Transportation

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Field Trip to Daviess and Henderson Counties for Inspection of Gravel-Bituminous Roads

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Memo. to: Dean D. V. Terrell
Director of Research

In a letter of August 15, 1951 to you, Mr. Bray asked that the Research Laboratory make an investigation of the use of uncrushed river gravel in bituminous mixes, particularly in Henderson and Daviess counties and also particularly in road mixes. At that time you indicated that this would be undertaken as soon as the sandstone project and other investigations in progress reached the point where the bituminous section could give it attention.

Several weeks in the period from January to March this year were spent on laboratory tests of gravel-bituminous mixes by the bituminous sections of the Division of Materials and Division of Research working jointly. These tests applied wholly to the hot-mix type material rather than road mixes, the latter being left to field observations since there were no appropriate laboratory tests to measure the qualities in question. On April 26 and 29, E. G. Williams and S. T. Collier from the Research Laboratory made inspections of the roads in Henderson and Daviess counties. For information dealing with the applications of different mixes the following were consulted: the resident engineer in Owensboro; Mr. Noel Patton, Assistant District Engineer for Maintenance and Rural Highways in District 2; the maintenance supervisor in Henderson and adjoining counties; and the special maintenance foreman with a crew operating at the time in Daviess County but having previously placed most if not all the road mixes with uncrushed gravel on county roads in Henderson County.

On the basis of the observations made on the roads in these two counties, Mr. Williams has prepared the attached memorandum report. Appended at the back of his report is Table 1 giving the results of laboratory tests on samples representing different courses and different ages of the plant-mix pavement on U.S. 60, Owensboro eastward. You will recall that we inspected this pavement in company with Mr. Bray on August 23, 1949, about one year after it was constructed, and found it in very good condition. The information in Table 1 starts with samples compacted on the job at the time of construction, so these data represent an investigation which is entirely separate from the laboratory tests made in January to March of this year.
Inasmuch as Mr. Williams' report represents the coverage we have on road mixes with uncrushed gravel, it is necessary to rely heavily on the comments of those who have worked with these mixes. Obviously the bituminous surfaces cannot be held accountable for the inadequacies of traffic bound bases, and unfortunately bases of this type influenced most of the roads surfaced with mixes containing uncrushed gravel. Even on those having a base of considerable thickness, the traffic has been heavy enough to cause failures that have no connection with surface qualities.

The illustrations in the report show sections that are doing well, and also some that are in very poor condition. Those that are doing well show that reasonably good mixes can be made with uncrushed gravel aggregates, but comments from crews who have experience with the mixing, spreading, and rolling of these mixes indicate that they are difficult to handle satisfactorily unless there is a substantial addition of crushed particles. It is practically impossible to start with observations of roads already in service and produce any definite evidence of the good or bad features of the type construction used, for that reason our information in this case is generalized at best.

With regard to plant mixes, the situation is more definite in view of the samples and tests supplementing observations of pavements in service. On the other hand, it appears that laboratory test data need a different correlation for mixes containing uncrushed aggregate than for mixes with crushed materials. For example, the initial stability values listed in Table 1 are so low that this pavement should have rutted and shoved on the basis of previous interpretations of normal Class I mixes containing crushed aggregate. Obviously the pavement shows no tendency toward displacement under load, and it did not fail when it was first placed or at the time when the measured stability values were lowest. Certainly this type test alone does not represent the value of mixes with rounded aggregate.

The tests made in January to March this year, which have not yet been recorded in full by a written report (because the work is still in progress), showed that mixes with well-graded but rounded aggregate could produce stabilities which are higher than those that we get in the ordinary Class I mixes with crushed aggregates*. Some typical data representing Type B and

*See memo. report to A. O. Neiser, dated March 19, 1952, giving recommendations of the Research Laboratory on high-type plant mixes with uncrushed river gravel. Recommendations requested by Mr. Galbreath following meeting of Department officials and Mr. Galbreath with gravel producers and representatives of National Sand and Gravel Association in Frankfort on March 12, 1952.
Type C surface course mixtures with the rounded aggregate were as follows:

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Bitumen Content</th>
<th>Stability</th>
<th>Flow</th>
<th>Total with</th>
<th>Filled Mix</th>
<th>Asphalt</th>
<th>Unit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type B</td>
<td>5.8</td>
<td>534</td>
<td>15</td>
<td>3.8</td>
<td>77.0</td>
<td>143.0</td>
<td></td>
</tr>
<tr>
<td>Type C</td>
<td>5.5</td>
<td>800</td>
<td>14</td>
<td>3.7</td>
<td>78.0</td>
<td>145.8</td>
<td></td>
</tr>
</tbody>
</table>

Comparison between these data on desirable mixes that can be recommended for high type construction and the results for the pavement on U.S. 60 at the east edge of Owensboro as listed in Table 1 at the close of this report, is sufficient to show how far the U.S. 60 pavement falls below a desirable level.

However, even with all its deficiencies this pavement is holding up well, the conditions illustrated in Figs. 7 and 8 of Mr. Williams' report are not unduly severe after four years of service, and there are no recorded instances of rutting or shoving. The core taken from a widened section with full-depth bituminous construction (see Fig. 6) gives the impression of excellent quality despite the extremely low bitumen contents, high percentage of voids, and low densities measured and recorded in Table 1. Certainly the pavement has not approached disintegration as the data indicate it should have.

We have no comparable coverage of the plant mix construction on SR-54 between Philpot and Owensboro, a section of which is illustrated in Fig. 4; and also we have no specific information on SR-71 between Owensboro and Hartford. In the latter case, a large percentage of crushed gravel was used, and I believe there is no concern over the use of crushed materials.

In summary, it appears to me that it may be possible to make satisfactory road mixes with uncrushed gravel aggregate, but with the limited information we have now it appears that their use could be justified only if the cost is considerably lower than that of more reliable mixes made with other types of coarse aggregate. Under this condition we would be buying a low cost pavement recognizing its limitations when we did so. However, there should be some assurance that it would turn out low cost, for it is evident that under present conditions road mixes with crushed aggregates are preferable when costs are comparable.
D. V. Terrell

So far as plant mixes are concerned, the evidence indicates that we can make Class I pavements with uncrushed gravel that will perform satisfactorily under relatively heavy traffic, and I believe that we can through the use of the Type C surface accommodate all but the heaviest loads, or perhaps moderate loads at places such as bus stops, traffic lights, and other spots where the tendencies toward shoving are great. Even the Type B surface can be made comparable with most of the Class I mixes with other aggregates, but obviously the crushed or angular particles are preferable as a factor of safety if nothing else - when costs are approximately equal.

As a final observation, I believe it would be a mistake to use a heavier asphalt cement in uncrushed gravel mixes with the object of increasing initial stability. The small increase in stability (if any) would not be worth the sacrifice toward hardness of the asphalt. Actually there are other factors which can and do influence hardness more than just the specified grade of the asphalt, but once again the softer asphalt provides a margin of safety against the other influences which could cause brittleness.

When we complete the full set of laboratory tests on mixes with crushed and uncrushed aggregates started in January, the data will be distributed as a supplement to this report. In the meantime, if there is some reason that the evaluation of uncrushed gravel should be extended, particularly for road mixes, I would like to have the problem discussed in a meeting of the Specification Committee or the Research Committee in order to reach a full understanding on the work. Perhaps a controlled field test project for observation would be desirable.

Respectfully submitted

L. E. Gregg
Assistant Director of Research

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MEMO TO: L. E. Gregg  
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SUBJECT: Field Trip to Daviess and Henderson Counties for Inspection of Gravel-Bituminous Roads.

This series of inspections started April 28, with inspection of pavements containing gravel located in Daviess County. It was found that most pavements containing this aggregate has been resurfaced last year using a crushed limestone aggregate. There were, however, three hot-mix and one road-mix pavements remaining.

**SR 142 (Philpot-Habit):** The first gravel-bituminous road inspected was SR-142 (Philpot-Habit). This is a road mix of approximately 125 lbs/sq. yd. The aggregate is No. 8 uncrushed river gravel and sand. Aggregate blend is not definitely known, but is approximately two-thirds gravel and one-third sand. The bitumen used was MC-3 applied at the rate of 12 to 14 gals/ton of aggregate. The base was traffic-bound gravel and had apparently almost no depth. Drainage is fair to very poor. The original treatment has been down two years and is breaking up badly in many locations. This treatment shows considerable maintenance and in areas of comparatively stable base is in fair condition. Surface particles have all stripped, pitting and raveling is general but not too serious. Fig. 1 shows one of the better sections.

At the time of inspection SR-142 was undergoing major maintenance repairs. This consisted of patches for the entire width (14 to 16 feet) of pavement and varied in length from 50 to 1000 feet. These patches were blade mixed and spread, and compacted with a three-wheel, 10-ton roller. The treatment consisted of 100 lbs/sq. yd. of uncrushed gravel and crushed limestone. Proportions were approximately two-thirds No. 8 gravel and one-third No. 9 limestone with approximately 12-gals/ton of MC-3. This mixture has a very open texture when rolled. Fig. 2 shows the mixture being prepared while Fig. 3 shows the mixture laid out. The finished texture is as shown in wheel tracks in this figure. Before rolling No. 9 stone is tailgated over the mix to prevent picking up by the roller.

The special crew conducting this operation was questioned as to working qualities of the type mixture. The opinion was that the added crushed stone resulted in much better handling, especially rolling. This mixture is, however, still fluid and will take only light rolling. Patches placed a week or more are very soft.
Fig. 1 One of the better sections of SR-142 (Philpot-Habit). Treatment is 125 lbs/sq. yd. of sand and uncrushed river gravel aggregate with 12 to 14 gallons MG-3 per ton. Age of this section is two years.
Fig. 2 Mixing patches on Philpot-Habit Rd. Mix is 2/3 No. 8 uncrushed river gravel and 1/3 No. 9 crushed limestone with 13 gal/ton of MC-3.
Fig. 3 Patching material laid out on Philpot-Habit road. Note obviously coarse mix.

Fig. 4 SR-54 (Philpot-Owensboro) General shot from intersection of SR-142 and SR-54. Pavement is one year old. This is a Class I, Type B surface using PAC-5 with uncrushed gravel and sand.
In general the patching is of considerable benefit but due to the condition of the base and pavement, high maintenance may be expected.

**SR-54 (Philpot-Owensboro):** This is a one-year-old, hot-mixed pavement using uncrushed river gravel and sand aggregate with a PAC-5 asphalt consisting of 100 lbs/sq. yd. Class I, Type B Surface. The surface appears very dense for this type surface. All surface particles are stripped and the surface appears slick - the Resident Engineer says it is not. A binder course was used intermittently as a leveling course and over soft spots but not over the entire project. Damage to date on this pavement is very slight and of no importance since the few failures have resulted from base weakness. This surface was laid over a soil-cement (?) stabilized base which had been sealed. Fig. 4 shows a general shot of the road at Philpot and representative of other portions.

**SR-71 (Owensboro-Hartford):** This pavement contains crushed river gravel (65% crushed) and sand with a PAC-5. The mat section consists of 1/2-inch insulation, 3-inch bituminous base (Class I), 1 1/2-inch Class I, Type A (?) binder and 1/2-inch Class I, Type B surface. This pavement is three years old and is in excellent condition. Slight raveling and pitting may be observed only on very close inspection. Surface particles are stripped but well bound. Again this mixture appears to be highly sanded. Fig. 5 shows the excellent surface texture typical of this pavement.

**U.S. 60 (Owensboro Extending East):** This is an uncrushed river gravel and sand pavement containing a PAC-5. Two-course construction of 150 lbs/sq. yd. of Class I, Type A binder and the same weight of Class I, Type B surface was employed. Also, Class I base was used for widened sections. (A cored specimen showing all three courses is shown in Fig. 6) The pavement has been in place four years and you are familiar with the details of previous investigations on this section. Condition is generally good but some sections are showing considerable damage. Pitting is general over the entire section, with some raveling as shown in Fig. 7 occurring in several locations. Cracks have appeared over cracks and joints of the underlying concrete and at the joint between old concrete and widened sections as shown in Fig. 8. Riding qualities are still good for the entire section. The raveling apparently reflects the low asphalt contents determined in earlier work on the section. All surface particles are stripped and the surface appears to be slick - Resident Engineer says it is not. Joints between lanes are beginning to open up, but the condition is not too serious as yet. A hard winter would cause severe damage to this pavement in its present state.
Fig. 5  SR-71 (Owensboro-Hartford) Texture photo. Crushed gravel (65%) and sand with PAC-5 Class I, Type B.
Fig. 6 Core cut from U.S. 60 east of Owensboro. Specimen is from widened section and shows surface, binder and base courses.
Fig. 7 U.S. 60 (Owensboro-Extending East) Uncrushed river gravel and sand in a Class I pavement with PAC-5. Age 4 years. Note raveling along joint.
Fig. 8 U.S. 60 east of Owensboro showing cracking along joints in underlying concrete and at joint between concrete and widened strip. Pitting may also be seen.
On April 29, inspections of gravel-bituminous roads in Henderson County were made. Numerous county roads near Henderson are surfaced with uncrushed gravel and sand. These roads were constructed by state forces. Part of the maintenance work on these roads is done by state forces and part by county forces.

**Basket Road (U.S. 60 to Basket):** This road has its second treatment of approximately 125 lbs/sq. yd. The first treatment, which broke up in two years, consisted of No. 8 uncrushed gravel and sand with MC-3. The second treatment was principally limestone with an unmeasured quantity of No. 8 gravel added, and the asphalt was MC-4. This road varies from very fat to lean and from thick to thin. It is narrow in spots and undoubtedly hard to mix and lay out. In general, the second treatment looks fair for a light traffic road and has required little maintenance on the second treatment (1 year old). Fig. 9 shows a general shot in Basket and is representative of the majority of the second treatment. A one-mile section not shown has only an initial treatment placed at the same time as the treatment shown in Fig. 9. This section is intact but excessively fat even for a road mix.

**SR-54 (Henderson to 3 Miles East of Hebbersville):** From Henderson to Zion the pavement is built up by at least three successive road mix treatments of uncrushed gravel and sand using MC-3. Base is traffic-bound gravel of unknown thickness. A limestone seal has been placed over the entire road and is generally fat. Condition of this section is good even though subjected to a coal haul of considerable magnitude. Total loads are probably between 25,000 and 35,000 pounds.

From Zion to Hebbersville the base is 4 to 6 inches of soil-cement and the surface is 150 lbs/sq. yd. uncrushed gravel and sand using an MC-3. This section is rather badly failed in the north lane due to the coal haul mentioned. This is not equal to the one previously discussed. Fig. 10 illustrates the general condition (right lane is the north lane mentioned). The coal haul apparently does not extend east of Hebbersville and this three-mile section is in good condition as shown in Fig. 11. This road was surfaced four years ago.

**Horseshoe Bend Road (County Road):** This road has heavy passenger car traffic and little else. It has received two treatments of 100 to 150 lbs/sq. yd. of sand and uncrushed gravel. The double treatment is rather badly failed but is the best of the county roads seen. Patching has been done with limestone chips by state forces. Drainage is poor and the gravel base is very light. Fig. 12 is typical of the road. The surface shown is 4 years old.
Fig. 9 Basket Road in Henderson County. Second treatment shown - containing principally limestone and MC-3 with approximately 1/3 No. 8 gravel added. First treatment was gravel and sand.
Fig. 10 SR-54 (Zion to Hebberdsville) 150 lbs/sq.yd. sand and gravel using MC-3 over 4 to 6 inches soil-cement base. Heavy coal haul has caused failure in right (north) lane.

Fig. 11 SR-54 (East of Hebberdsville) Same pavement shown in Fig. 10, but in location not subjected to coal haul.
Fig. 12  Horseshoe Bend Road (Henderson County). Two treatments of sand and gravel mix. 4 years old.

Fig. 13  Watson Lane (Henderson County) single treatment of sand and gravel at 100 lbs/sq.yd. using MC-3.
Watson Lane (County Road): This is a narrow road typical of most of those observed in the county system. The pavement is 12 to 14 feet wide. Drainage is generally poor and base negligible. The treatment is approximately 100 lbs/sq.yd. of sand and uncrushed gravel using an MC-3. Maintenance is the responsibility of the county and for the most part is non-existent at present. The section shown in Fig. 13 is four years old and has received little or no maintenance in the past year. This pavement is so badly broken up that it has no value at present and can have little value as base for additional courses.

In addition to the two county roads discussed the following were inspected: Country Club Road, King Road, Watham Lane, and Green River Road. These roads varied in age from two to four years and in quality from total failure for the older roads to condition equal to the Horseshoe Bend Road—the younger roads, of course, being in the best condition.

Comments: The hot-mixed pavements were, of course, superior to road-mixed pavements. Crushed gravel appeared superior to uncrushed gravel at a comparable age.

Road mixes using uncrushed gravel and having a thickness of no more than 1½ inches may be expected under light traffic, to give satisfactory service for approximately 2 years without excessive maintenance. Built up mats or properly based mats have performed reasonably well.

From various discussions with the people who work with this material, the following points were brought out:

1. Gravels (uncrushed) are considered generally unsatisfactory when used alone with liquid asphalts but when combined with one-third to one-half crushed limestone they perform rather well.

2. All persons contacted favored the use of crushed gravel if available but emphasized the point that crushed gravels were virtually impossible to obtain locally.

3. Gravels were preferred for initial treatment if such use would make limestone available for traffic-bound surfacing.

4. Whenever possible resurfacing of gravel pavements is being done with crushed limestone.
From a personal point of view, the situation - based on observations made on this trip - is as follows:

The mixture design of hot-mixed pavements using uncrushed gravel is inadequate since the deterioration observed is greater than would be expected in comparable limestone mixtures. The rounded particles encourage raveling and pitting. Since this is based on U.S. 60, the low asphalt contents probably share the blame for this condition.

Crushed gravel (65% crushed) has produced a pavement apparently equal to comparable limestone pavements. Other factors unknown to me may well have a bearing on this pavement, but it looks encouraging.

Use of uncrushed gravel and liquid binders in most, if not all cases, produces a very low type of initial treatment. Unless there is a material saving by the use of such treatments, their use can not be justified since the life of such pavements averages approximately two years.

If a mat is built through successive treatments at two-year intervals, it is possible to obtain a stable pavement. This would seem to be the hard way to do the job.

Ellis G. Williams
Research Engineer