
2. California kneading compactor,

3. Mobile steel wheel simulator,
4. Arizona vibratory-kneading compactor, and
5. Marshall mechanical hammer.

## CONCLUSIONS

The Texas gyratory compactor ranked first in terms of its ability to produce compacted mixtures with engineering properties similar to those produced in the field. Because of its operational simplicity and the potential to use the large gyratory models capable of fabricating large-size specimens, and thus accommodating large-size aggregate, the Texas gyratory seems the most prudent choice as the compaction device to be used for future preparation of specimens for mixture design and analysis.

The California kneading compactor tied for second place on the basis of its ability to replicate field conditions. The California kneading compactor is the only device capable of fabricating any size cylindrical specimen as well as rectangular beams, such as those used in beam fatigue testing. This flexibility makes the California kneading compactor an appealing choice for compaction purposes.

The mobile steel wheel simulator closely simulated field compaction based on all mixture properties. This high correlation may be partially influenced, however, by the disturbance effect involved in the core drilling operation required to obtain both field cores and specimens compacted with the steel wheel. No other laboratory compaction processes require coring. Additionally, the potential to use the mobile steel wheel simulator as a standard laboratory tool is hampered by the difficulty of using the device. The device prepares samples in the form of a 6-in. by 12-in. by 4-in. prism. To produce a standard 2.5-in. by 4-in. cylinder requires a large-core drill to core a specimen from the compacted prism. Substantial modifications to the system would be required to produce cylindrical specimens capable of being tested in compressive creep for axial or diametral resilient modulus. Two persons are typically required to perform the compaction procedure.

The Marshall hammer did the poorest job of simulating field conditions. The absence of the kneading effect during the compaction operation, which is due to the uniform impact-type load applied by the mechanical version of the Marshall hammer, is probably the major reason behind the poor correlation shown by this compaction device. A manual compactor is expected to perform somewhat better because the tamping action imparted by the operation will not always fall in the same portion of the specimen; it will thus provide for rearrangement of aggregate particles after every blow.

This comparison of laboratory and field compaction is based on samples cored from the field following compaction without traffic densification. Thus, a final analysis of the ability of laboratory compaction devices to duplicate in situ conditions must await further testing in the AAMAS program in which the same field pavement sections will be cored and the cores evaluated.

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