

Commonwealth of Kentucky
Department of Highways

Highway Materials Research Laboratory
132 Graham Avenue, Lexington 29, Ky.
November 29, 1951

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D.1.7

To: D. V. Terrell
Director of Research

Re: Vibratory Compaction of Base Courses

Early this month, on a field trip with Mike Logan of the Bureau of Public Roads and R. D. Medley, Asst. Director of Design, I had an opportunity to look over a project in Ohio where a vibratory method of compaction was being used in the construction of a macadam base course. This type of compaction is relatively new, it having been tried for the first time in this country about four years ago. To my knowledge, the first published report on the procedure was made in the Proceedings of the Highway Research Board, Volume 27, page 148, 1947.

This report, by Messrs. Allen and Linzell, entitled "Use of Vibration In Placing Screenings In Macadam Bases" described the two types of machines which were tried experimentally, and illustrated some of the results. One machine was a vibratory roller (assembled as a model by Buffalo Springfield) consisting of a design originated in Denmark. The roller looked very much the same as an ordinary 8-ton tandem, except that in the middle a third roll (slightly smaller than the two outer rolls) was mounted in such a way that it could be vibrated by an unbalanced shaft operating at high speed.

The other type machine was called a vibro-tamper. It consisted of a frame driven by crawlers and having mounted on it a battery of vibrating shoes. According to the report, both machines successfully accomplished the placement of screenings in the coarse aggregate to form a dense, well compacted base. For this investigation, single course construction to a depth of 8-inches as well as construction in two 4-inch courses was tried.

In the interim since 1947, there have been improvements in the design of the vibro-tamper and usually the procedure has been to advertise for a flexible pavement with either water-bound macadam base or a vibrated dry-bound macadam base, the lower bid being accepted in the same way that we do on our alternate type bidding. Apparently there have been several contractors interested, and the few jobs over a period of three years doesn't indicate a slight use, because the predominance of rigid pavements and other types of bases for bituminous pavements in Ohio would not offer very many opportunities for macadam bases placed in this manner.

At any rate, on the job which was in progress this year, only the one-course, 8-inch thick base was used throughout. This was the first single-course job with limestone aggregate (the one in 1947 being made with slag). We were there at a time when the base was practically complete, and a hot mix binder and surface was being placed on the far end of the project. We had no opportunity to ride over the finished bituminous surface, but indications were that this method of base construction could not offer much toward improving riding qualities of flexible pavements with macadam bases.

However the simplicity of operation, and the obvious ease of working screenings into the voids of the coarse aggregate are worthy of note. There is no doubt that a base properly laid in this manner is structurally sound, and the procedure may be economical, particularly if it is understood and tried by several contractors. All these things combined offer enough promise that vibratory compaction should be studied further by our Department and worked into a project for comparison. After there is more discussion on the subject we may have something definite to recommend.

In the meantime, the attached photographic report will serve as a record of our observations on the Ohio project.



L. E. Gregg
Assistant Director of Research

Copies to: Research Committee
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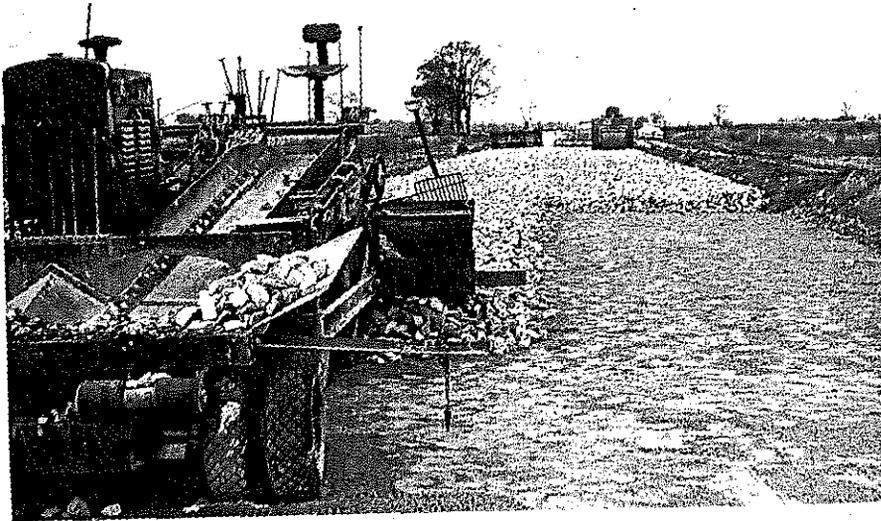


Fig. 1. A layer of screenings about 1-inch in depth was spread over the subbase, and this was rolled with the flat three-wheel roller. Following that, coarse stone (Ohio No. 12) was spread to a loose depth of approximately 11 inches by means of an Apsco Elevating Spreader shown on the left. The entire depth of loose stone was laid with a single pass in each lane.

Comparisons between Ohio No. 12 and Kentucky No. 1 and No. 2 stone are:

Sieve Size	<u>Percentage Passing For</u>		
	<u>Ohio No. 12</u>	<u>Ky. No. 1</u>	<u>Ky. No. 2</u>
4"	100	100	-
3½"	90-100	90-100	-
3"	65-85	-	100
2½"	25-60	25-60	90-100
2"	-	-	35-70
1½"	0-15	0-15	0-15

Note that there are no edge boards used in this operation.



Fig. 2. Coarse stone for the base contained an unusually high percentage of elongated pieces, as can be seen at several points in this photograph. This was not particularly detrimental in the spreading or compaction of the material, and the base was well keyed when final compaction was completed. Note the indicated depth of loose spread.



Fig. 3. Initial compaction of the loose stone was obtained with the vibratory tamper rather than the three-wheel roller. Here the tamper is shown compacting loose stone, the effect of which is shown by the contrast between compacted material behind the machine and loose material on the right.

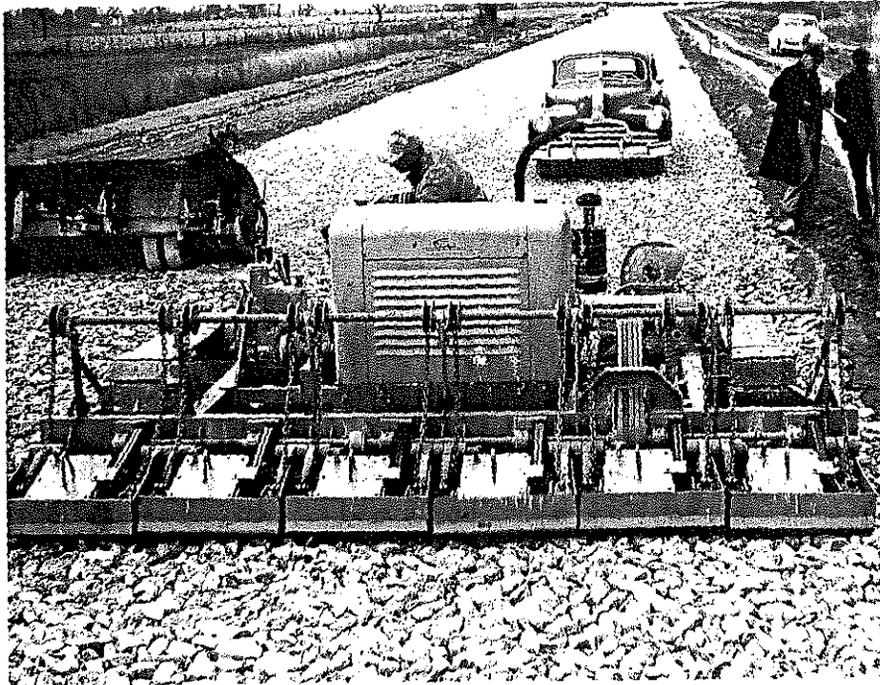


Fig. 4. The vibratory tamper consists essentially of a crawler-propelled frame upon which is mounted a battery of six vibrating shoes. All shoes receive power from a single source but they operate independently of each other. As the machine travels forward at a rate of perhaps 25 or 30 feet per minute (maximum attainable speed is probably much greater than this) the shoes are rapidly lifted and forced downward through a very slight distance on to the surface being compacted.

On the far left in this photograph is a Buckeye-type spreader box used for spreading screenings in the usual manner.



Fig. 5. Vibrator Shoes in the lifted or traveling position. Each shoe is 20 x 25 inches in size, and weighs 180 pounds. When in operation, these shoes produce 2800 vibrations per minute. This particular machine is manufactured by the International Vibration Company, Cleveland, Ohio, and at present it is the only one of this general design commercially available. However, a competitive product of similar design is supposedly due on the market in the near future. Also, of course, there is the vibrating roller having a middle roll mounted on an eccentric which in essence could be a competitive product.



Fig. 6. After the coarse stone has been placed and has received the initial compaction by the vibrator, $1/2$ of the total quantity of screenings are spread uniformly over the surface. These screenings are vibrated in with one pass of the vibrator. Following this, $1/4$ of the screenings are spread uniformly and these are vibrated in the same manner. At that point vibration is discontinued, it having been found that if the remainder of the screenings are placed by vibration, there is danger of "floating" the coarse stone in the screenings thus destroying the stability of the keyed coarse stone.

Application of the final $1/4$ of the screenings is made and these are rolled and broomed, sprinkled, and finished in the traditional manner of water-bound macadam construction.

This view shows a surface which has received the final application of screenings and some brooming and rolling, but has not been finished because of weather conditions.

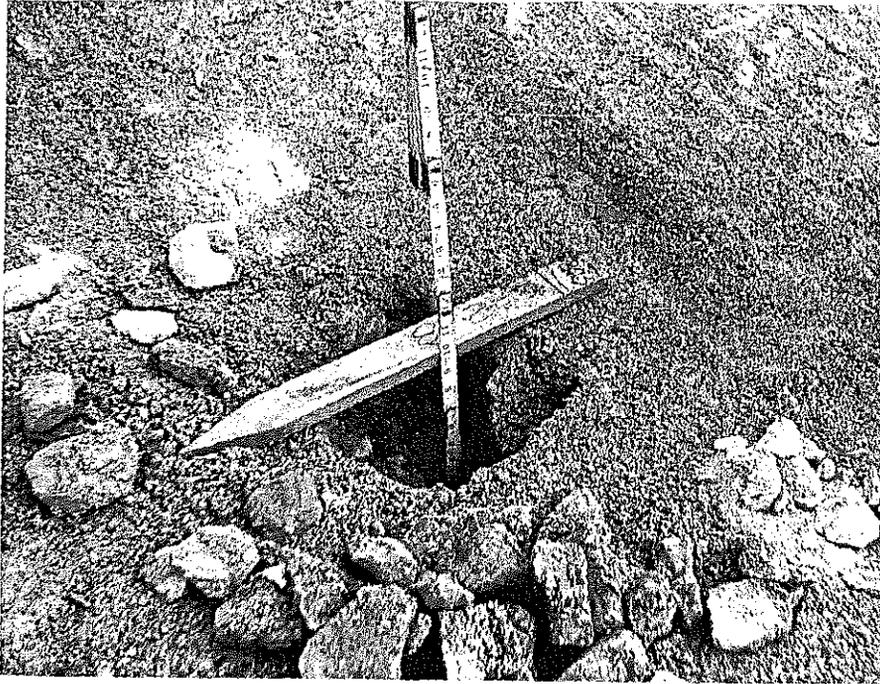


Fig. 7. Near view of a hole excavated in the finished base course. Note the distribution of screenings throughout the entire depth, and the fact that the original 11-inch depth of stone has been reduced to 8 inches in the compacted base.

Comparison between the screenings specified for Ohio WBM base course and the Kentucky No. 10 is as follows:

<u>Sieve Size</u>	<u>Ohio M-2.7</u>	<u>Ky. No. 10</u>
3/4"	-	100
1/2"	100	90-100
3/8"	90-100	-
No. 100	10-30	5-30

For this particular vibratory compaction job, 27½% of the total aggregate was screenings and 72½% coarse stone. Water-bound macadam bases are generally designed for 30 lb. of screenings with each 100 lb. of coarse stone, which on a percentage basis equals about 23% screenings and 77% coarse stone. These figures indicate, and the appearance of the excavated base shows, that more screenings can be placed in a base by vibration than by rolling and brooming even though the depth of placement is twice as great.

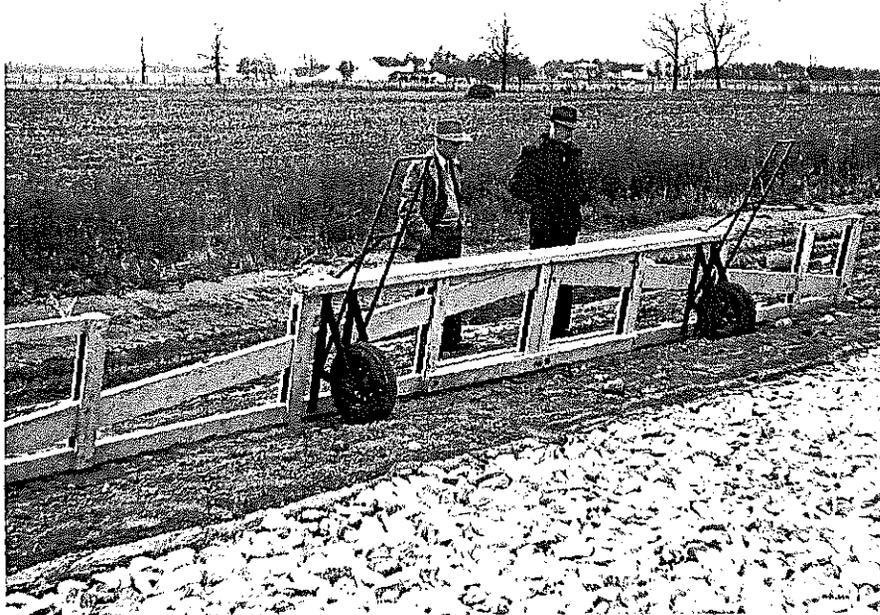


Fig. 8. Cross section template or crown board used for control of the contour of the base course - theoretically at least. The unique mounting for this template indicates that the easier it is made for handling the more it will be used. Any type of mounting, of course, does not overcome the limitation of a template which for reference elevation depends on something in the constructed base rather than something completely free of the construction process. If at the time measurements were made, the template rested on fixed objects set to grade, the evaluation of the surface contour would be absolute.