Transportation

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University of Kentucky

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Study of Light Compaction-Equipment for Maintenance Patching

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December 5, 1961

MEMORANDUM

TO: T. J. Hopgood  
   Director of Maintenance

FROM: W. B. Drake  
   Director of Research

SUBJECT: Study of Light Compaction Equipment

Attached is a memorandum report by R. L. Florence on the compaction equipment study that was performed in co-operation with the Maintenance Section of District 7, in Lexington. Mr. J. C. Spurrier, Principal Assistant District Engineer for Maintenance, Traffic and Equipment, made the necessary administrative arrangements for the project. The three vibratory units were supplied through manufacturer representatives, while the pneumatic roller and light static roller were owned by the Highway Department.

Figure 12 of the report further illustrates deficiencies in the present Class I, Type B surface gradation when using all natural sand for the fine aggregate. The lack of continuity in the gradation between sieves No. 8 and No. 16, and the relatively small percentages passing the No. 80 sieve are evident. This is not a mix that would normally provide high densification under the rollers. The Marshall test data, averaged from several specimens made from samples taken from the trucks, are as follows:

Stability - 978 lbs. (Avg. of 45 specimens)  
Flow - 6.5 (in 1/100") (Avg. of 45 specimens)  
Unit Wt. - 145.2 pcf (Avg. of 15 specimens)  
% Voids, Agg. Only - 19.0% (Avg. 13 specimens)  
% Voids Filled - 72.7% (Avg. 13 specimens)  
% Voids, Total Mix - 5.2% (Avg. 13 specimens)

It should be noted that 95% of Marshall density would provide approximately 10% voids in the pavement. This is a rather high void content for asphaltic concrete surface.
The Department is at present requiring a blend of 60% natural sand and 40% manufactured, Class I sand, Fine Aggregate in Class I, Type B surface in lieu of the fine aggregate used on this project. The resultant mixture is more compactable, produces higher densities, and should prove to be more durable.

Figures 10 and 11 show the compaction characteristics of the equipment used for two application rates of the Class I, Type B surface mix containing only natural sand fine aggregate. The vibratory rollers produced somewhat more erratic densities than the static rollers. It appears also that the vibratory rollers may have "broken" density in some instances where the surface course applications were quite thin.

You will note that field densities of 96.3% and 97.5% of laboratory density were obtained in the top half and bottom half respectively of the 5-in. deep patch using the Essick Vibratory roller. This might indicate, of course, that compaction or densification proceeds from bottom to top in relatively thick application of materials when vibratory equipment is used. For the thicker surface course, eight (8) coverages were required by the Littleford, Essick, Gallion, and Buffalo-Springfield pneumatic-type rollers to produce 95% or better of laboratory density. Neither of the two courses compacted by the Rosco Vibratory roller provided densities equal to 95% of laboratory density.

I am of the opinion, that the changes now in effect or contemplated for the Class I, Type B surface mix will also provide an improved mix for maintenance purposes. It may also be necessary to modify patching mixtures for specific types of patching conditions. Perhaps these modifications should include finer aggregate gradings, use of a different bitumen grade and bitumen content. Considerable research is presently under way by the Department on bituminous mix designs.

We will be pleased to work with you further in better defining any of the items discussed.

WBD:dl
Encs.
cc: A. O. Neiser
Research Committee Members
Bureau of Public Roads (3)
MEMORANDUM

TO: W. B. Drake
Director of Research

SUBJECT: Study of Light Compaction-Equipment for Maintenance Patching

Patching pot-holes and resurfacing small areas of pavement entail certain compaction-equipment difficulties for the maintenance crews. Areas in need of repair are often small but may be widely scattered. Large steel-wheeled rollers are difficult to transport from one location to another and tend to bridge across small, deep pot-holes. The bridging effect can be reduced by use of small rollers or pneumatic-tired rollers, which conform better to the area to be patched. The efficiency of a patching crew depends greatly upon its mobility. The compaction equipment, therefore, should be portable, should conform to the area to be repaired, and should produce adequate density.

At the request of the Maintenance Division, we observed the construction of a test section and evaluated the densities achieved by several small self-propelled rollers. A section of roadway (see Fig. 1) located on the University of Kentucky's Spindletop Farm was selected for the test project. This location provided a low traffic volume,
and a uniform base condition. The road was closed by a gate, and it was possible to keep traffic off the test section until all samples had been obtained.

Self-propelled, vibratory rollers were supplied by local equipment dealers. A pneumatic roller and a 4- to 6-ton steel-wheel roller were supplied by the Maintenance Division. The various rollers are shown in Figs. 2 through 6.

The paving mixture was Class I, Type B surface—consisting of approximately 60 percent limestone, 40 percent natural sand, and 5.9 percent PAC-5. The mixture was laid with a Littleford Spreader—at the full spreader-width of 8 ft. Ample room was allowed for vehicles to pass without traveling on the test section. One to two truck loads of material were laid before each roller—at 1-1/2 inches compacted thickness. After a roller had completed a specified number of coverages uniformly, it was dropped back some distance and additional coverages were made. In this way, sub-sections were easily partitioned—according to the number of coverages. Sections having a 2-inch compacted thickness were also laid for each roller. Rolling was done longitudinally and began at one edge. A 50-percent overlap was maintained for all rollers except the Essick Vibratory roller which was used with a minimum overlap. Thus, when a section was rolled with a 50-percent overlap, two coverages had been made. Of course,
the time required to compact an area varied greatly with the size and speed of the roller. Two static coverages were made by the vibratory rollers while the mixture was hot and prior to turning the vibrators on. The section compacted by the pneumatic roller received one coverage by the 4- to 6-ton Galion while the mixture was hot. This was necessary in order to prevent the hot mixture from being picked-up by the tires of the pneumatic roller.

Material was sampled from each truck-load at the plant and was taken to the laboratory in an insulated bucket. Marshall specimens were then prepared from each sample (50-blow compaction at 240°F). Three specimens were prepared from each of the 16 truck-loads of material used. Bulk densities of the specimens were then determined. The asphalt content and gradation of each sample was also determined. The location in the test section and the temperature of each load when laid was also noted.

Four-inch diameter cores were taken the two days following construction of the test strip. Four cores were taken at a point midway in each of the 35 sub-sections of the test road. Bulk densities of the cores were determined in the laboratory by weighing and measuring. The asphalt content and gradation were checked on many of the cores.
The bulk densities and the percentages of Marshall densities achieved in each sub-section are recorded in Table 1. These data are also shown graphically in Figs. 10 and 11.

A small patch, 5 inches deep, was compacted with the Essick Vibratory compactor. The average densities of the top and bottom halves of two cores taken from the patch were as follows:

Top: 139.8 lb/cu.ft. (96.3% of Marshall)

Bottom: 141.6 lb/cu.ft. (97.5% of Marshall)

The gradations of the sampled mixtures and of the cores offer some opportunity to study the degradation of aggregate due to crushing by rolling and cutting the core. Degradation appeared to be due primarily to the cutting of the aggregate during coring inasmuch as the amount of degradation did not increase in relation to the number of coverages of the roller. Average gradations of the mixtures sampled and of the cores are shown graphically in Fig. 12. The gradation of the aggregate was rather uniform throughout the project.

In relating the number of coverages of the vibratory rollers to density, it may be noted from the graphs in Fig. 10 that the pavement densities increased little after two "static" and two "vibratory" coverages; whereas in Fig. 11, the densities increase uniformly with increased coverages by the so-called "static" rollers. There, the densities seemed to increase somewhat through the tenth coverage.
The usual minimum field-density requirement for surface mixtures is 95 percent of laboratory density*. In this respect, and under the conditions of this test, no one roller or type of roller showed an appreciable advantage in achieving 95 percent of the laboratory density.

In summary, attention is directed to another recent study† in which "static" rollers were compared with "vibratory" rollers in the compaction of bituminous concrete bases and surface courses. The results from this study were reported by R. C. Deen, February, 1961. The only significant conclusion that can be drawn from the present study is that about 6 to 8 coverages of light rollers are needed in order to produce densities approaching 95 percent of laboratory density.

[Signature]  
Robert L. Florence  
Research Engineer Associate
Fig. 1. Typical Appearance of Test Section Prior to Resurfacing.
Fig. 2. Essick, Model VR-28W, Vibratory Roller, Weight 865 lbs., can be Transported by Hooking it on the Tailgate of a Truck.
Fig. 3. Littleford, Model 125-V, Vibratory Roller, Weight 1900 lbs., can be Hauled, by Truck, on a Flat-Bed Trailer.
Fig. 4. Rosco, "Vibrapac", Vibratory Roller, Weight 2400 lbs.,
can be Hauled, by a truck, on a Flat-Bed Trailer.
Fig. 5. Galion, Model P, Single Roll "Static" Roller, Weight 4 to 6 Tons, can be Towed by a Truck, with the Steel Roll Elevated.
Fig. 6. Buffalo-Springfield, Model PSR 9, Pneumatic Roller, Weight 10 Tons, can be Transported under its Own Power.
Fig. 7. Littleford Spreader. Maximum width of the lay was 8 feet. Through traffic could pass without traveling on the test strip.
Fig. 8. Pneumatic roller tire marks on the finished surface. Marks are less apparent on sections of increased coverages.
Fig. 9. Pneumatic Rolling Produced a Tighter Appearing Surface than Rolling with Steel-Wheeled Rollers.
Fig. 10. Relationship of Density to Vibratory Roller Coverage
Fig. 11. Relationship of Density to "Static" Roller Coverages. The sections compacted by the pneumatic roller received one coverage by the 4- to 6-ton Galion.
Fig. 12. Gradation Curves.
# TABLE I.
## SUMMARY OF DATA

<table>
<thead>
<tr>
<th>ROLLER</th>
<th>ROSCO VIBRATORY</th>
<th>ROSCO VIBRATORY</th>
<th>LITTLEFORD VIBRATORY</th>
<th>LITTLEFORD VIBRATORY</th>
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<td>Rolling Speed (ft/sec.)</td>
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<td>max. 2.6</td>
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<td>270</td>
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<td>1.5</td>
<td>2</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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<td>Vibratory Coverages</td>
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<td>Section Length (ft.)</td>
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<td>37</td>
<td>37</td>
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<td>Density (lb/cu.ft.)</td>
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<td>% Marshall Density</td>
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<td>90.7</td>
<td>91.8</td>
<td>91.9</td>
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**REMARKS**
Ran out of water during rolling.
<table>
<thead>
<tr>
<th>ROLLER</th>
<th>GALION</th>
<th>GALION</th>
<th>ESSICK VIBRATORY</th>
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<td>2</td>
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<td>5.9</td>
<td>6.2</td>
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<tr>
<td>Static Coverages</td>
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<td>6</td>
<td>8</td>
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<td>Section Length (ft.)</td>
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<td>50</td>
<td>52</td>
<td>52</td>
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<tr>
<td>Density (lb/cu.ft.)</td>
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<td>134.2</td>
<td>135.4</td>
<td>136.2</td>
</tr>
<tr>
<td>% Marshall Density</td>
<td>91.6</td>
<td>92.4</td>
<td>93.7</td>
<td>93.3</td>
</tr>
</tbody>
</table>

**REMARKS**
- Mix rolled while hot and tended to pick up on roller wheel. Minimum overlap.
- Minimum overlap.
\begin{table}
\centering
\begin{tabular}{|l|c|c|c|}
\hline
ROLLER & Buffalo-Springfield Pneumatic & & \\
\hline
Roller Wt. (lbs.) & 18000 & & \\
Rolling Speed (ft./sec.) & variable & & \\
Laying Temp. (°F.) & 255 & & \\
Tire Pressure (psi) & 60 & & \\
Design Thick. (in.) & 1.5 & 2 & \\
Avg. Thick. (in.) & 1.68 & 2.06 & \\
Asphalt Content (%) & 5.6 & 5.6 & 6.0 & \\
\hline
Galion Coverages & 1 & 1 & 1 & 1 & 1 & \\
Pneumatic Coverages & 2 & 4 & 6 & 8 & 10 & \\
Section Length (ft.) & 50 & 50 & 52 & 52 & 50 & \\
Density (lb/cu.ft.) & 131.1 & 136.7 & 135.8 & 138.2 & 140.3 & \\
% Marshall Density & 90.3 & 94.1 & 91.5 & 95.2 & 96.6 & \\
\hline
REMARKS & *Mix picked up on roller wheels when hot. Used Galion prior to rolling with pneumatic roller. & & \\
\end{tabular}
\caption{(Cont.)}
\end{table}