# EXPANDED CLAY HOT MIX STUDY

Final Report

Part I

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EXPANDED CLAY HOT MIX STUDY

## ABSTRACT

Expanded Clay Aggregate has been accepted in Louisiana's hot mix specifications for approximately nine years; however, there remains relatively few expanded clay hot mix pavements in the State today. The reason being, the contractors as well as, the highway engineers are not familiar enough with the properties of the aggregate and were somewhat reluctant to use it, even though past projects constructed with expanded clay hot mix performed satisfactorily.

This is part one of a two part final report on expanded clay hot mix, conducted in cooperation with the Bureau of Public Roads, to (1) evaluate the use of various expanded clay mixtures under high traffic counts; (2) accumulate through experience and testing, suitable information on the physical properties of the expanded clay aggregates and mixtures, for recommending adequate testing and control procedures on expanded clay mixtures; (3) prepare a suitable expanded clay hot mix specification.

In order to evaluate expanded clay hot mix, four control sections, consisting of a standard Type 1 gravel hot mix, were constructed as a basis of comparison with sixteen expanded clay hot mix sections, varying in aggregate proportions, mineral filler and asphalt content. The evaluation consisted of physical properties of expanded clay mixes at the plant, the laydown and compaction operation in the field, testing of roadway cores original and one year after construction, roughness, skid resistance and present serviceability index measurements on the roadway at various time intervals after completion and visual observation of the general appearance of the roadway after being subjected to traffic.

Expanded clay hot mix appears to be a satisfactory material for use in hot mix pavements. However, there are some problems to be considered when testing expanded clay mixes for their physical properties.

The physical properties normally include such tests as specific gravities, percent voids, voids filled with asphalt, voids in the mineral aggregate, extracted gradations and percent of laboratory gravity. All of these tests are determined by weight measurements and because of the weight differences in two of the components, expanded clay and sand, this presents some problems that do not exist in other mixtures where the specific gravities of all the aggregate components

are approximately equal.

The intent of this study is to present the problems that may be encountered in the control of expanded clay mixes and to recommend a suitable solution to solving such problems, as well as, developing suitable mix design criteria and specifications.

## SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS

The following summary of results and conclusions are based on the experience obtained during construction, in the laboratory and on the evaluation of the data obtained immediately and 12 months after compaction.

1) It appears at this time that the blending of a synthetic expanded clay aggregate with sand, mineral filler and asphalt cement will result in a suitable expanded clay hot mix for use on roadways having traffic densities as high as 3,100 vehicles per lane, per day. It is therefore recommended that expanded clay hot mix be considered as an acceptable alternate to gravel hot mix.

2) It was found that for expanded clay hot mixes, containing coarse expanded clay aggregate, sand and mineral filler, there is a linear relationship between roadway or laboratory density and percent of expanded clay contained in the specimens. As the percent expanded clay increased the density decreased due to the difference in weight between two of the major components, namely, expanded clay and sand. The correlation coefficient for the plotted roadway curves was 0.79 and 0.83 and for the laboratory curve 0.96, 0.88 and 0.97 indicating significant correlation.

3) Results showed that in order to determine an accurate percent compaction of a compacted expanded clay hot mix, the percent of expanded clay present in each individual roadway core must be determined by means of extracting the core and obtaining the percentage as based on the aggregate in the core. A laboratory curve should also be made with varying expanded clay percentages and used as a basis for determining percent compaction.

4) When recovering the expanded clay aggregate from a specimen, it was found that the extracted aggregate when soaked in carbon tetrachloride will enable the expanded clay aggregate to float while the heavier sand and gravel will remain immersed making it very easy to separate the expanded clay from the fine aggregate.

5) The average original percent compaction showed a maximum of one percent difference when varying the asphalt content on a given expanded clay mix from 7.0 to 8.0 percent, indicating that the asphalt content does not appear to be as critical on expanded clay mixes as on less absorptive mixes. As based on this study a recommended asphalt content range for design purposes would be from 6.0 to 8.5 percent by wt. of the total mix.

6) In order to get an accurate percent of voids and voids filled the theoretical specific gravity used to determine this criteria should be calculated according

to how much expanded clay is present in each individual specimen to be tested. Each specimen may have a different theoretical gravity if the expanded clay percentage in the specimen differs. Results showed that when the theoretical gravity is not corrected for the percent of expanded clay in each specimen the standard deviations for voids and voids filled with 1.3 and 5.5 respectively, as compared to 0.8 and 3.1 when correcting the theoretical gravity for each individual specimen.

7) The average voids and voids filled percentages on the original roadway cores ranged from 5.8 to 6.8 and 62.4 to 69.1 respectively; on the expanded clay mixes having 30 percent coarse expanded clay and 3 percent filler, with asphalt contents ranging from 7.0 to 8.0 percent.

8) The average Marshall Stability results for a given mix was approximately 1600 lbs. at 7.0 and 7.5 percent asphalt and increased to 1720 lbs. at 8.0 percent asphalt. This was higher than the gravel control sections which had a average stability of 1550 lbs. The results indicated that there was not a very large deviation in Marshall Stability due to changes in asphalt contents from 7.0 to 8.0 percent. The greatest influence on the Marshall Stability for expanded clay mixes was the percent of expanded clay in the mix. The average Marshall Stability for a mix containing 25 percent plus No. 4 expanded clay was 1180 lbs. for 30 percent 1580 lbs. and for 35 percent 2140 lbs. Results also showed that a mix having 35 percent expanded clay which included 10 percent minus No. 4 material had an average stability of 1750 lbs. It is recommended that the plus No. 4 expanded clay in a mix range from 25 to 35 percent by weight of the mix depending on the properties of the other aggregates.

9) The expanded clay mix without mineral filler proved to be unstable. Using 30 percent expanded clay without mineral filler had an average stability of 980 lbs. When using three and five percent filler, stabilities averaged approximately 1600 lbs. with very little distinction between the two. The test section constructed without mineral filler does not show any detrimental effects after 12 months of service, however there was some difficulty in spreading and rolling the material during construction. It is recommended that 3 percent mineral filler be used as long as the other fines in the mix are sufficient to give the necessary minus 200 material.

10) Skid resistance measurements at 40 mph, as obtained by a standard skid trailer, showed that the average original skid number for all of the expanded clay test sections was 45 as compared to 38 for the gravel control sections. Skid numbers obtained at 4,8 and 12 months showed a continuous rise with wear. The 12 month results showed that the expanded clay test sections increased from an average skid number of 45 to 57 and on the gravel control sections from 38 to 47.

11) The average skid numbers for the expanded clay sections were influenced more by the percentage of coarse expanded clay in the mix than by asphalt content or any other characteristic of the mix design. With 25 percent expanded clay in the mix the original and 12 month results showed average skid numbers of 42 and 46 respectively. With 35 percent expanded clay in the mix the skid numbers for the original and 12 months results showed 55 and 59 respectively. There was little or no change in average skid numbers due to varying the asphalt content.

12) The most suitable rolling temperature for the pneumatic roller was approximately 200°F. The results when varying the roller passes from 13 to 19 did not give a definite optimum number of passes. It appears that between 13 and 19 would have been satisfactory. There was no signs of flushing at 19 passes with 8.0 percent asphalt and it is believed that the overrolling is not as critical as on gravel mixes.

13) When varying the breakdown roller passes from 3 to 5 the results indicated that 3 passes of the breakdown roller, followed by the penumatic roller, gave higher percent compactions than 5 passes.

## METHODOLOGY

### Location of Test Sections

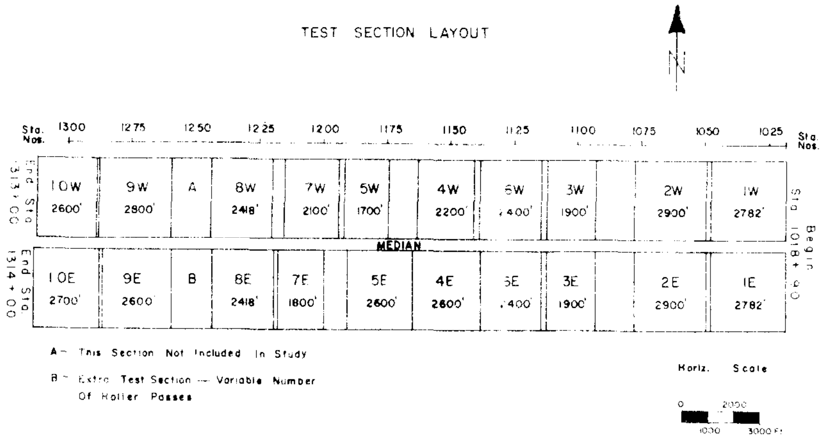
Twenty separate test sections were constructed on State Project 8-03-20 FAP F-169 (25) on La. U.S. 190 (Livonia-Elliot City Highway).

This is a four lane highway consisting of an eastbound and westbound roadway with each roadway carrying an average daily traffic of approximately 6200.

Each test section was approximately 0.5 of a mile in length. Four of the twenty test sections were control sections using a crushed gravel hot mix. The other sixteen test sections utilized expanded clay as the coarse aggregate in the mix in place of crushed gravel. The test sections varied in percentages of expanded clay, mineral filler and asphalt cement.

The asphalt cement used throughout the study was a 60-70 penetration grade asphalt from Humble Oil and Refining Company. The physical properties of the asphalt cement and the aggregates may be found in Appendix "C".

A detailed description of each of the individual test sections may be found in Appendix "A". The following diagram gives the location and distance of each of the test sections.



In the description, from Appendix "A", for sections 9W and 10W of the westbound roadway the term "Regular Expanded Clay" is used on certain lifts for these test sections. The regular expanded clay is an aggregate that was obtained from a different source than the expanded clay used in the other test sections which is sometimes termed super light expanded clay. The difference between the two expanded clays is primarily the unit weight. The regular expanded clay has a dry loose unit weight of approximately 45 lbs. per. cu. foot whereas the super light expanded clay has a unit weight of only 36 lbs. per.cu.foot.

It was intended in this study to evaluate the regular expanded clay in both lifts of test sections 9W and 10W. However, due to some difficulties in production at the lightweight plant, only a limited supply of regular expanded clay was furnished. Therefore, as described, certain lanes of these test sections were constructed with the super light expanded clay. Only the inside lane of section 9W has the regular expanded clay on the top and bottom lifts, therefore, it could hardly be used as a basis of comparison with the super light expanded clay material. The super light expanded clay which is used in the majority of the test sections of this study will be termed merely "expanded clay" and any deviation from this aggregate will be designated as such.

There was one extra test section included in the study that was not mentioned in the description of the test sections. This section was 1600 feet in length and was located on the eastbound roadway between sections 8E and 9E. The mix used on this section was the same as that in section 8E. The object of this test section was to vary the roller passes to try to determine what affect it would have on the roadway density.

## Plant Control During Construction

The plant control during construction was very similar to the control used on other hot mix projects with the exception that a greater number of samples were tested.

Approximately seven to nine specimens were molded per section per lane, using 75 blows on each face with a standard Marshall hammer. Loose mix samples were obtained for gradation and bitumen content determinations.

The Marshall specimens and loose mix samples were tested according to the following procedures.

| Method of Test | Designation |
|---|---|
| (1) Determination of Specific Gravity of Compressed Bituminous Mixtures | LDH TR 304 |

| Method of Test | Designation |
|---|---|
| (2) Method of Test for Stability and Flow of Asphaltic Concrete Mixtures - Marshall Method | LDH TR 306 |
| (3) Method of Test for Bitumen Content of Paving Mixtures by Reflux Extractor | LDH TR 307 |
| (4) Method of Test for Mechanical Analysis of Extracted Aggregate | LDH TR 309 |

Field Control During Construction

Compaction of the test sections was accomplished by means of a three wheel roller, pneumatic roller and tandem roller used in sequence. The roller passes were kept constant for all test sections with the exception of the extra test section in which the roller passes were varied.

The pneumatic roller was a Bros SP 6000 consisting of 7 wheels having 11.00-20, 18 ply tires. The total weight of the roller was approximately 18,600 pounds with tire pressures of 90 p.s.i. This resulted in a contact pressure of 70 p.s.i.

The number of passes of the rollers were carefully controlled on each test section in which the three wheel roller made 5 passes, the pneumatic 13 passes and the tandem made the necessary passes to eliminate the roller marks.

The three wheel roller began rolling immediately behind the spreader. The mix was allowed to cool to approximately 200°F before pneumatic rolling began. This temperature appeared to be the most suitable and was held constant throughout the project.

Test Performed to Evaluate Test Sections

The evaluation of the test sections consisted of many types of physical tests. Approximately 225 roadway cores were taken approximately 24 hours after compaction and again after 1 year of service. These cores were tested in various ways to determine the effects of the percentages of expanded clay aggregate in the mix, the changes of asphalt content and mineral filler and also to determine what affect would varying the pneumatic roller passes have on the mix.

Other tests for evaluating the test sections included measuring longitudinal grooves after one year of service, roughness measurements immediately after completion and after one year of service, skid resistance measurements by means of a standard skid trailer, taken at intervals of 0, 4, 8 and 12 months after completion, and present serviceability index values were obtained by means of a PCA

Roadmeter one year after completion.

Correlations were attempted between many of these tests with some of the physical characteristics of the various mixes. An explanation of these correlations are found in the Discussion of Results.

## Expanded Clay Aggregate

The expanded clay aggregate used in this study was obtained from two different sources. The majority of the expanded clay came from Big River Industries Incorporated which is located in Erwinville, Louisiana approximately 15 miles west of Baton Rouge. The regular or heavier expanded clay used on the inside lane of test section 9W was obtained from Louisiana Lightweight Aggregate Company located in Alexandria, Louisiana.

The expanded clay aggregate from both sources was manufactured by the Rotary Kiln Process. This same type expanded clay aggregate is being used in lightweight structural concrete for building construction, building blocks, built up roofing, precast and prestressed concrete building members, and in highway construction for bituminous surface treatments and slurry seals.

The manufacturing process of expanded clay aggregates is described in detail with plant photographs in Appendix "B".

# DISCUSSION OF RESULTS

This project was conducted very similar to most hot mix projects constructed in Louisiana. The various mixes were controlled at the plant by Department personnel. Laboratory briquettes were made each day and tested for its physical properties. Since this was a research study the number of samples per day were increased to approximately nine specimens per test section.

One of the most important criteria in the specifications is roadway density. The specifications state that the average specific gravity of the roadway cores shall be a minimum of 95 percent of the average laboratory specific gravity.

Roadway cores were taken approximately 24 hours after compaction on all of the test sections. As work progressed it became obvious that the percent compaction when determined as mentioned above was ranging anywhere from the low 80's to approximately 102 percent on the expanded clay hot mix sections.

This behavior was anticipated due to the large differences in unit weight between the components of the expanded clay mixtures. The expanded clay hot mix was predominantly made up of plus No. 4 expanded clay aggregate, which has a loose unit weight of approximately 36 lbs. per.cu.foot, a coarse and fine sand which has a loose unit weight of approximately 98 to 100 lbs. per.cu.foot, and a mineral filler which is similar in weight to the sands.

The specific gravity of a roadway core or laboratory briquette is determined by weighing the specimen in air and in water and dividing the weight in air by the volume of the specimen. Should one specimen which is equal in volume to another specimen, contain a higher percentage of expanded clay, then the dry weight of that specimen would be lower than the weight of the specimen containing more sand due to the large difference in weight between the two components.

As a hypothetical example, the average specific gravity of the laboratory specimens are used as a basis of determining percent compaction of the roadway cores, and that these laboratory specimens are made using the hot mix obtained from a truck immediately upon discharge from the pugmill. Even though the plant may be weighing out 30 percent by weight expanded clay aggregate into the mix, this sample obtained by the plant inspector for this Marshall specimen may have on the low side 28 percent, or on the high side 32 percent expanded clay. Assuming that the laboratory specimen contains only 28 percent expanded clay, this would result in a higher specific gravity since the specimen contains more of the heavier material, namely sand. Lets assume a roadway core is taken and it contains 32 percent expanded clay. This of course would result in a low specific gravity due to the larger percent of the lighter material, expanded clay.

In calculating the percent compaction the higher specific gravity of the laboratory specimen is divided into the lower specific gravity of the roadway core which naturally compounds the problem and results in what appears to be a very low percent compaction.

Although this is a hypothetical example, it is highly probable that this happens a number of times during construction. The laboratory specimens, as well as the roadway cores, are only four inches in diameter and naturally a variation in percentage of coarse to fine material can be expected. Until using expanded clay hot mix, this did not present a problem in our State since all the hot mix components were approximately equal in weight with, of course, the exception of the asphalt cement.

Correlation of Roadway Density and Percent of Expanded Clay in the Specimen

In an attempt to correlate the roadway density with the percentage of expanded clay aggregate in the specimen, Figure 1 is presented to show density results of all the wearing course roadway cores taken 24 hours after compaction, from test sections 3W, 4W and 5W. These mixes contained plant weight values of 30 percent plus No. 4 expanded clay aggregate, 67 percent sand (both coarse and fine) and 3 percent mineral filler (silica dust). The difference between these test sections was the asphalt content. Test sections 3W, 4W, and 5W had asphalt contents of 7.0, 8.0 and 7.5 percent respectively.

After determining the density of the roadway cores in lbs/cu.ft. the cores were then extracted by a reflux extractor and the percentage of expanded clay in the core determined as based on 100 percent aggregate. In order to get all of the expanded clay out of the extracted sample it was necessary to soak the cleaned aggregate in carbon tetrachloride, enabling the expanded clay to float while the heavier sand remained immersed. It was only necessary to soak the fine material (passing the No. 4) since the coarse expanded clay was very easy to sieve out. Even though only plus 4 expanded clay was supposedly added in these test sections, there are some fines that do get into the fine bin that had to be taken into account. Through this method the exact percentage of expanded clay was determined for each of the roadway cores representing these test sections.

Figure 1 shows the curve for the percent of expanded clay in the roadway core versus the roadway core density. The straight line represents the best fitting curve for the plotted points as determined by standard statistical procedures. The correlation coefficient was 0.79 which indicates good correlation. As the percent expanded clay increases the density of the core decreases. Had it been assumed that each roadway core contained 30 percent expanded clay the variation in core density could have been very deceiving.

There is still the question "What influence does the variation in asphalt content have on this curve?" It is logical that higher asphalt contents will usually result in

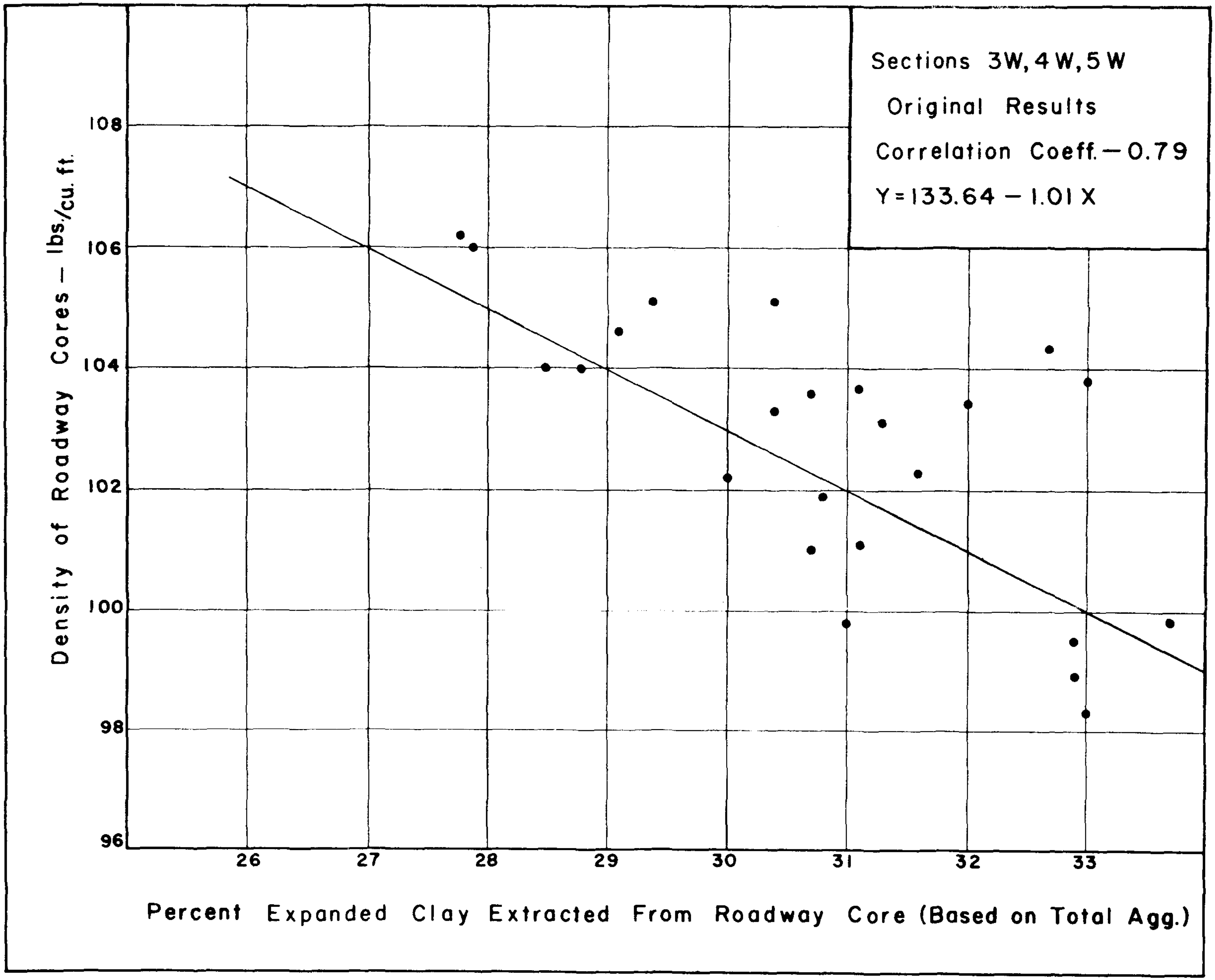



*Figure 1 - The Density of the Original Roadway Cores Versus Percent Expanded Clay Extracted from the Roadway Core for Sections 3W, 4W, and 5W.*

higher roadway densities due to filling more voids with asphalt. Expanded clay hot mix is no different than other type mixtures in that respect. However, it is believed that the asphalt content is not as critical with expanded clay mixes as it may be with a gravel hot mix. That is to say that plus or minus 0.5 percent from optimum would not appreciatively change the physical properties to any great extent.

The reason a separate curve was not made for each of the three sections was because there was not enough points to get a reliable correlation. Therefore, the sections were combined and evaluated as such. In evaluating this curve it was determined that the greatest influence on the core density was due to the difference in expanded clay percentages rather than asphalt content.

Using the same procedure as that described for Figure 1, the 12 month results for test sections 3W, 4W and 5W were also plotted as shown in Figure 2. Again there was significant correlation (0.83) between the density of the roadway cores and the percent of expanded clay in the core. The slope of the curve was very similar to the curve in Figure 1.

Laboratory Curves Made From Bin Samples

From the correlations obtained in Figures 1 and 2, it was evident that the greatest influence on density was the percent expanded clay in the core. In order to determine the percent compaction of each of these cores some adjustments had to be made which would alter the normal procedure for determining percent compaction. An ideal way of determining percent compaction would be to make a number of laboratory compacted samples using the mix taken from the trucks. The specific gravities of these samples would be obtained, as well as the percentages of expanded clay in each, as described previously. A curve could then be obtained, which would be similar in appearance to Figures 1 and 2 and used as a basis to determine the percent compaction of the roadway cores, depending on the percent expanded clay in the core. In order to use this method, it would be necessary to get a rather large variation in the expanded clay percentages for the compacted specimens to insure a reliable laboratory curve. It is not known at this time exactly how much variation in expanded clay percentages could be expected if this procedure was used.

Due to lack of foresight this method was not used on this study. However, laboratory specimens were molded using the bin samples which represented test sections 3W, 4W and 5W. These specimens were mixed and molded in the laboratory after construction was completed and are represented by Figures 3 and 4. The curves in these figures give the relationship of specific gravity versus percent expanded clay in the specimens. The coefficient of correlation for Figures 3 and 4 were 0.96 and 0.88 respectively. Each of the laboratory curves were made using the same bin samples with 7.5 percent asphalt cement. The specimens for each curve

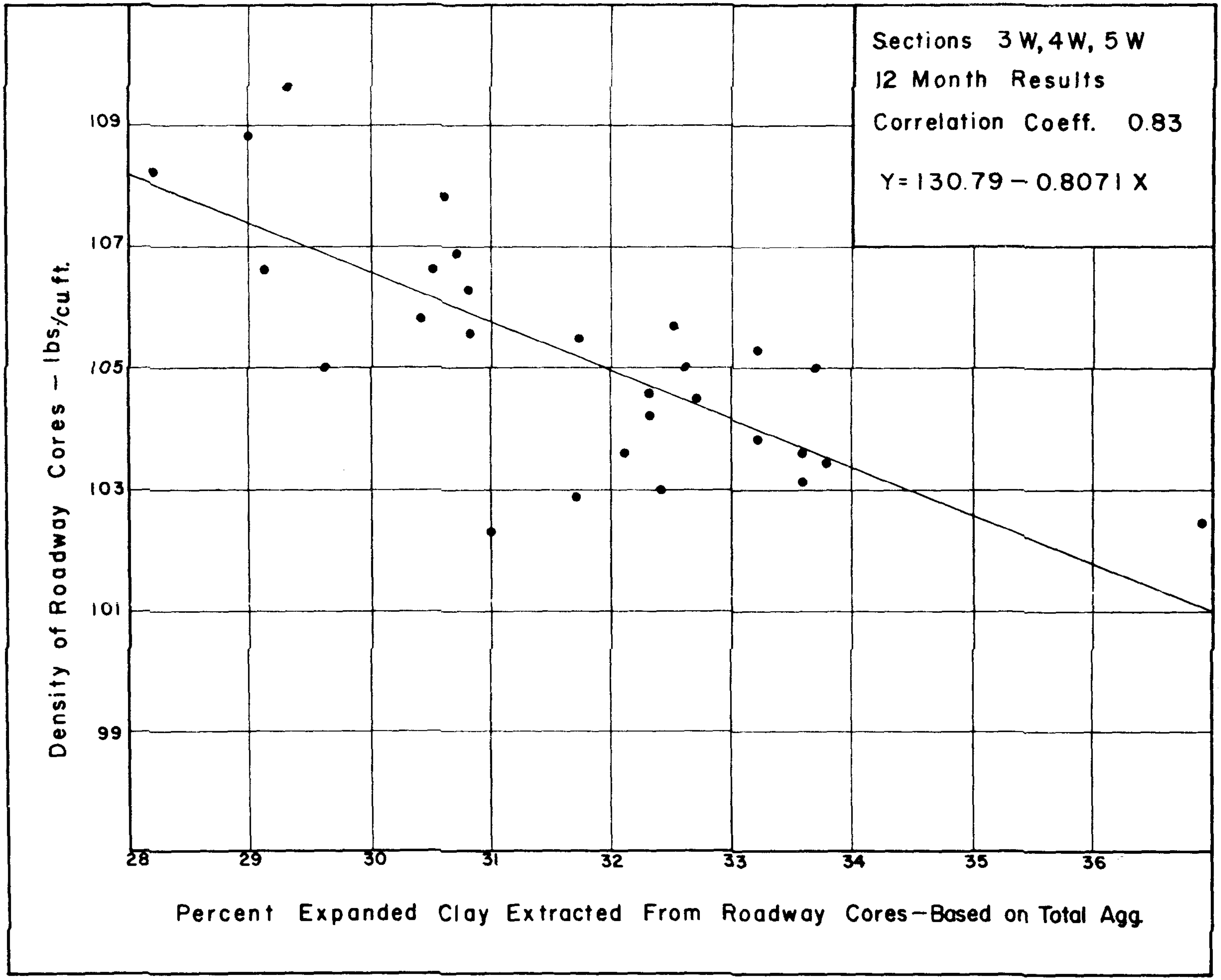



*Figure 2 - The Density of the 12 Month Roadway Cores Versus Percent Expanded Clay Extracted from the Roadway Core for Sections 3W, 4W, and 5W.*

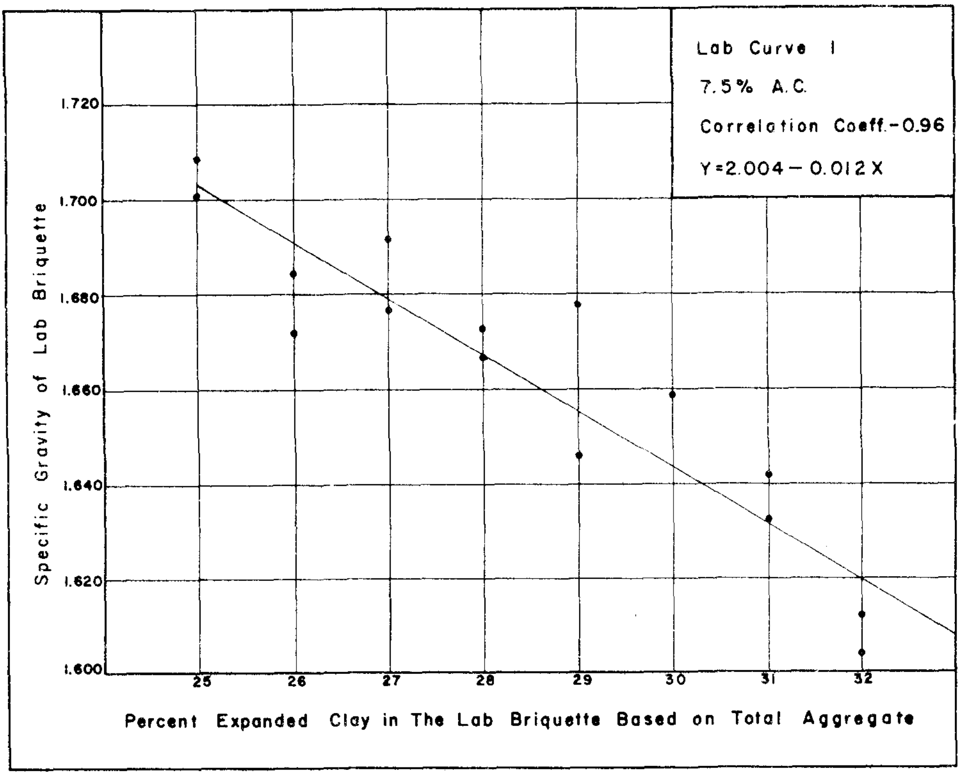



*Figure 3 - The Specific Gravity of the Laboratory Briquettes Versus Percent Expanded Clay in the Laboratory Briquettes for Laboratory Curve 1*

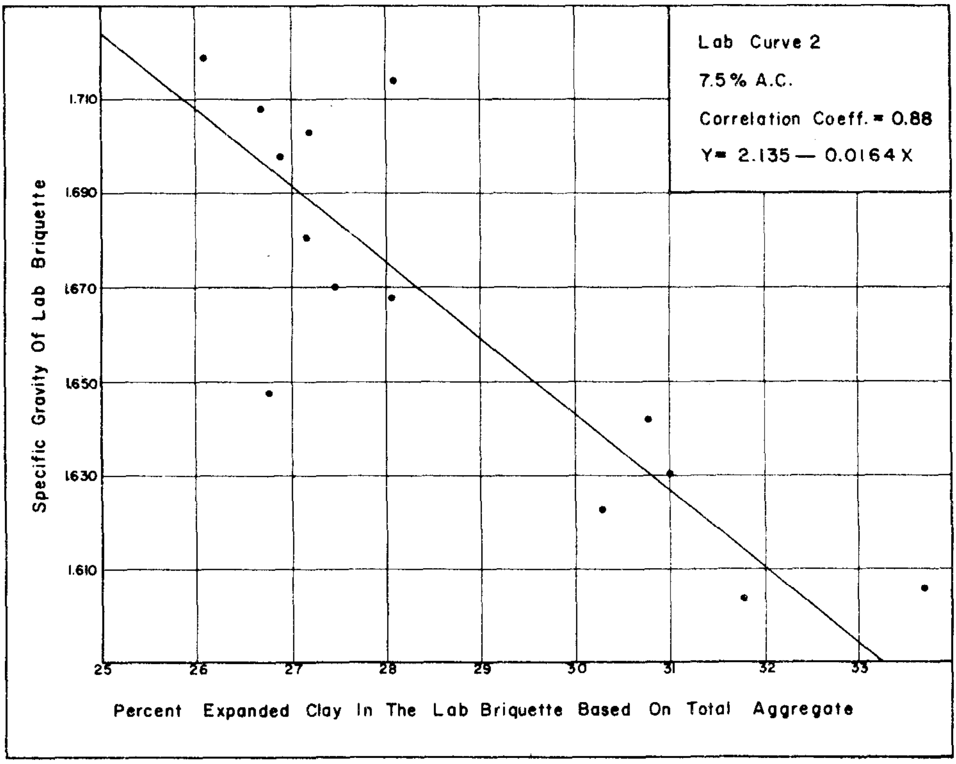



*Figure 4 - The Specific Gravity of the Laboratory Briquettes Versus Percent Expanded Clay in the Laboratory Briquettes for Laboratory Curve 2*

were molded at different times of the year and comparisons were made between curves to determine what variation may occur if a laboratory curve was used as a basis for determining percent compaction of the roadway cores.

Figure 5 represents the comparison between laboratory curves 1 and 2, giving the relationship between the density of the laboratory briquettes versus the percent expanded clay in the briquettes. As the figure indicates the laboratory curves are very similar. The greatest difference in density occurring between the curves was 1.3 lbs. per.cu.ft. at the 25 percent expanded clay increment. With the exceptions of the 25 and 26 percent increments all of the other values were below 0.9 lbs. per.cu.ft. difference.

This would indicate that a laboratory curve may be a reliable means of determining a laboratory specific gravity for varying percentages of expanded clay.

Figure 6 shows the relationship between percent expanded clay extracted from the cores and roadway density of the cores for the original and 12 month results, as compared to laboratory curve 2. It should be noted that the curve for the original cores had slightly higher densities than the laboratory compacted curve. However, all three curves were practically parallel. The 12 month curve, as anticipated, was higher in density, due to traffic densification.

There are at least two logical explanation for the laboratory curve being lower in density than the original curve, however, neither has definitely been proven. It is safe to say that the compaction in the field is different than the compaction in the laboratory since one method utilizes a pneumatic roller and the other a Marshall impact hammer. Nevertheless the Marshall method has always been used to determine a laboratory specific gravity as a basis for percent compaction, and as a rule, the density of the plant mixed Marshall specimens are higher than the densities obtained in the field 24 hours after compaction.

One possible cause for exception to this rule may be the difference in mixing that occurs at the plant from that in the laboratory. Since the expanded clay aggregate is a more absorptive aggregate than gravel, it may be possible that the additional time consumed during pugmill mixing and the time the mix remains in the trucks before sampling, causes the aggregate to absorb more asphalt and results in slightly higher densities.

Another consideration concerns the roadway cores for the original curve. The original roadway cores were cut with a diamond bit and cooled with water during coring. The specific gravity of these cores were calculated the same day the cores were cut, without making any special effort to dry the cores. Though the cores appeared dried it is possible that the dry weight contained some moisture. If this was the case it would result in a somewhat higher density. The magnitude of an increase in density due to moisture is not exactly known, since the cores

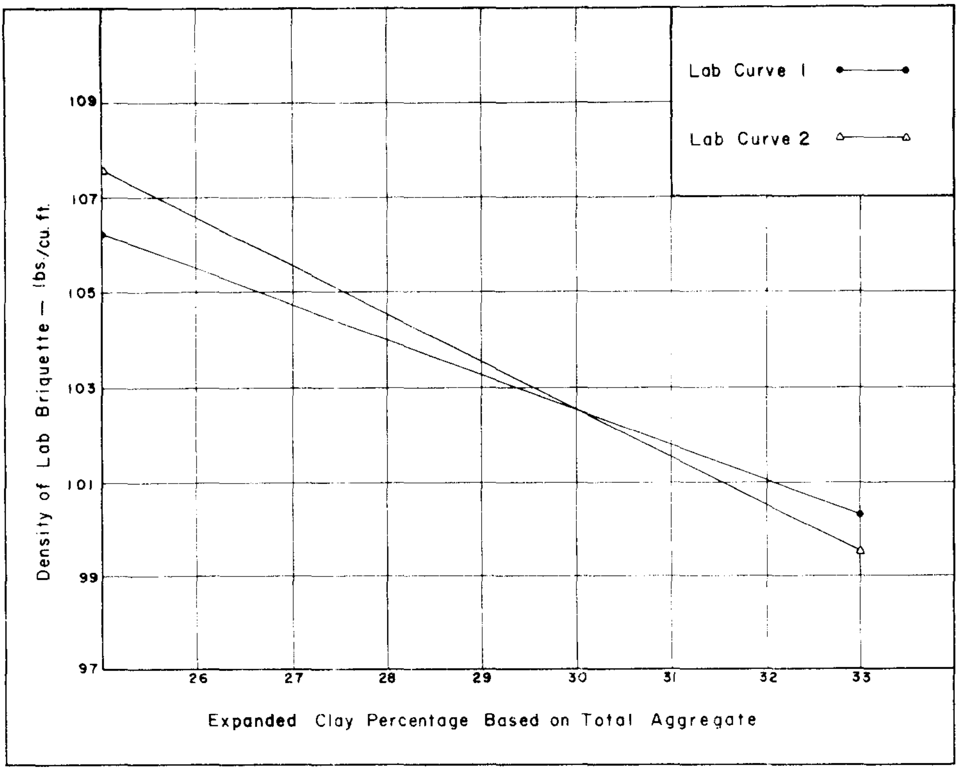



*Figure 5 - Comparison of Laboratory Curves 1 and 2 for Density of the Laboratory Briquettes Versus Percent Expanded Clay in the Briquette*

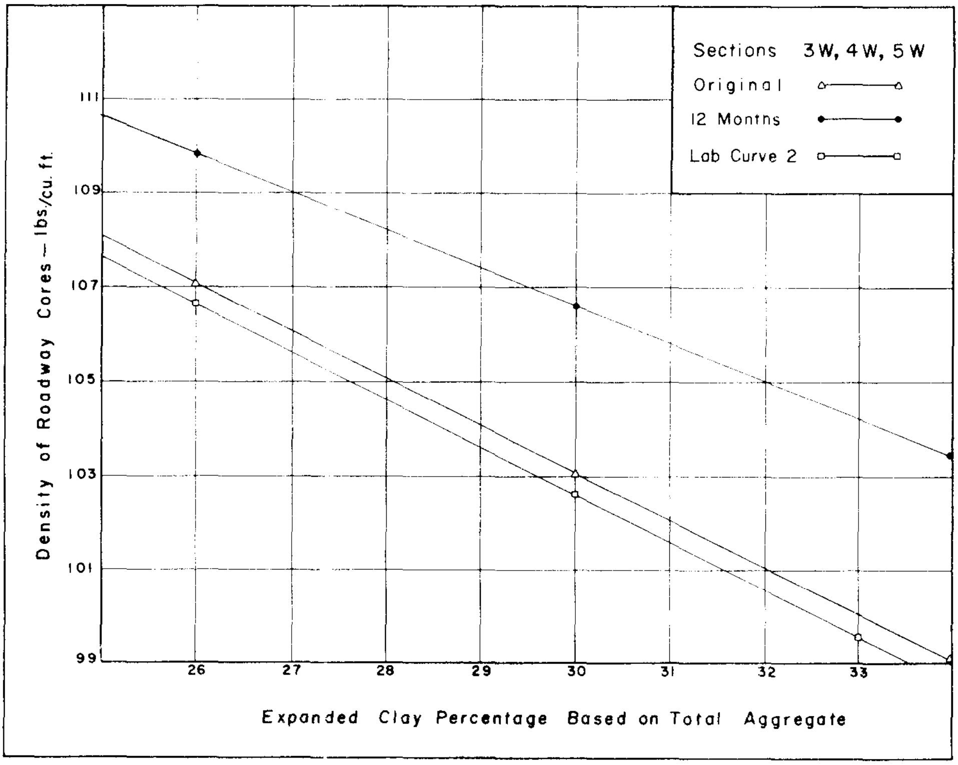



*Figure 6 - Comparison of Laboratory Curve 2 with the Original and 12 month Results for Density of the Roadway Cores Versus Expanded Clay Percentage in the Cores on Sections 3W, 4W, and 5W*

were extracted and check test could not be made. These explanations are merely speculation and not a proven fact. It is hoped that this may be followed up on future expanded clay hot mix projects.

Determining Percent Compaction Using a Laboratory Curve

It appears that the only way to get reliable data on the physical properties of the expanded clay mixtures, as well as the percent compaction in the field, is to determine the percentage of expanded clay in the roadway cores and Marshall specimens. A laboratory curve is essential, whether it be made at the plant using pugmill mixed material or in the laboratory using bin samples. The laboratory curve which has proven to be a straight line, provides a laboratory specific gravity for any possible range of expanded clay percentages that may be encountered. The laboratory curve is used primarily to determine the percent compaction that is being obtained in the field.

When determining the percent compaction of a roadway core, the core must first be tested for its bulk saturated surface dry specific gravity. In doing so the volume of the core should first be determined then the core should be dried to a constant weight and the weight in air determined. With this data a specific gravity of the roadway core may be calculated. The core should then be extracted and the percentage of expanded clay determined, as based on the aggregate. The percentage of expanded clay may be determined as previously described or any other suitable method may be used. Once the percentage of expanded clay in the core is obtained, the laboratory specific gravity from the laboratory curve may be selected at the corresponding percent of expanded clay that was found in the core. Dividing the roadway core specific gravity by the selected laboratory specific gravity will determine the percent compaction obtained in the field.

Using laboratory curve 2 (Figure 4) the percent compaction was calculated for the roadway cores from test sections 3W, 4W, 5W. Figure 7 shows the relationship between the average percent compaction versus asphalt content for the original and 12 month cores. As discussed previously the percent compaction for the original cores is slightly above 100 percent as based on the laboratory curve. Whether or not this trend will continue on future expanded clay projects is unknown at this time. However, the relationships of the percent compaction for the original and one year results versus asphalt content should be valid. As indicated by the figure, there was very little change in the percent compaction of the original cores, when varying the asphalt content from 7.0 to 8.0 percent. The 8.0 percent asphalt content was slightly higher. After being subjected to traffic for one year the increase in percent compaction was considerably higher. At 7.5 and 8.0 percent asphalt the increase in percent compaction after 12 months was approximately 4 to 5 percent, whereas at 7.0 percent asphalt the greatest increase was 3 percent.

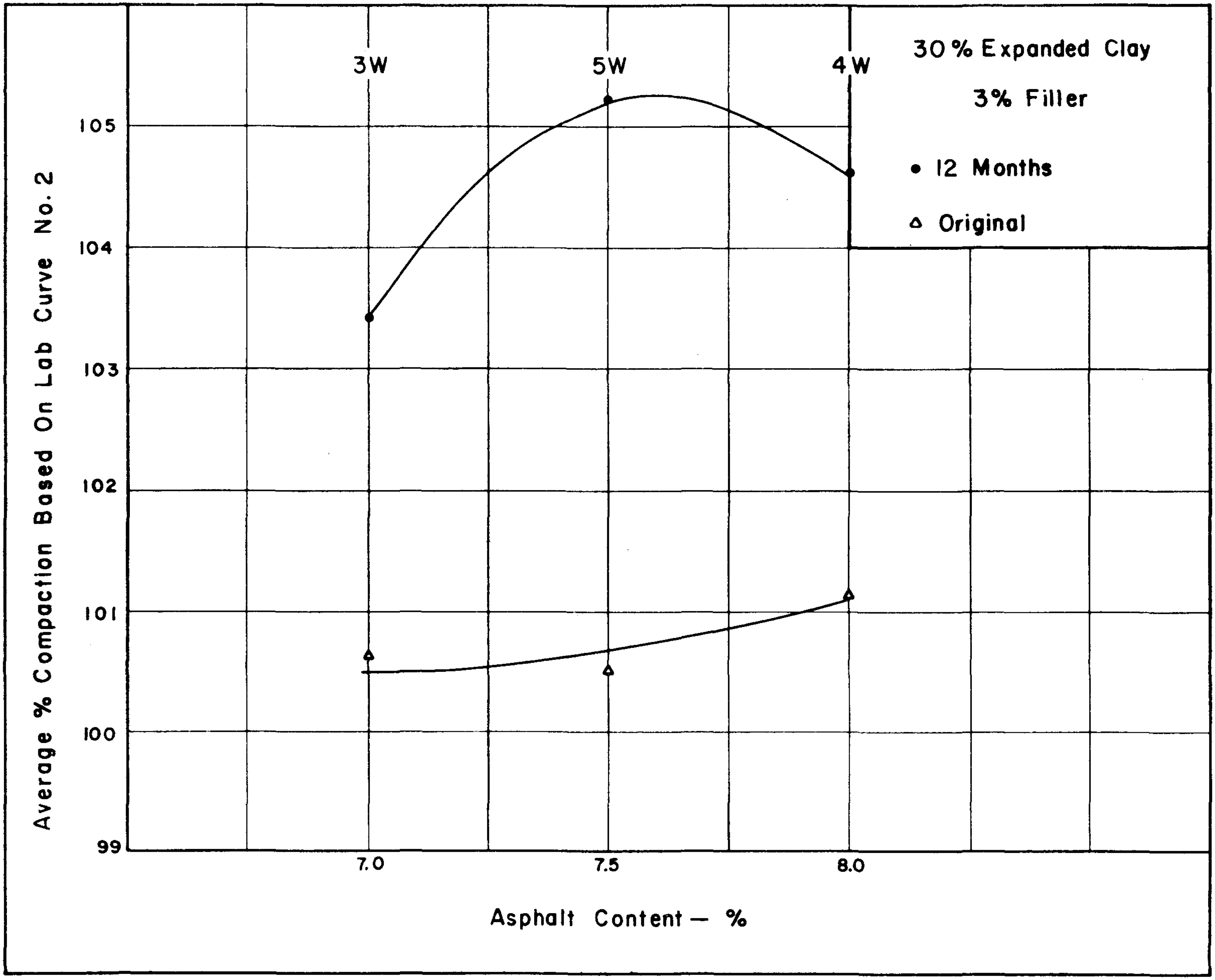



*Figure 7 - Average Percent Compaction Based on Laboratory Curve 2 Versus Asphalt Content for Sections 3W, 4W, and 5W.*

The relationship of the average increase in percent compaction from the original to 12 months versus asphalt content is shown in Figure 8. This bar graph gives the comparison of the expanded clay sections when varying the asphalt content and it also shows the percent increase obtained on the gravel control section. As indicated in the figure the gravel mix changed the least in percent compaction for the one year period. Section 3W at 7.0 percent asphalt was just slightly higher while section 5W was substantially higher. The significance of increases in percent compaction due to traffic, is that as the compaction increases in the wheelpaths, the longitudinal grooves usually increase. However, this is not the only factor that influences rutting. If poor construction practices are used, ruts can be built into the pavement at the time of compaction, or ruts may be caused by low stability mixes. On overlays where the existing pavement is badly rutted, a greater thickness of loose mix is required to fill the rut. The rutted area may consolidate more after compaction than the section having the thinner depth. Ruts may also occur due to excessive asphalt in the mix, causing the mix to shove under traffic.

Figure 9 shows the longitudinal grooves in millimeters, versus asphalt content for the same test sections. The gravel section gave the lowest grooves of 2.5 millimeters (0.1 inches) as compared to 5 millimeters (0.2 inches) for sections 3W and 5W. Section 4W having the highest asphalt content, also showed the highest longitudinal grooves. The rutting on these test sections are not considered to be excessive after 12 months of heavy traffic.

Determination of Voids and Voids Filled For Expanded Clay Mixes

The percent voids and voids filled with asphalt are values which are used to evaluate some of the physical properties of a mix. By dividing a theoretical specific gravity into an actual specific gravity of a specimen and with some additional calculations these values can be determined. The method used in Louisiana for determining the theoretical specific gravity of bituminous mixtures, is to determine the individual apparent specific gravities of each bin and to calculate the theoretical gravity for the proportions used. The procedure for determining the specific gravity of expanded clay aggregate is somewhat different from that of gravel or sand.

Expanded clay aggregate contains numerous voids within the structure of the aggregate. This is the primary reason why the material is so light in weight. Contrary to some beliefs the surface of the aggregate is somewhat glazed and the voids cannot be seen at the surface. Since the voids are primarily internal the aggregate does not absorb as much asphalt as some people seem to think. The only asphalt absorption that occurs is at the surface.

On the other hand when soaked in a less viscous fluid such as water, more of the internal voids are filled depending on the time allowed to soak and the procedure used in trying to fill the voids. In determining a specific gravity for expanded clay aggregate a procedure should be used that will fill approximately the same amount of voids in the aggregate that would be filled by an asphalt cement in a hot

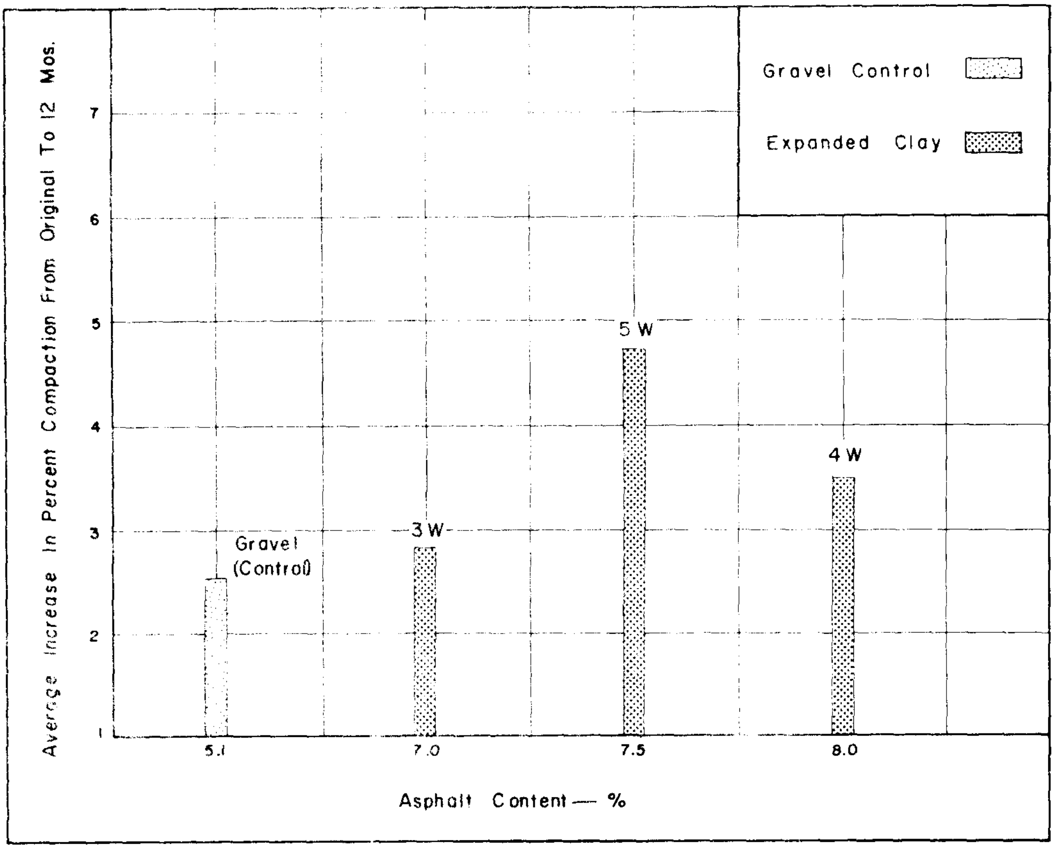



*Figure 8 - Average increase in Percent Compaction from original to 12 months Versus Asphalt Content for Sections 3W, 4W, 5W, and Control.*

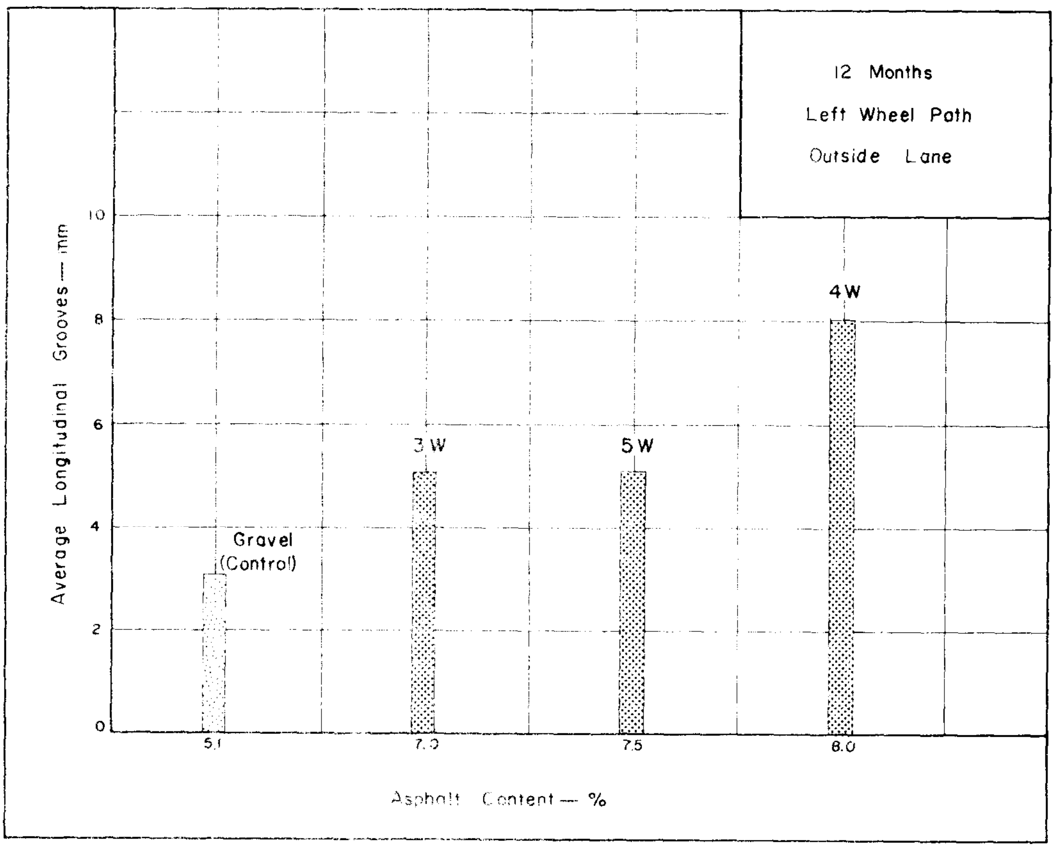



*Figure 9 - Average Longitudinal Grooves Versus Asphalt Content after 12 months for Sections 3W, 4W, 5W, and Control.*

mix. In trying to develop such a test procedure, many different procedures were utilized. The specific gravities of the expanded clay aggregate ranged from 0.97 to 2.40 depending on the procedure used and the amount of voids in the aggregate filled.

After trying several procedures the most realistic specific gravities determined were performed in accordance with a modified version of LDH TR 312 (Determination of Specific Gravity of Coarse Lightweight Aggregate). The average specific gravity for the expanded clay using this method was 1.112. The specific gravities for the sand and mineral filler in the mix were determined as always by LDH TR 301 (Method of Test for Apparent Specific Gravity of Fine Aggregate and Mineral Filler for Bituminous Mixtures). Both of these test procedures may be found in Appendix "H" of this report. With the specific gravities of the individual components a theoretical gravity may be established.

In order to get reliable data for voids and voids filled, it is again necessary to determine the percentage of expanded clay in the specimen. When this is determined the theoretical gravity should be calculated by making the necessary changes in the percentages of the aggregates as determined by the extraction of the specimen. This means that a separate theoretical gravity would be calculated for each specimen tested. The following are just a few results showing the differences that occur when correcting for the percentage of expanded clay in the specimen.

Original Cores

| | Uncorrected Results | | Corrected Results | |
|---|---|---|---|---|
| Station | Voids-% | V.F.A. - % | Voids-% | V.F.A. - % |
| 1094 I | 6.7 | 62.6 | 5.8 | 65.9 |
| 1104 I | 5.4 | 67.8 | 6.2 | 64.8 |
| 1109 I | 5.9 | 67.4 | 7.2 | 61.1 |
| 1112 I | 7.5 | 59.8 | 7.6 | 59.4 |
| 1094 O | 3.9 | 74.8 | 5.8 | 66.6 |
| 1109 O | 7.1 | 61.2 | 5.6 | 66.6 |
| Standard Deviation | 1.3 | 5.5 | 0.8 | 3.1 |

The above results show the uncorrected and corrected values for percent voids and V.F.A. The uncorrected results were determined using the specific gravity of the roadway core, divided by the theoretical gravity, which was obtained using the proportions established at the plant for the batch weights. The corrected results were obtained by determining the specific gravity of the roadway cores, as well as, the percent of expanded clay in the core, based on the aggregate and obtaining the corrected percentages of the component aggregates to calculate the theoretical gravity. As indicated, the standard deviations for voids and V.F.A.

are considerably higher on the uncorrected results. Had corrections not been made for the expanded clay percentages, the results could have been very misleading.

When determining the theoretical gravity for the individual cores it is very easy to establish a curve, such as that in Figure 10. This figure represents the calculated theoretical gravity versus the percent expanded clay extracted from the laboratory or roadway specimen.

The curves may be easily determined by merely calculating two or three points and connecting them by a straight line. Since the values are calculated values a perfect straight line should be obtained each time. It should be noted that the expanded clay percentage shown on the curve is based on the total aggregate in the specimen. When calculating the theoretical gravity this percentage should be adjusted, as based on the total mix, which includes the asphalt cement.

Figure 11 shows the relationship between the corrected average voids and V.F.A. versus asphalt content for test sections 3W, 4W and 5W. The solid lines represent the results obtained on the original cores. As anticipated, the voids decrease as the asphalt content increases and the V.F.A. increases as the asphalt content increases. The dashed lines represent a theoretical curve for the data obtained in laboratory curve 2 (Figure 4). The results in laboratory curve 2 were for an asphalt content of 7.5 percent. However theoretical points were plotted for voids and V.F.A. on this figure at 7.0 and 8.0 percent asphalt, to determine a suitable range to be used as design criteria. You may recall that the original cores had higher density results than the laboratory made curve (Figure 6). This is the reason for the higher voids and lower V.F.A. percentages for the theoretical laboratory curve as opposed to the field data.

Marshall Stability

The previous discussion had dealt primarily with criteria for design and control of expanded clay mixtures, using data from test sections 3W, 4W and 5W. One other very important criteria to be considered is the Marshall Stability of the mixes. To evaluate Marshall Stability and the factors which influence it, the data from some of the other test sections are utilized in addition to the three test section discussed thus far.

Figure 12 shows the relationship for the average Marshall Stability versus asphalt content. The stability results shown on the curve represent the average of all the applicable results obtained at the plant during construction. These mixes contained approximately 30 percent expanded clay by weight and 3 percent mineral filler. The curve indicates the Marshall Stability was practically the same at approximately 1600 lbs. for 7.0 and 7.5 percent asphalt, and increased to 1720 lbs. at 8.0 percent asphalt. Based on previous experience with gravel mixes, it appears that the asphalt content is not as critical on an expanded clay

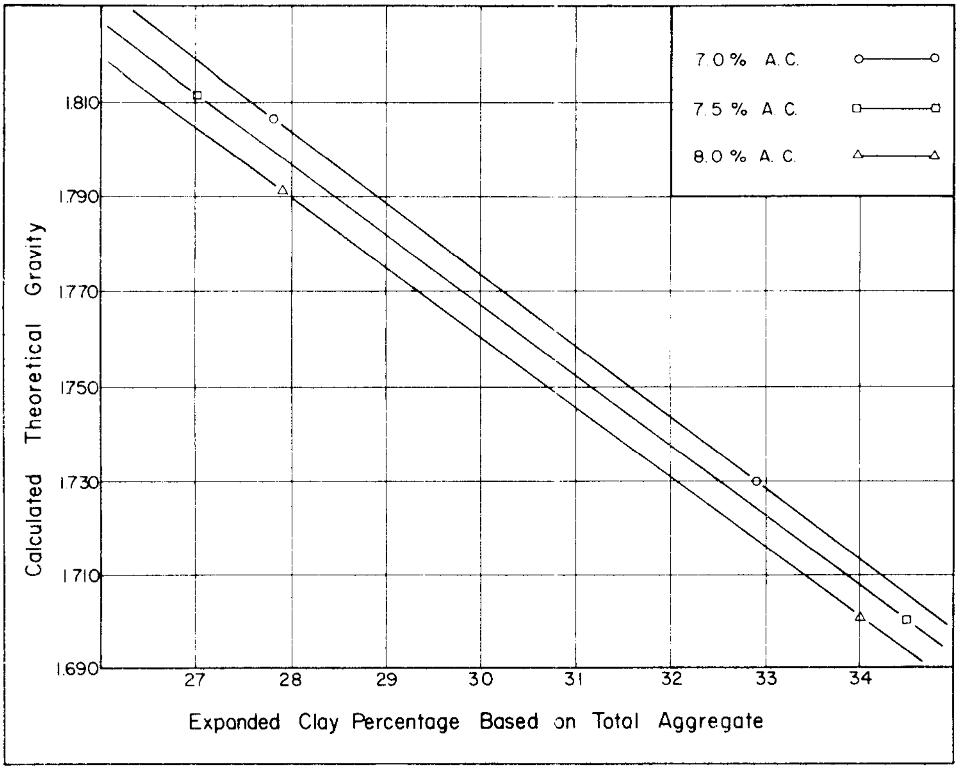



*Figure 10 - Calculated Theoretical Specific Gravity Versus Expanded Clay Percentage at various Asphalt contents*

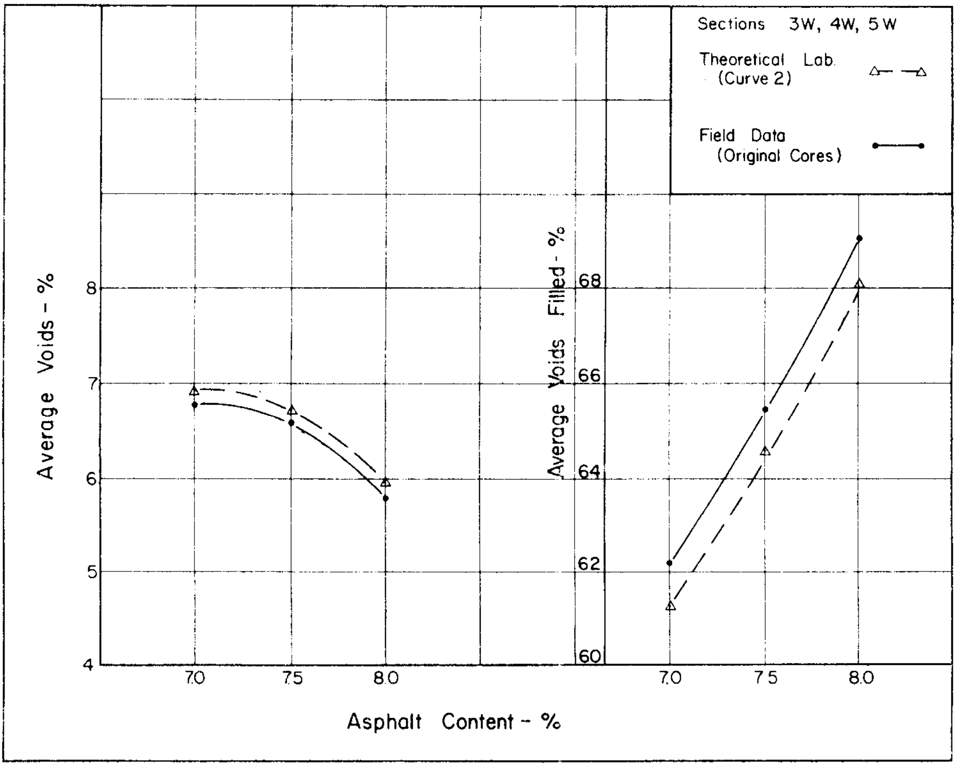



*Figure 11 - Average Voids and Voids filled for the original Cores versus Asphalt Content from Sections 3W. 4W, and 5W*

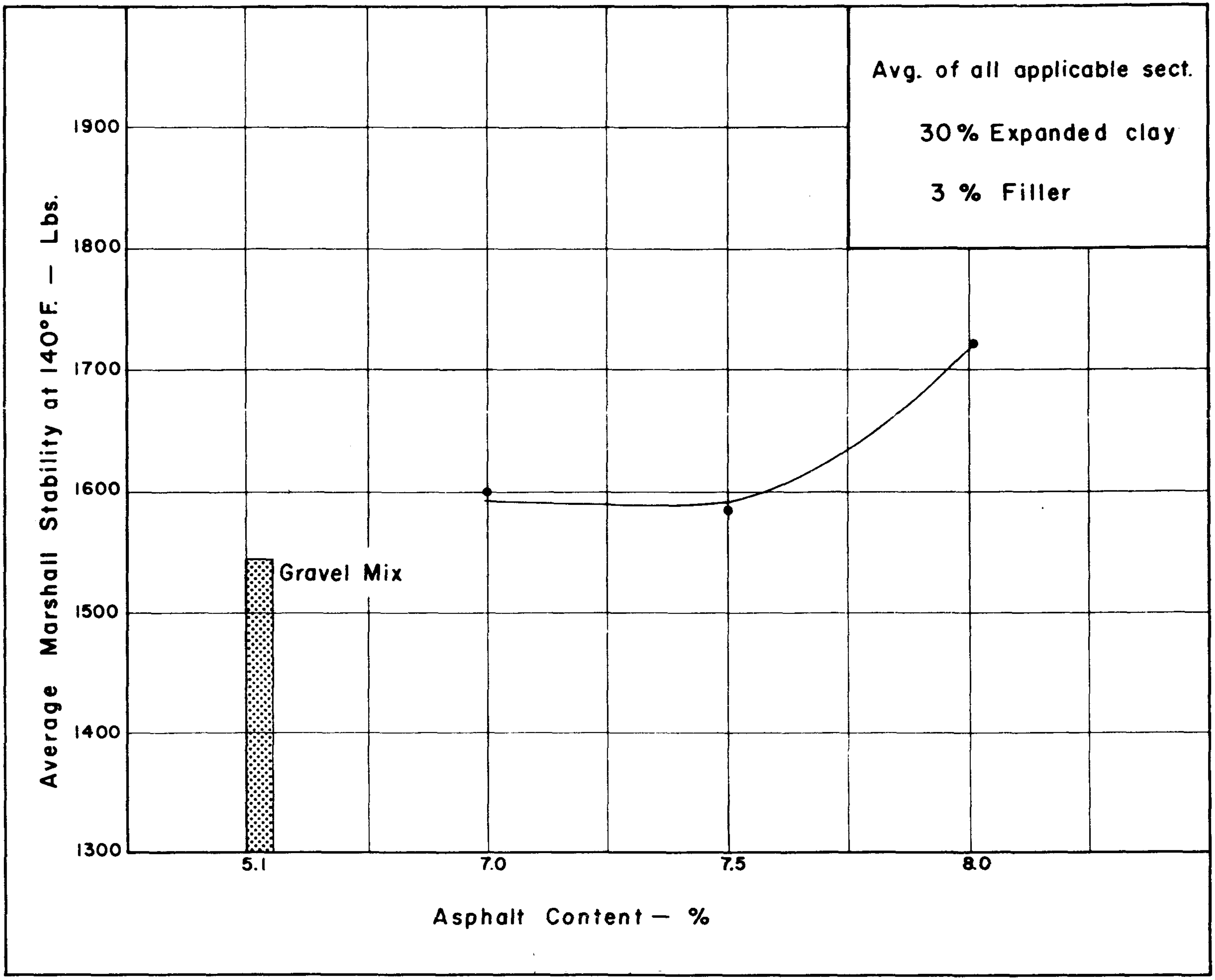



*Figure 12 - Average Marshall Stability Versus Asphalt Content for Expanded Clay and Gravel Sections.*

mix as it is on a gravel mix, probably due to the absorption characteristics of the expanded clay. The bar graph in the figure represents the Marshall Stability for the control gravel mix, in which the asphalt content was held constant at 5.1 percent.

In some of the test sections the mineral filler percentage was varied to determine what affect the mineral filler had on expanded clay mixes. Figure 13 shows the effect mineral filler has on Marshall Stability. The curve indicates that a mix without mineral filler defintely produces a low stability mix. After 12 months of service the test section constructed without mineral does not appear to show any detrimental effects, however during construction there was some difficulty with the spreading and rolling of this mix. For this reason only one test section was constructed without mineral filler.

The values using 3 and 5 percent filler were all within the same stability range of approximately 1500 to 1700 lbs. The stability for the mix without filler was approximately 1000 lbs. It appears that 3 percent filler will produce the same results as 5 percent filler and for economic reasons 3 percent should be used.

Probably the largest single influence on Marshall Stability found in this study was the percentage of plus No. 4 expanded clay aggregate in the mix. Figure 14 shows the relationship between Marshall Stability and the percentage of plus 4 expanded clay. As indicated by the curve there is a sharp increase in stability as the expanded clay percentage increases. The dashed line represents the path of the curve when the 35 percent expanded clay includes 10 percent minus 4 expanded clay. The 35 percent coarse material gives a stability of approximately 300 lbs. higher than the 35 percent including 10 percent minus 4 material. It may be noted, however, that the 10 percent minus 4 expanded clay in the mix did increase the stability from 1200 lbs. at 25 percent plus 4 to 1760 lbs.

Recommended Design Criteria for Expanded Clay Hot Mix

The following is the design criteria, as based on the results from this study, to be used as a guide for expanded clay hot mix projects.

| Gradation<br>U. S. Sieve | Percent Passing-by weight |
|---|---|
| 3/4" | 100 |
| 1/2" | 80-100 |
| No. 4 | 55-80 |
| No. 10 | 45-75 |
| No. 40 | 20-55 |
| No. 80 | 10-30 |
| No. 200 | 4-15 |

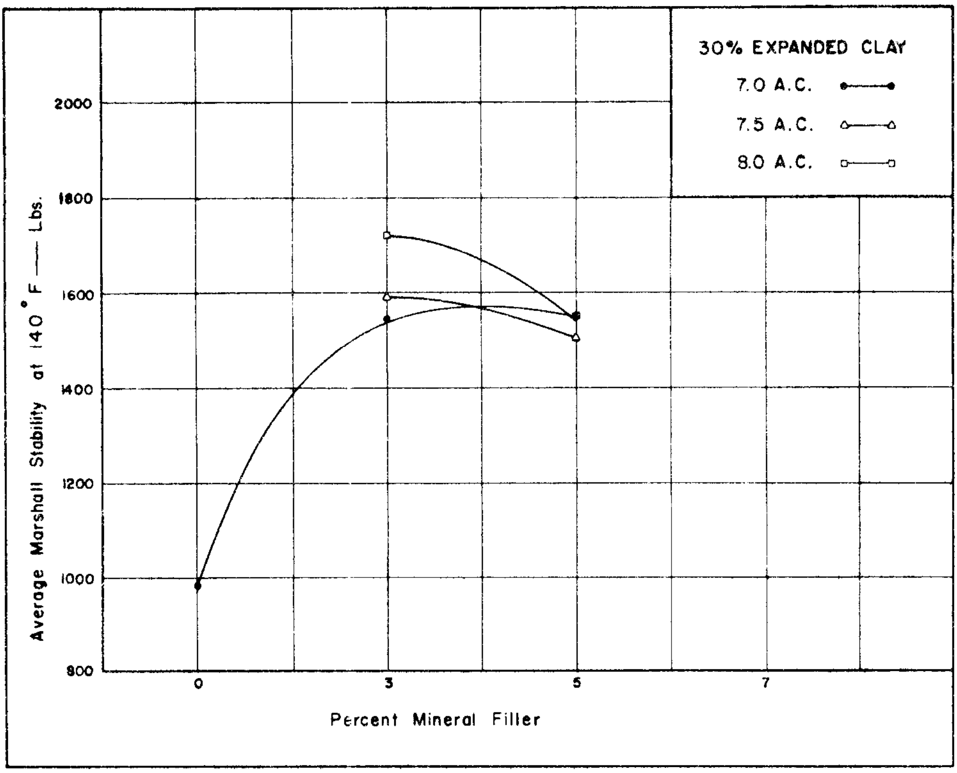



*Figure 13 - Average Marshall Stability Versus Percent Mineral Filler at Various Asphalt Contents for the 30 Percent Expanded Clay Mixes*

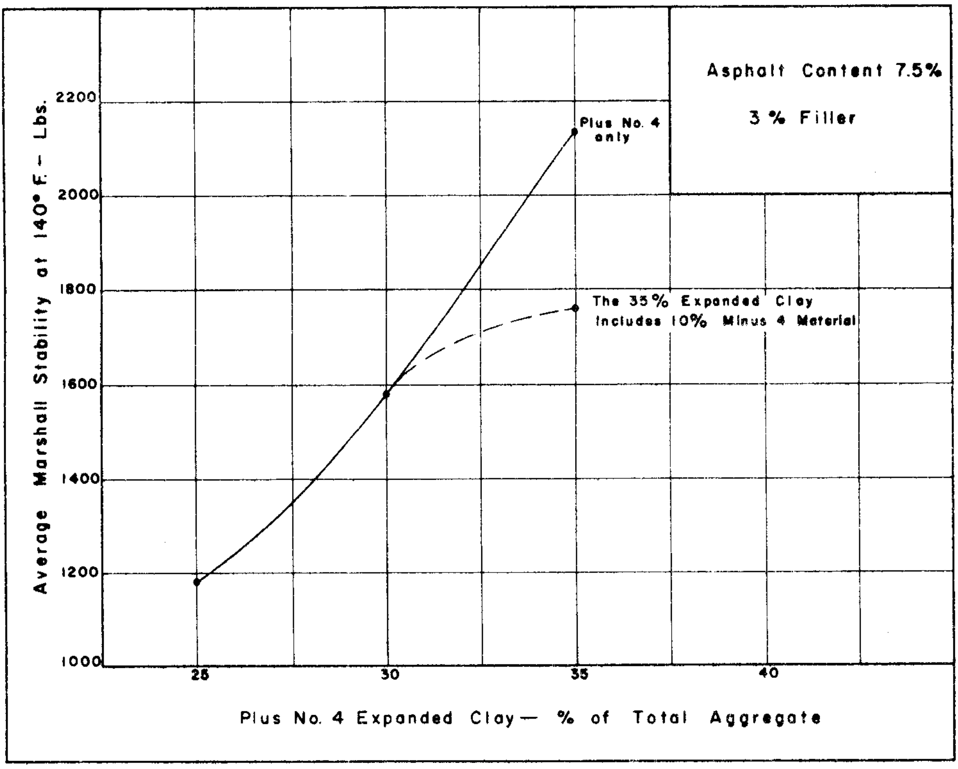



*Figure 14 - Average Marshall Stability Versus Plus No. 4 Expanded Clay in the Total Aggregate*

| | Percent Passing - by weight |
|---|---|
| Bitumen, % | 6.0- 8.5 |

Design Criteria

| | |
|---|---|
| Voids - Total Mix % | 5-8 |
| Voids Filled with Bitumen - % | 55-75 |
| Marshall Stability @ 140°F - Lbs. | 1200 min. |
| Flow 1/100 inch | 15 max. |

The theoretical gravities used to determine the voids and voids filled, were corrected values for the percentage of expanded clay in the specimens. The individual specific gravities of the components of the mix were determined using apparent specific gravities. A modified version of LDH TR -312 was used in determining the specific gravity of the expanded clay aggregate.

The limits used in the design criteria for voids and voids filled will depend primarily on the method selected for determining the theoretical gravity of the mix. Should different test methods be used, then the design criteria is likely to change from that specified in this report.

Effect of Rolling on Percent Compaction

In an effort to determine whether or not an optimum compactive effort could be determined, an extra test section was incorporated into the study. The number of passes of the pneumatic roller were varied from 13 to 19 on both lanes of the eastbound roadway of this test section. On the inside lane the three wheel breakdown roller made 3 passes and on the outside lane 5 passes. The objective was to determine whether or not a optimum rolling condition could be established for both the three wheel and pneumatic rollers. The mix on this test section consisted of 25 percent plus 4 expanded clay, 10 percent minus 4 expanded clay, sand, and 5 percent mineral filler at a 8.0 percent asphalt content.

As discussed previously a laboratory curve is essential in obtaining a true value for percent compaction. Figure 15 shows the laboratory curve, which is designated as laboratory curve 3, for this test section. The specimens used to determine this curve were compacted in the laboratory using the bin samples representing the extra test section. The correlation coefficient for this curve was 0.97, which indicates significant correlation. Three roadway cores were taken for each given number of passes of the pneumatic roller on the original cores and two on the 12 month cores. The cores were tested for specific gravity and extracted to determine the percentage of expanded clay. With this data the laboratory specific gravity was taken from laboratory curve 3 corresponding to the percentage of expanded clay in

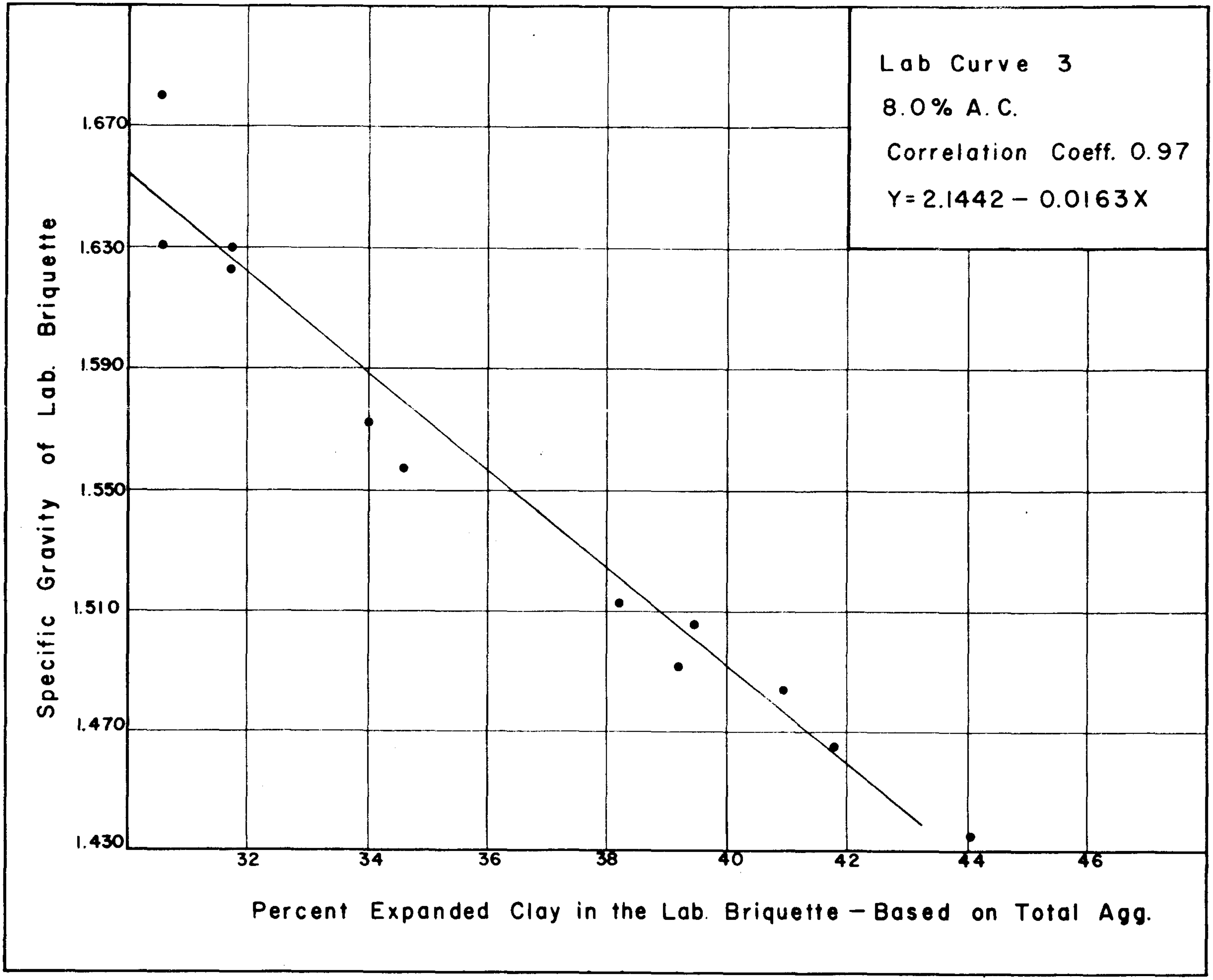



*Figure 15 - The Specific Gravity of the Laboratory Briquettes Versus Percent Expanded Clay in the Laboratory Briquettes for Laboratory Curve 3.*

the roadway cores.

Figure 16 shows the relationship of the average percent compaction versus the number of passes of the pneumatic roller. The figure shows that on the inside lane where only 3 passes of the three wheel roller was made, the percent compaction was higher than the outside lane having 5 passes with the breakdown roller. The only exception to this was at 17 passes of the pneumatic roller. Since the pneumatic roller is used primarily to obtain compaction from the bottom up, it is logical to believe that some bridging may occur if too many passes of the breakdown roller were used. This may have been the case for these particular curves, however, there is another point to be considered during breakdown, and that is whether or not the mix can support the pneumatic roller when using a minimum of breakdown passes. If during intermediate rolling the mix shows signs of rutting or shoving this may result not only in low compactions but also a very rough riding surface.

The two curves in Figure 16 are not considered to be ideal, however experience on other compaction studies proved to indicate similar variations. There are probably many other variables influencing the percent compaction at given locations which cannot be measured.

One very important observation concerning these curves, is that the percent compaction for all the plotted points is below 99 percent. This is considered a normal occurrence, however the previous laboratory curves 1 and 2 resulted in low specific gravities giving percent compactions of approximately 100 to 101. The reason for this is unknown at this time. Laboratory curves 1, 2 and 3 were determined using the same procedure with the only variation being the mix proportions and bin samples. It is not believed that the compaction in test sections 3W, 4W and 5W was any greater than that in the extra test section. Hopefully, these discrepancies can be solved on future projects.

Figures 17 and 18 show the relationship between percent compaction versus the number of passes of the pneumatic roller for the original and 12 month results on the inside and outside lanes respectively. There is not much to be said for these curves except that the percent compaction increased on both lanes after 12 months of service, as was anticipated. After 12 months there was no noticeable difference in the field due to varying the roller passes.

The only recommendation when rolling expanded clay mixtures is to use accepted standard practices. It is personally believed that the number of passes of the pneumatic roller is not critical on these mixes. All of the other test sections in this study were constructed with 5 passes of the three wheel roller, 13 passes of the pneumatic roller and the necessary tandem rolling to eliminate the roller marks. There was no evidence of the mix flushing even when as high as 19 passes were made with the pneumatic roller.

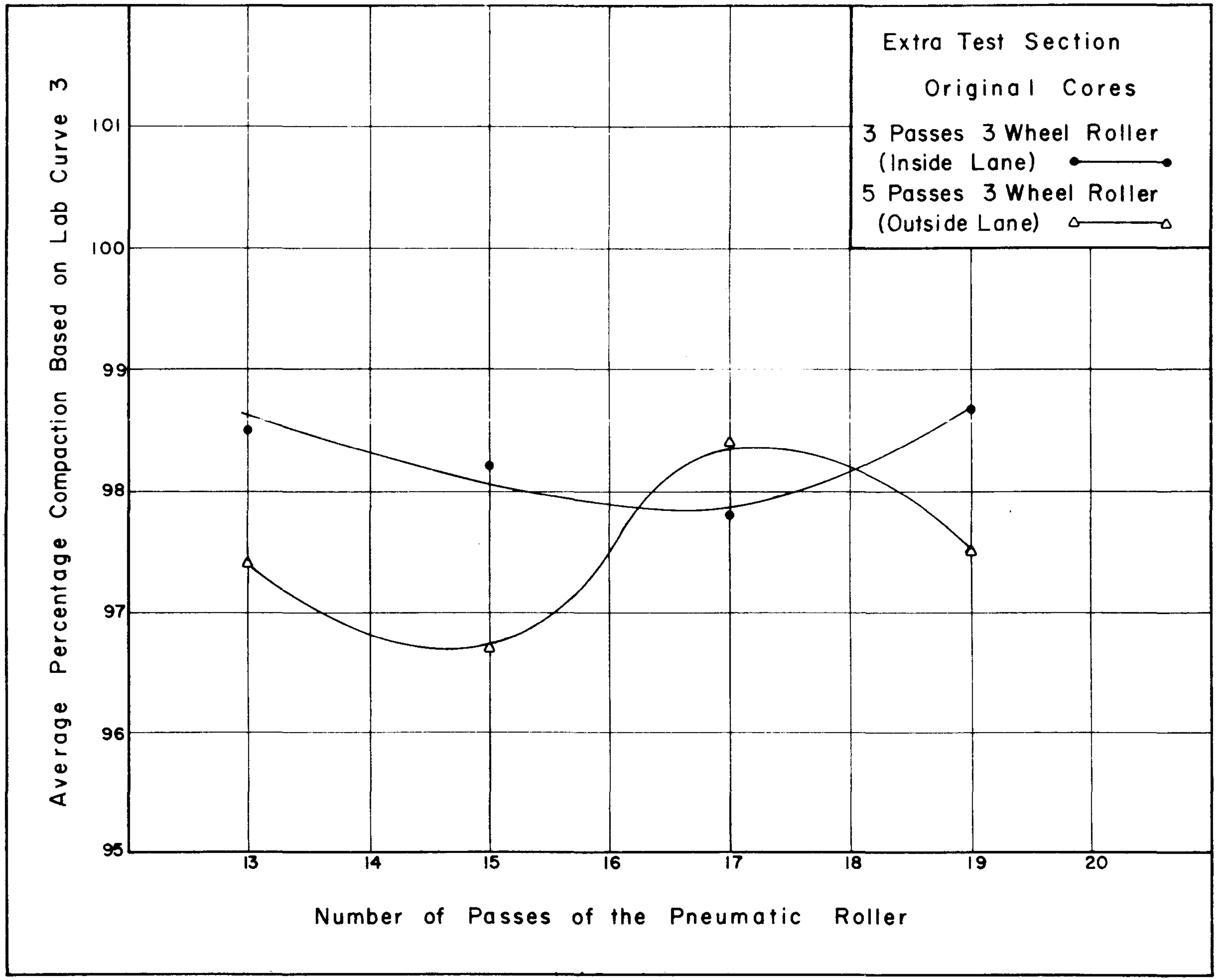



*Figure 16 - Average Percent Compaction Based on Laboratory Curve 3 Versus Number of Passes of the Pneumatic Roller on the Original Cores for the Extra Test Section.*

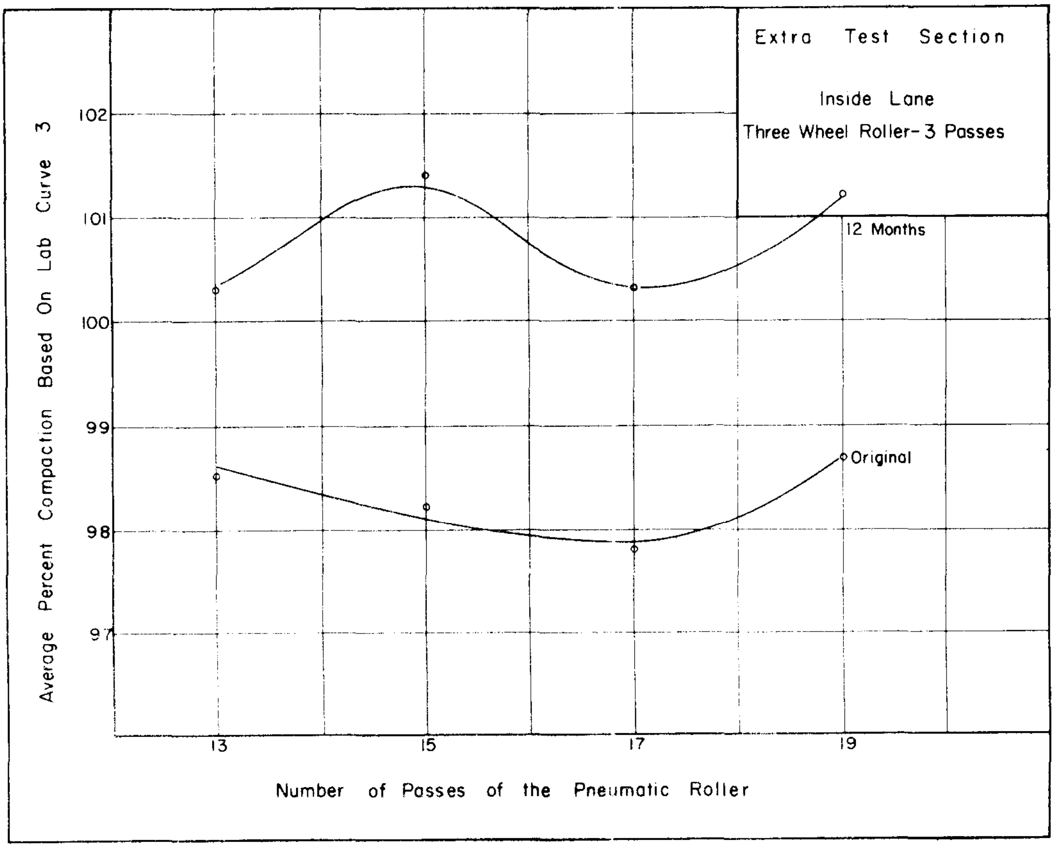



*Figure 17 - Average percent compaction based on Lab Curve 3 versus Number of Passes of the Pneumatic Roller Inside Lane for the original and 12 month cores*

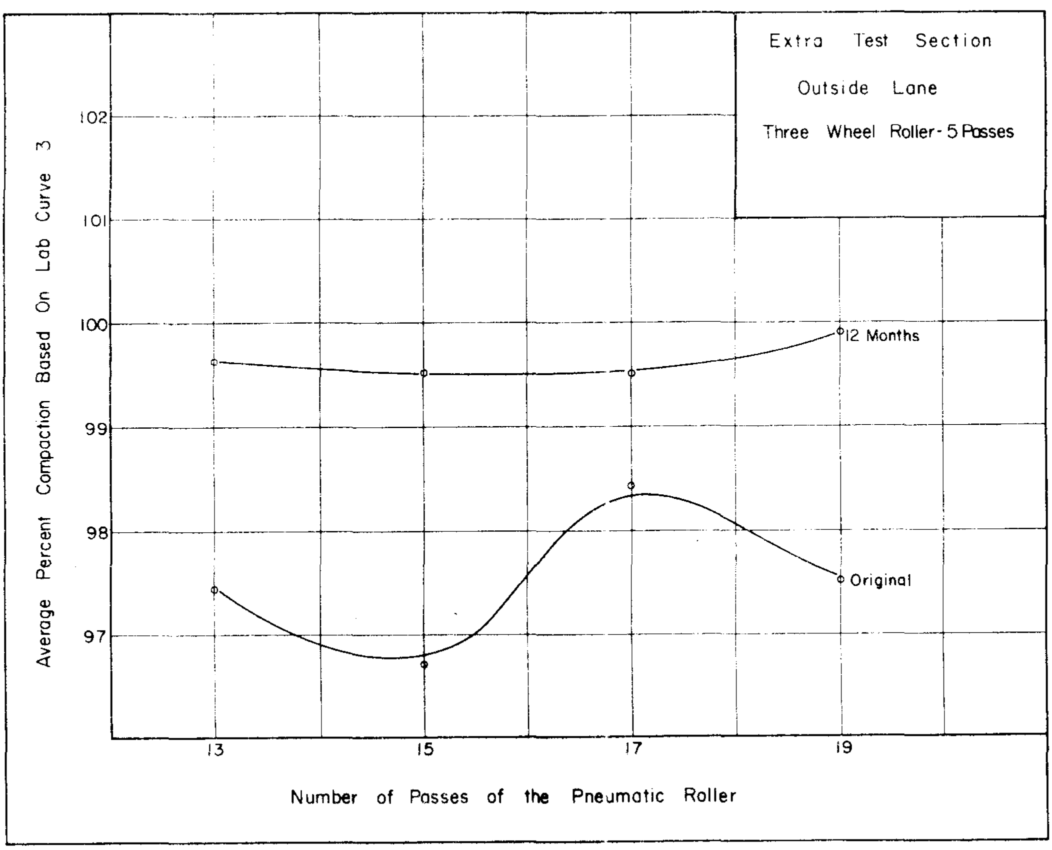



*Figure 18 - Average percent compaction based on Lab Curve 3 versus Number of Passes of the Pneumatic Roller Outside Lane for the original and 12 month cores*

## Longitudinal Grooves After 12 Months of Service

Longitudinal groove measurements otherwise known as rutting, is one method used to evaluate the surface condition of the pavement after being subjected to traffic. Approximately 25 measurements were taken on each test section, and the average of these measurements were used in attempting to find some correlation with the severity of the rutting. In general the rutting on this project was not excessive after 12 months of heavy traffic. The wheelpath having the highest average, measured 5mm (0.2 inches) with the lowest being 0.6mm or 0.002 inches.

Figure 19 shows bar graphs for each wheelpath of the eastbound and westbound roadways depicting the average longitudinal grooves for all the test sections. The graphs indicate that the most critical rutting occurs in the left wheelpaths of the outside lanes on both roadways. This is understandable since these are the lanes that carries the heavier truck traffic.

Figure 20 gives the relationship of the average longitudinal grooves versus the percent expanded clay and the percent asphalt content. Only the averages of the left wheelpaths outside lanes were used since it was the most critical. The graphs don't appear to give any particular trend. The 25 percent expanded clay mix showed the lowest grooves, however, there is no logical reasoning for this. It may be significant that the highest asphalt content gave the highest grooves. It should be emphasized that there are many factors that influence rutting, therefore these graphs represent what was found on this study and should not be taken without reservation. The difference in the magnitude of the grooves was not substantial and therefore, it would be inaccurate to relate any one characteristic of the mix to the deviations in grooves.

Figure 21 shows the relationship of longitudinal grooves versus asphalt content. This curve may be somewhat more significant since it deals with a mix having 30 percent expanded clay and is not an average for mixes having different expanded clay percentages, as in Figure 20. As indicated by the curve the grooves were approximately the same at 7.0 and 7.5 percent asphalt and increased approximately 1.7 millimeters at 8.0 percent. It is too soon to determine whether 8.0 percent asphalt is excessive or whether the rutting will continue to increase. At this time rutting is not a problem on any of the test sections.

## Skid Resistance

Probably one of the most important characteristics of a finished hot mix surface is its resistance to skidding. Skid resistance measurements were made on each test section at 4 month time intervals, from immediately after construction until 12 months after construction. The skid numbers at 40 mph are listed in Table 17 Appendix "G" for each of the test sections at the various time intervals. The skid numbers, which is the coefficient of friction multiplied by 100, shown in

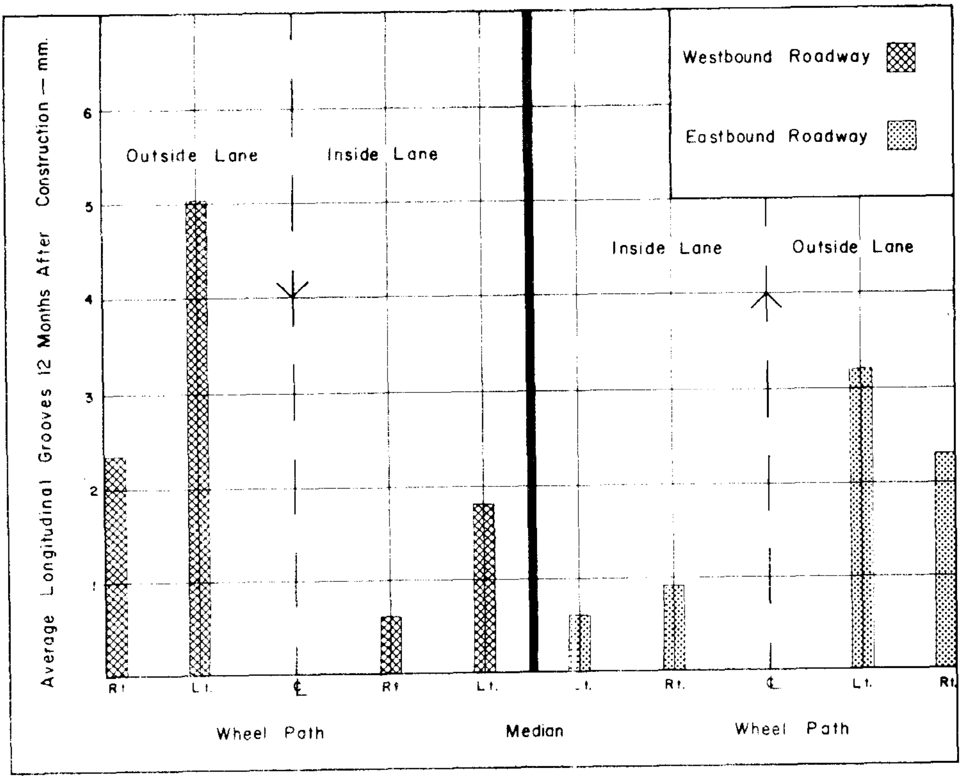



*Figure 19 - Average Longitudinal Grooves for the Various Wheelpaths of the Westbound and Eastbound Roadways after 12 Months of Service*

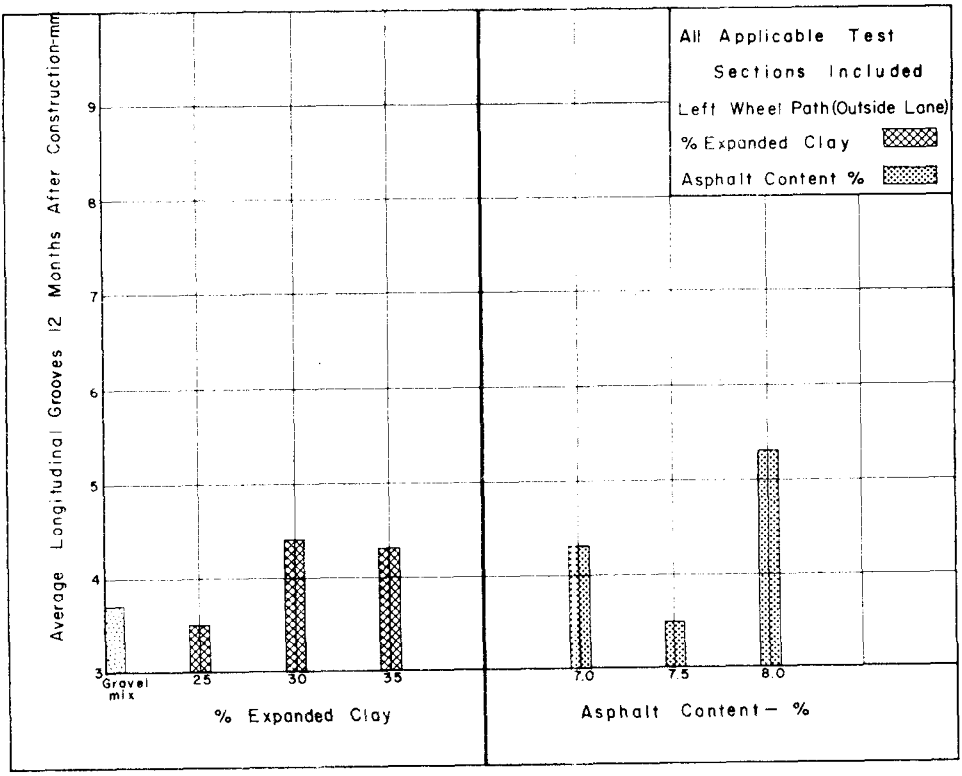



*Figure 20 - Average Longitudinal Grooves Versus Percent of Expanded Clay and Asphalt Content after 12 Months of Service*

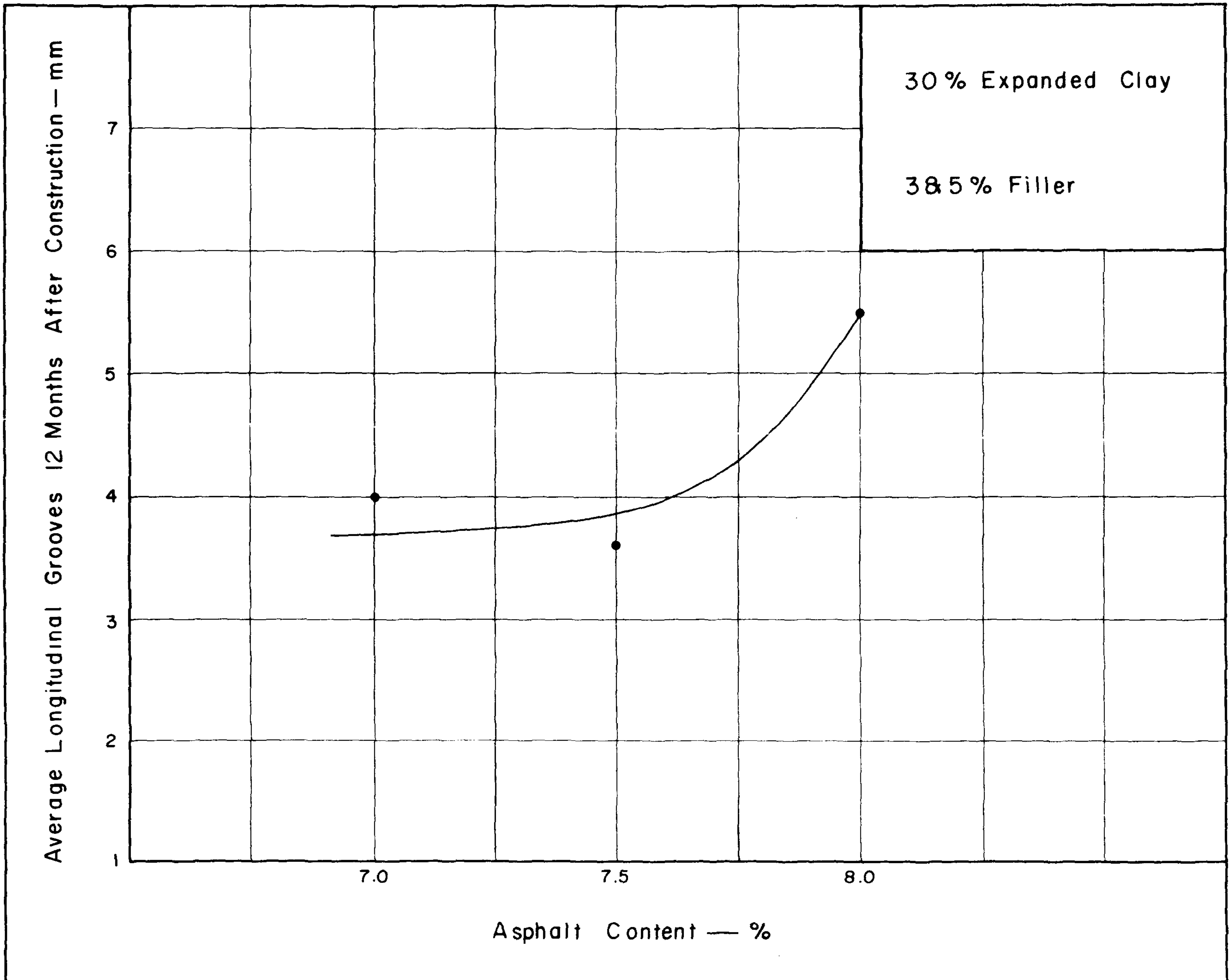



*Figure 21 - Average Longitudinal Grooves Versus Asphalt Content After 12 Months of Service for the 30 Percent Expanded Clay Mixes.*

the table is an average of five measurements per test section. The skid resistance was measured by means of a standard skid trailer, which was built by the Department in accordance to ASTM E-274 entitled "Skid Resistance of Pavements Using A Two-Wheel Trailer".

Figure 22 shows the average skid number versus asphalt content for all of the applicable test sections. It appears from the graphs that the asphalt content did not have any major influence on the skid numbers for the expanded clay mixes either on the original or 12 month results. The gravel mix on both graphs are lower in skid number than the expanded clay mixes. The original average skid number was approximately 45 for the expanded clay mixes and 38 for the gravel mix. After 12 months of service the skid number increased to 57 for the expanded clay mixes and 47 for the gravel mix.

The largest influence on skid resistance due to the mix design appears to be the percentage of expanded clay in the mix. Figure 23 shows the relationship between the average skid number and the percent of expanded clay in the mix. The skid numbers obtained immediately after construction (0 month) showed an increase as the percentage of expanded clay in the mix increased. Each of the curves showed an increase in skid numbers with age. After approximately 4 months of service the skid numbers for 30 and 35 percent expaned clay were practically the same. The skid numbers at 25 percent expanded clay also increased with time, however, they were lower than the 30 and 35 percentages at the corresponding time intervals.

Figure 24 shows the relationship of the average skid numbers versus age. All of the average skid numbers increased with age up to 12 months. The slope of the gravel mix curve was less than the expanded clay curve indicating that the expanded clay mix is increasing in skid resistance at a greater rate. Whether or not the skid numbers begin to level off, or continue to increase remains to be seen. It is anticipated that the expanded clay mixes will begin to level off and that the gravel mix will tend to decline. The reason for this assumption is that the coarse gravel aggregate becomes exposed, due to traffic wear, much quicker than the coarse expanded clay aggregate. The exposed gravel being a harder material will tend to polish rather than wear down. On the other hand the coarse expanded clay aggregate will usually wear as the fines in the mix wear, and the expanded clay being a very porous material is able to maintain its skid resistance.

Figure 25 shows three photographs of the surface after being subjected to traffic for 12 months. Photograph A shows a close up of an expanded clay mix and as can be seen the only exposed aggregate showing is the very small gravel particles that were in the fines. The coarse expanded clay aggregate remains completely coated with asphalt, and after 12 months has not become exposed. Photograph B shows a close up of the gravel mix, and it is very obvious that the coarse gravel particles have become exposed. It has been observed on many gravel hot mixes

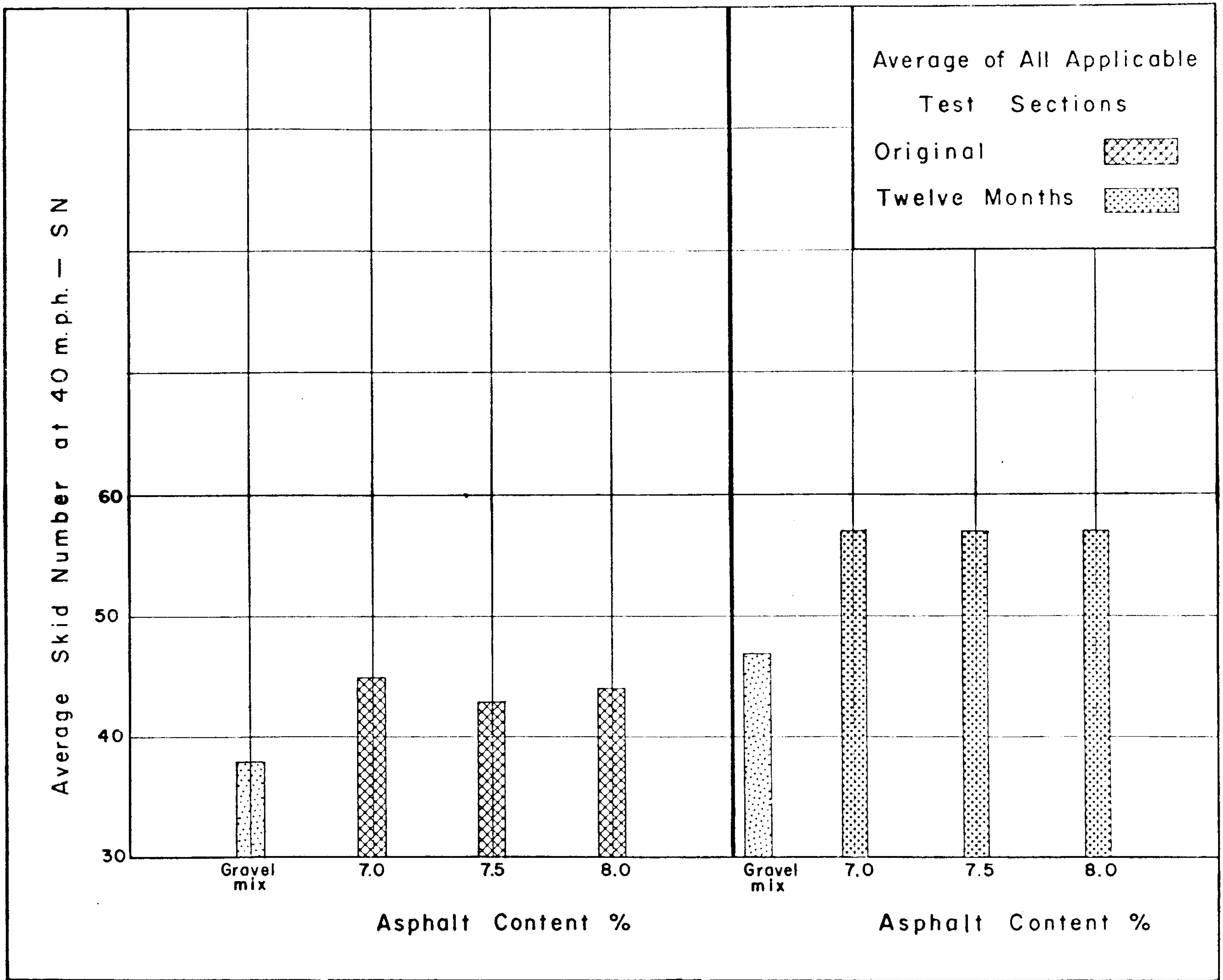



*Figure 22 - Average Skid Number at 40 M.P.H. Versus Asphalt Content for the Original and 12 Month Intervals.*

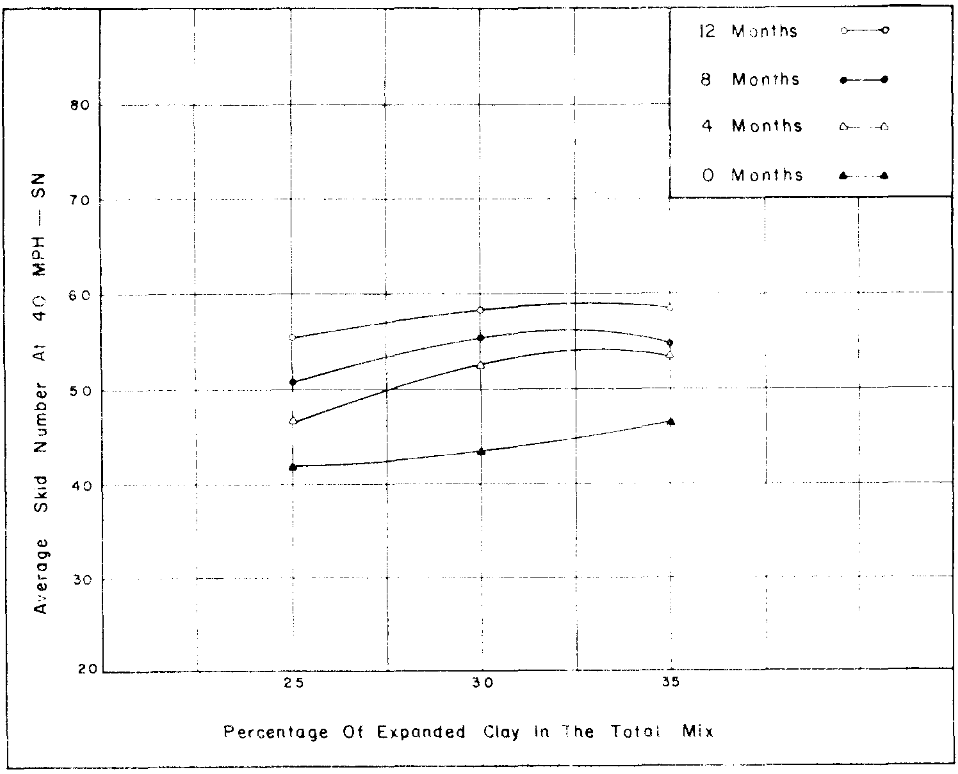



*Figure 23 - Average Skid Number of 40 M.P.H. Versus Percent of Expanded Clay in the Mix at various time Intervals*

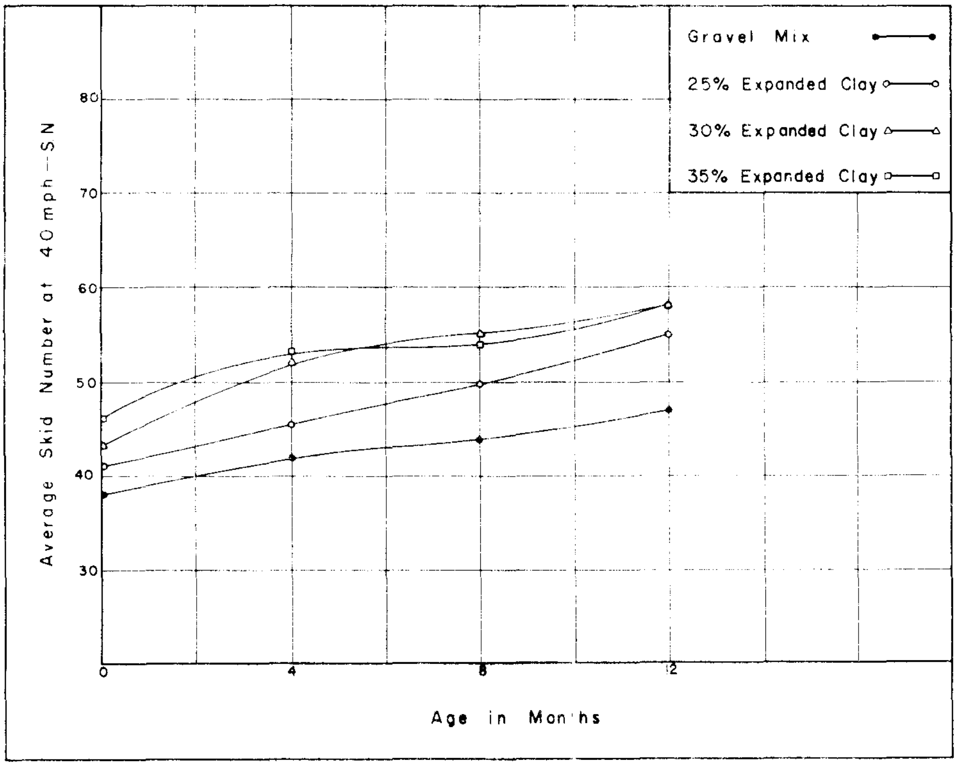
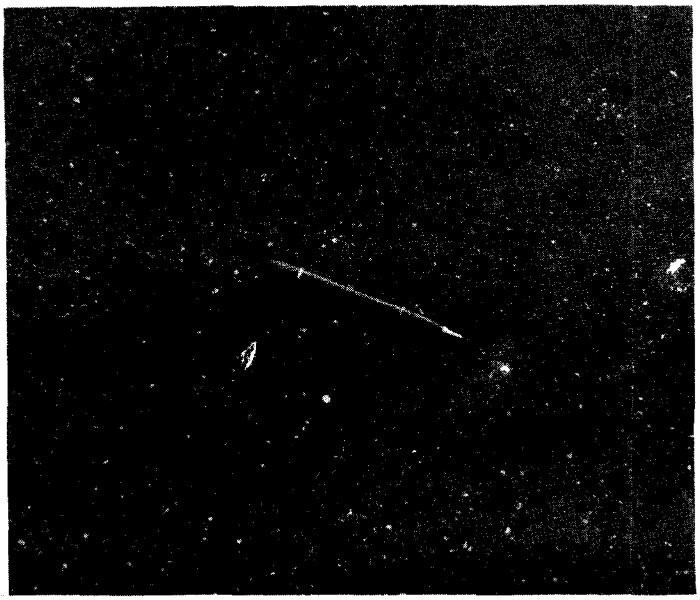
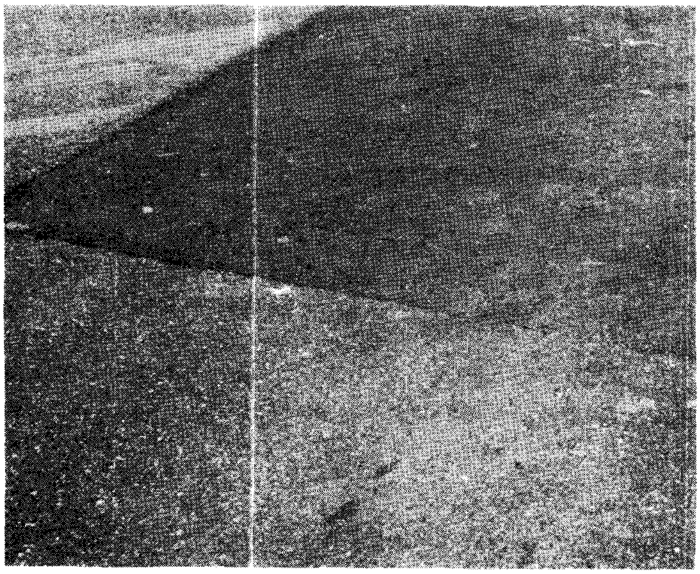



*Figure 24 - Average Skid Number at 40 M.P.H. Versus Age of the Gravel Mix and Various Expanded Clay Mixes*



*(A) Expanded Clay Mix*

*(B) Gravel Mix*



*(C) Expanded Clay and Gravel Mixes*

*Figure 25 - Photographs of a typical expanded clay and gravel test section after 12 months of service*

that the asphalt wears off the aggregate in a very short period after it has been open to traffic. In some instances evidence of this can be seen during pneumatic rolling.

The explanation for this is simply the difference in absorption between the expanded clay and gravel aggregates. The expanded clay absorbs the asphalt at the surface, whereas, the gravel is merely coated with asphalt, as if it were painted on. Photograph C of Figure 25 shows the difference in appearance between the expanded clay mix and the gravel mix after 12 months of traffic. The upper portion of the photograph is the expanded clay mix which gives a much darker appearance than the gravel mix (lower portion). This, of course, is due to the exposure of the gravel on the surface. Skid resistance measurements will be continued, at least up to a period of twenty four months, at which time final conclusions on skid resistance will appear in Part II of the final report.

## Roughness Results

Roughness results were obtained on each test section immediately and 12 months after construction. The roughness results obtained for the various test sections were very erratic. An attempt was made to determine what physical characteristics of the different mixes, influenced the roughness. However, this attempt was in vain due to the wide variations in roughnesses between the test sections. It was impossible to get any reliable data by averaging results due to these variations.

Regardless of the roughness values, the test sections were inspected by riding over the project immediately after construction and in general the test sections were considered rough. Whether or not this roughness was due to one or several properties of the mix is undetermined. There are a number of things to be considered when evaluating the roughness of these test sections. Probably one of the most important is that these mixes were spread with a conventional self propelled spreader without electronic screed control. The existing surface on which these test sections were laid was in very poor condition. Due to a 6 month strike by the sand and gravel truckers, this project was delayed nearly a year from the anticipated starting date. Many of the new concrete patches were already badly cracked by the time overlay began. Some areas were worse than others, which is probably the reason for the variations between test sections.

The roughness results obtained on all the test sections are shown in Table 19 Appendix "G". It may be noted that the majority of the roughnesses increased after service. The right wheelpath of the outside lane on the eastbound roadway showed the highest roughness results, however, that was the wheelpath where a longitudinal crack developed at the joint of the existing pavement and the 3 foot widening. The 3 foot widening was a Portland cement concrete widening constructed only on the eastbound roadway.

## Present Serviceability Index on the Wearing Surface

Another method of evaluating the riding surface of a pavement is by determining the present serviceability index (psi). These values were determined by the use of a Portland Cement Association roadmeter which is mounted on the rear axle of an automobile. The values determined with this equipment is somewhat different than that obtained with the Roughness Indicator. The values depict the roughness a motorist would feel when riding over a particular pavement. The psi values were determined for each test section 12 months after construction.

Figure 26 shows the average psi values for each lane on the eastbound and westbound roadways. Values below 2.5 indicate that the surface is rough. The inside lane of the westbound roadway and the outside lane of the eastbound roadway both have average values below 2.5. As mentioned for roughness the low psi value in the outside lane is probably due to the longitudinal crack caused by the 3 foot widening.

Figure 27 shows the relationship between psi and asphalt content with the parameters being the percent of expanded clay aggregate in the mix. The curves indicate that the psi values decrease as the asphalt content increases. It also shows that the higher percent of expanded clay in the mix gives higher psi values at a given asphalt content. It may be recalled that the highest percentage of expanded clay in the mix also gave the highest stabilities. This could be a factor in the psi values after 12 months of service, however, with all the other variables involved it is very difficulty to single out one, as a basis for evaluation. The gravel mix represented by the bar graph in Figure 27 had an average psi value of 2.5.

The average psi values for all the test sections are shown in Table 20 of the Appendix. It is evident from the table that variations occur when using the same mix in different locations. Therefore, it is believed that the largest influence on the riding surface is the quality of the existing surface rather than the type of mix or mix design.

## Appearance of the Roadway After 12 Months Service

The appearance of the test sections in general is satisfactory. There was very little difference indicated on the roadway between test sections. There was no excessive rutting, shoving, ravelling or flushing in any of the test sections.. There was some reflection cracking on all sections, however, no more than would normally be expected on any hot mix overlay. Figure 28 photograph A shows a typical longitudinal crack on the old existing pavement. With cracks like these and an overlay of only 3 1/2 inches, reflection cracking is inevitable. Photograph B shows a view of the eastbound roadway. The darker mix toward the front of the photograph is an expanded clay mix. The ligher mix toward the back is a gravel control mix. This is typical of all the test sections after 12

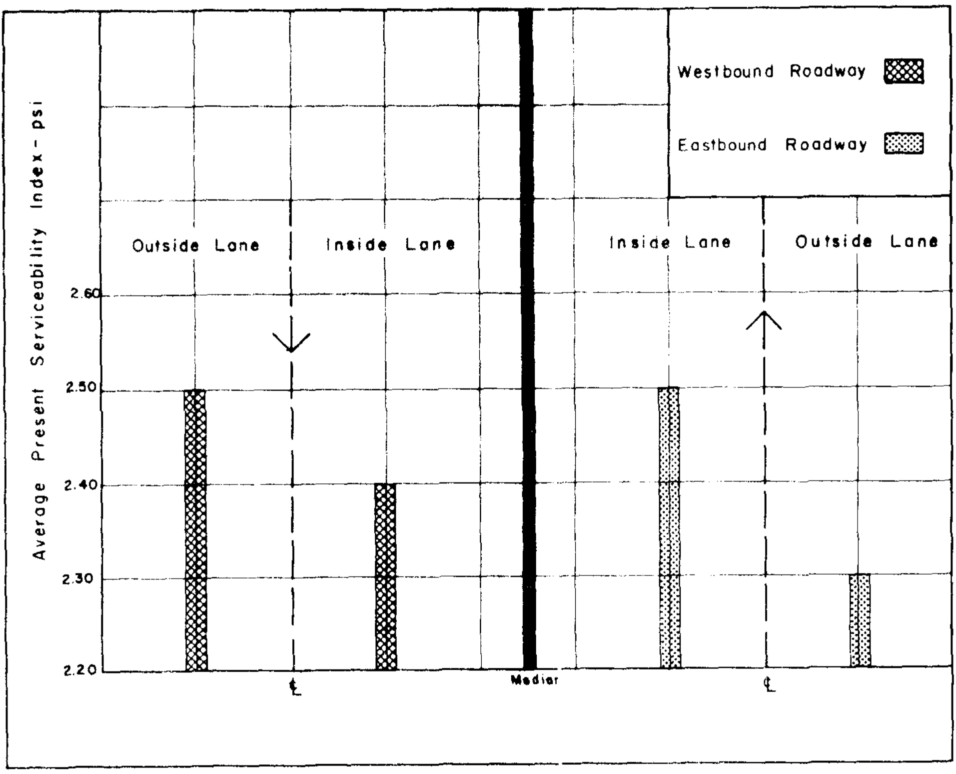



*Figure 26 - Average Present Serviceability Index for Each Lane of the Westbound and Eastbound Roadways After 12 Months of Service*

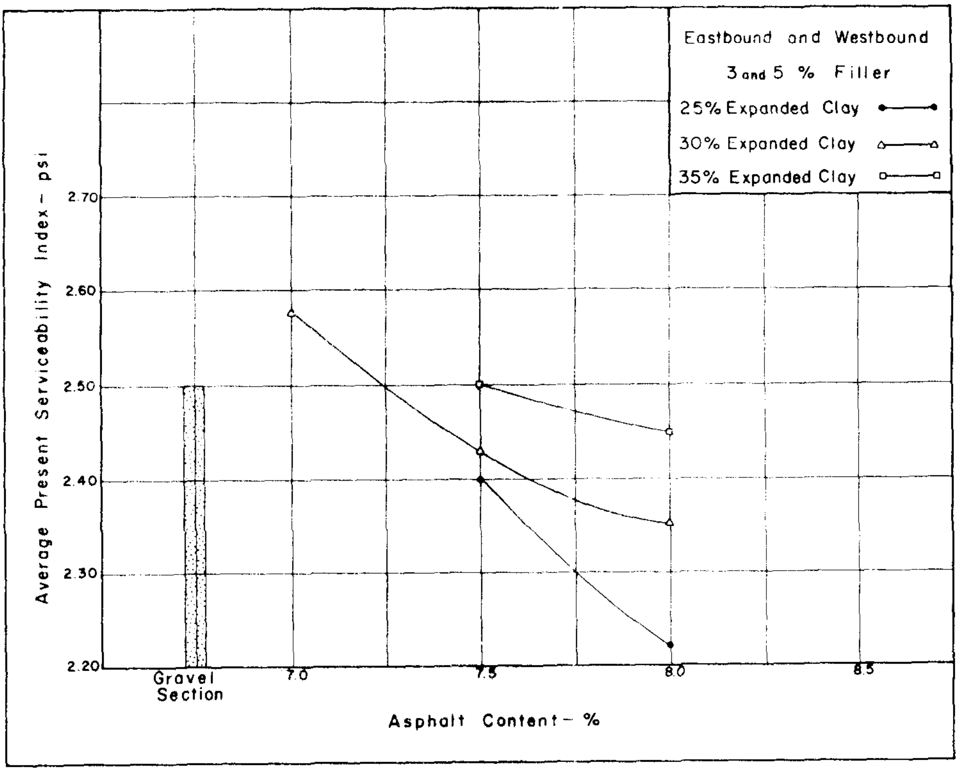
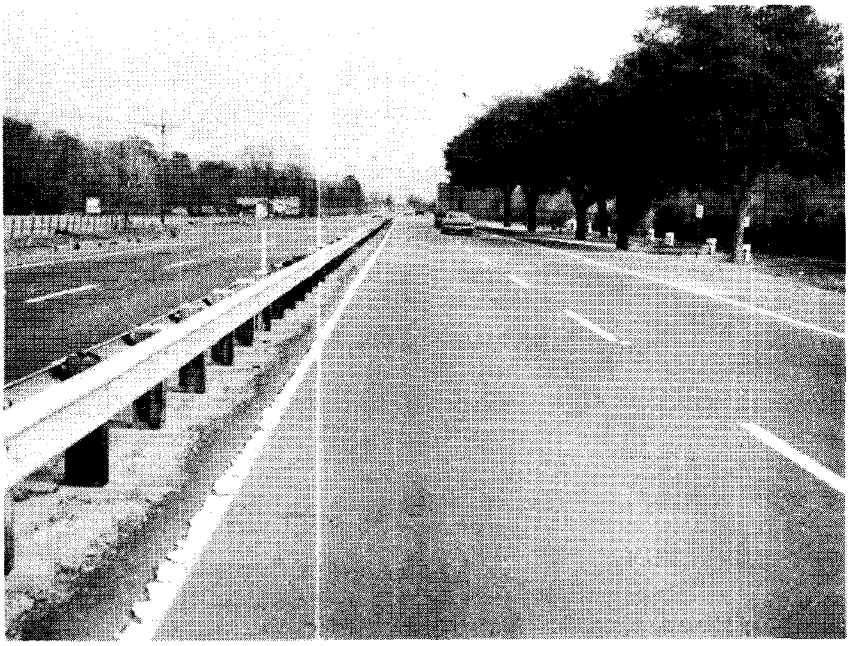



*Figure 27 - Average Present Serviceability Index Versus Asphalt Content at Various Expanded Clay Percentages after 12 Months of Service*

*(A) Existing Pavement Crack before Overlay*



*(B) Typical Test Section after 12 months of service*

*Figure 28 - Photographs of the Roadway Condition before overlay and after 12 months of service*

*Figure 29 - Photograph of the Pumping and Cracking occurring on the Concrete Widening of the Eastbound Roadway 12 months after overlay*

The photograph also shows the pumping that occurs at the transverse widening crack. There was no other pumping observed on the westbound or eastbound roadways with exception of the widening. The existing pavement was undersealed prior to overlaying.

During construction of the hot mix test sections, it was observed that reflection cracks were developing as little as one day after compaction inside of the widening.

Even though the project was considered to have a rough riding surface, and pumping occurred in the widening, this should have no bearing on the evaluation of expanded clay hot mix. These same problems were encountered on the gravel hot mix and probably would have occurred on any other hot mix if constructed under the same conditions. Expanded clay hot mix, at this time, appears to be suitable for use as an alternate for any other hot mix used in Louisiana.

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# APPENDIX "A"

## DETAILED DESCRIPTION OF TEST SECTIONS

DETAILED DESCRIPTION OF TEST SECTIONS

Eastbound Roadway

A typical section for the eastbound roadway consisted of a 1 1/2 inch Wearing Course lift overlaying an existing concrete pavement and asphaltic concrete pavement overlay.

| Test Section | Station | Description |
|---|---|---|
| 1E | 1018-1048 | Control section Type 1 Wearing Course mix consisting of crushed gravel, sand, 5% mineral filler and 5.1% asphalt cement. |
| 2E | 1050-1079 | Type 4 mix 30% plus No. 4 expanded clay, sand, 3% mineral filler and 7.5% asphalt cement. |
| 3E | 1094-1113 | Type 4 mix 30% plus No. 4 expanded clay, sand, 5% mineral filler and 7.0% asphalt cement. |
| 4E | 1139-1165 | Type 4 mix 30% plus No. 4 expanded clay, sand, 5% mineral filler and 8.0% asphalt cement. |
| 5E | 1165-1191 | Type 4 mix 30% plus No. 4 expanded clay, sand, 5% mineral filler and 7.5% asphalt cement. |
| 6E | 1115-1139 | Control section Type 1 Wearing Course mix consisting of crushed gravel, sand, 5% mineral filler and 5.1% asphalt cement. |
| 7E | 1200-1218 | Type 4 mix 25% plus No. 4 expanded clay, 10% minus No. 4 expanded clay, sand, 5% mineral filler and 7.5% asphalt cement. |
| 8E | 1219-1243 | Same as section 7E with the exception of 8.0% asphalt cement. |
| 9E | 1259-1285 | Type 4 mix 25% plus No. 4 expanded clay, sand, 3% mineral filler and 7.5% asphalt cement. |
| 10E | 1287-1314 | Same as section 9E with the exception of 5% mineral filler. |

Westbound Roadway

A typical section for the westbound roadway consisted of a 1 3/4 inch Binder Course and a 1 3/4 inch Wearing Course overlaying an existing concrete pavement. In all test sections except 4W and 5W, a Wearing Course mix was used for both lifts.

| Test Section | Station | Description |
|---|---|---|
| 1W | 1018-1048 | Control section Type 1 Wearing Course mix consisting of crushed gravel, sand, 5% mineral filler and 5.1% asphalt cement. |
| 2W | 1050-1079 | Type 4 Wearing Course mix 30% plus No. 4 expanded clay, sand, No mineral filler<br>Bottom lift - 1 3/4 inches, 8% asphalt cement<br>Top lift - 1 3/4 inches, 7% asphalt cement. |
| 3W | 1094-1113 | Type 4 Wearing Course mix, 30% plus No. 4 expanded clay, sand, 3% mineral filler.<br>Top and Bottom lift - 7% asphalt cement. |
| 4W | 1141-1163 | Type 4 mix 30% plus No. 4 expanded clay, sand, 3% mineral filler.<br>Bottom lift - Binder Course mix 2 inches thick, 8% asphalt cement.<br>Top lift - Wearing Course mix 1 1/2 inches thick, 8% asphalt cement. |
| 5W | 1174-1191 | Type 4 Mix<br>Bottom lift - Binder Course mix 35% plus No. 4 expanded clay, sand, 3% mineral filler, 2 inches thick, 7.5% asphalt cement.<br>Top lift - Wearing Course mix 30% plus No. 4 expanded clay, sand, 3% mineral filler, 1 1/2 inches thick, 7.5% asphalt cement. |
| 6W | 1115-1139 | Control section Type 1 Wearing Course mix consisting of crushed gravel, sand, 5% mineral filler and 5.1% asphalt cement. |
| 7W | 1193-1214 | Type 4 mix 25% plus No. 4 expanded clay, 10% minus No. 4 expanded clay, sand, 3% mineral filler.<br>Bottom and Top lift - 7.5% asphalt cement. |

| Test Section | Station | Description |
|---|---|---|
| 8W | 1219-1243 | Same as section 7W with the exception of 8.0% asphalt cement. |
| 9W | 1258-1277 | Inside lane - Top and Bottom lifts - Type 4A mix 35% plus No. 4 (Regular expanded clay), sand, 3% mineral filler, 7.5% asphalt cement.<br>Outside lane - Bottom lift - Type 4A mix 35% plus No. 4 (Regular expanded clay), sand, 3% mineral filler, 7.5% asphalt cement.<br>Top lift - Type 4 Wearing Course mix 35% plus No. 4 expanded clay, sand, 3% mineral filler, 7.5% asphalt cement. |
| 10W | 1287-1313 | Inside lane - Bottom lift - Type 4A mix 35% plus No. 4 (Regular expanded clay), sand, 3% mineral filler, 8% asphalt cement.<br>Outside lane - Top and Bottom lifts - Type 4 Wearing Course mix 35% plus No. 4 expanded clay, sand, 3% mineral filler, 8% asphalt cement. |

# APPENDIX "B"

# MANUFACTURING PROCESS OF EXPANDED CLAY AGGREGATE

## MANFACTURING PROCESS OF EXPANDED CLAY AGGREGATES

The expanded clay aggregate is manufactured by the Rotary Kiln Process. The expanded clay aggregate is made from a heavy clay, A-7-6 soil, having a plasticity index of approximately 52.

The following photographs show the manufacturing process in sequence for expanded clay aggregates.

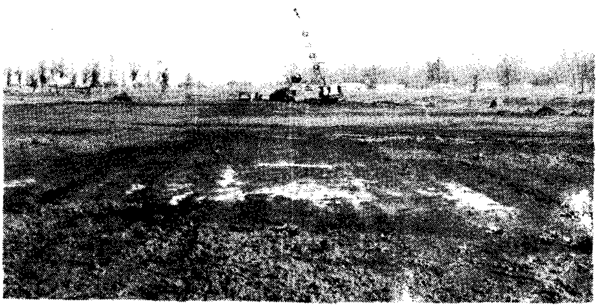
Photograph A shows a typical clay field located at Big River Industries. The raw material is obtained from this field and several other similar fields located on the plant site. The clay may be hauled from the fields by large scrapers or may be dug out with a dragline and hauled to the plant site in trucks. In this particular photograph the raw material was being dug out by a dragline.

The raw material is then hauled to an area shown in Photograph B in which a bulldozer is used to feed the raw material into a underground screw feeder (photograph C). The screws are used primarily to break the large clay chunks into smaller pieces approximately 4 inches in diameter. This is also aided by a continuous flame located below the screws which helps to drive out some of the free moisture in the clay.

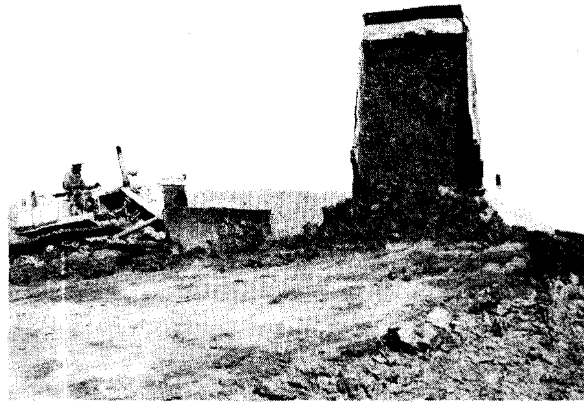
After the raw material passes through the screws it is lifted up to a gas dryer by means of a conveyor belt (photograph D). The material when entering the dryer may have a moisture content of approximately 35 percent. On leaving the dryer the moisture content of the material may be approximately 15 percent. Again by conveyor the material is transported to the dry shed (photograph E). From the dry shed the material is lifted to the kiln. Photograph F shows the conveyors which transports the material to the kiln, and Photograph G shows the four rotary kilns. In the kiln the material is heated to a temperature of 2000°F for approximately 45 minutes at which time it is discharged from the rear of the kiln (photograph H).

The expanded clay after discharge is then stockpiled (photograph I) and later screened into individdal sizes by means of a screening plant (photograph J). The material can then be loaded directly into box cars are blended together to a given gradation.

This is basically the manufacturing process incorporated by Big River Industries and the process by which the expanded clay aggregate used in this study was manufactured.

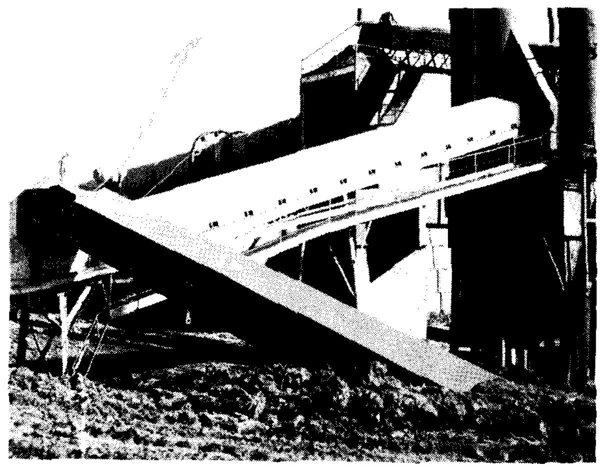


A

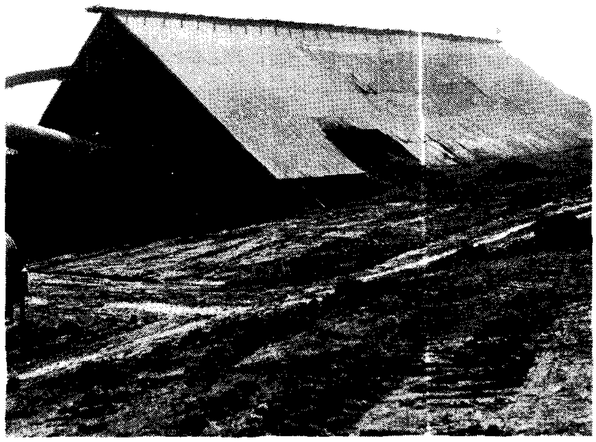


B

C

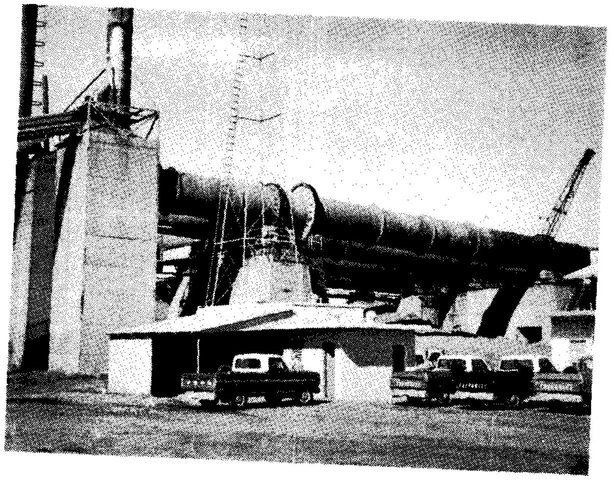


D

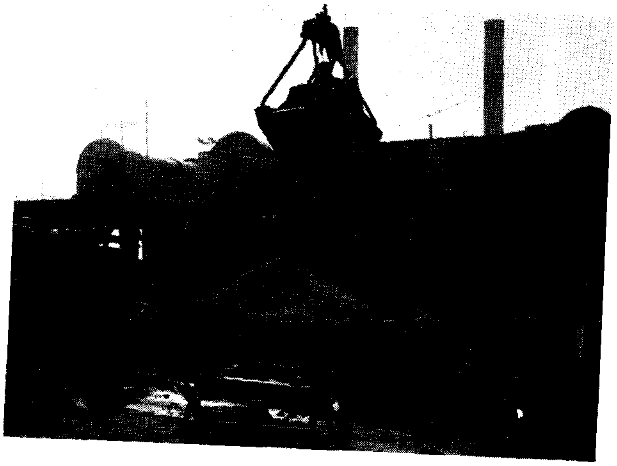


E

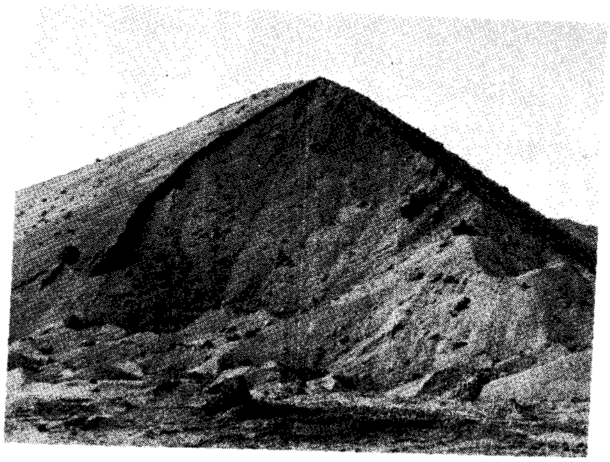
F



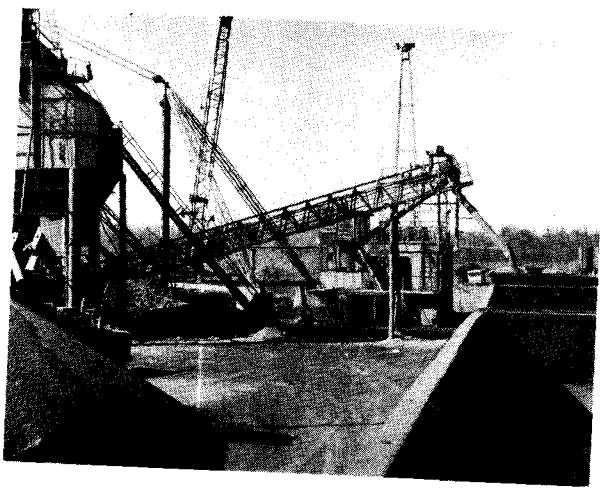
G



H



I



J

# APPENDIX "C"

## TEST RESULT ON ASPHALT CEMENT
## TYPICAL BIN GRADATIONS FOR THE VARIOUS TEST SECTIONS
## (WEARING & BINDER COURSES)
## BIN PROPORTIONS FOR THE TEST SECTIONS

TABLE 1

TEST RESULTS OF ASPHALT CEMENT

Refinery - Humble Oil Company 60/70

| | |
|---|---|
| Laboratory Number | 941666 |
| Specific Gravity 77°F | 1.027 |
| Specific Gravity 60°F | 1.030 |
| Wt. per gallon at 60°F lbs. | 8.587 |
| Flash Point, C. O. C. °F | 610 |
| Viscosity | |
| Saybolt Furol Sec. @275°F | 306 |
| Absolute @ 140°F poises | 3,690 |
| Penetration @ 77°F, 100 g., 5 sec. | 61 |
| Thin Film Oven Test | |
| Loss % @ 325°F, 5 hrs. | 0.01 |
| Penetration of Residue @ 77°F | 49 |
| Residue Penetration, % of Original | 80 |
| Ductility of Residue @ 77°F | 100+ |
| Solubility in $CS_2$, % | 99.84 |
| Homogeniety Test | Negative |
| Mixing Temperature | 319-326 |

Remarks: This sample conforms to specifications for 60/70 grade asphalt cement

TABLE 2

TYPICAL BIN GRADATIONS FOR THE VARIOUS TEST SECTIONS
Wearing Course Mixes

| U. S. Sieve | Section 1 and 6 E & W Bin 1 | Section 1 and 6 E & W Bin 2 | Sections 2, 3, 4 & 5 E & W Bin 1 | Sections 2, 3, 4 & 5 E & W Bin 2 |
|---|---|---|---|---|
| | % Passing | | | |
| 3/4" | | 100 | | 100 |
| 1/2" | | 98 | | 91 |
| 3/8" | 100 | 77 | 100 | 44 |
| No. 4 | 98 | 3 | 99 | 2 |
| No. 10 | 82 | | 92 | 0.3 |
| No. 40 | 46 | | 51 | |
| No. 80 | 12 | | 14 | |
| No. 200 | 4 | | 4 | |

| U. S. Sieve | Sections 7 & 8 E & W Bin 1 | Sections 7 & 8 E & W Bin 2 | Section 9 W (Regular Expanded Clay) Bin 1 | Section 9 W (Regular Expanded Clay) Bin 2 |
|---|---|---|---|---|
| 3/4" | | 100 | | 100 |
| 1/2" | | 97 | | 98 |
| 3/8" | 100 | 55 | 100 | 75 |
| No. 4 | 99 | 2 | 97 | 1 |
| No. 10 | 88 | | 83 | |
| No. 40 | 47 | | 44 | |
| No. 80 | 13 | | 11 | |
| No. 200 | 3 | | 5 | |

| U. S. Sieve | Sections 9 & 10 E & W Bin 1 | Sections 9 & 10 E & W Bin 2 |
|---|---|---|
| 3/4" | | 100 |
| 1/2" | | 96 |
| 3/8" | 100 | 70 |
| No. 4 | 99 | 2 |
| No. 10 | 92 | |
| No. 40 | 57 | |
| No. 80 | 17 | |
| No. 200 | 4 | |

TABLE 2 (CONTINUED)

TYPCIAL BIN GRADATIONS FOR THE VARIOUS TEST SECTIONS
Binder Course Mixes

Section 4 & 5 E & W

| U. S. Sieve | % Passing | |
|---|---|---|
| | Bin 1 | Bin 2 |
| 3/4" | | 100 |
| 1/2" | | 72 |
| 3/8" | 100 | - |
| No. 4 | 99 | 1 |
| No. 10 | 92 | |
| No. 40 | 56 | |
| No. 80 | 13 | |
| No. 200 | 4 | |

Apparent Specific Gravities

| | |
|---|---|
| Bin 1 | 2.651 |
| Bin 2 | 1.231 (Expanded Clay) - 2.608 (Gravel Control) |
| Mineral Filler | 2.743 |
| Asphalt Cement | 1.030 |

| | Test Method | Expanded Clay | Gravel |
|---|---|---|---|
| Los Angeles Abrasion Loss -% | LDH TR 111-67 | 27.7 | |
| | AASHO T 96 | | 19.3 |
| Soundness $MgSO_4$ | AASHO T 104 | 6.7 | 3.2 |

TABLE 3

BIN PROPORTIONS FOR TEST SECTIONS

| | Eastbound Roadway - Percent (Wearing Course) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | 1E | 2E | 3E | 4E | 5E | 6E | 7E | 8E | 9E | 10E |
| Bin 1 (Coarse & Fine Sand) | 55 | 67 | 65 | 65 | 65 | 55 | *70 | *70 | 72 | 70 |
| Bin 2 (Expanded Clay) | - | 30 | 30 | 30 | 30 | - | 25 | 25 | 25 | 25 |
| Bin 2 (Crushed Gravel) | 39.5 | - | - | - | - | 39.5 | - | - | - | - |
| Mineral Filler | 5.5 | 3 | 5 | 5 | 5 | 5.5 | 5 | 5 | 3 | 5 |
| Asphalt Content | 5.1 | 7.5 | 7.0 | 8.0 | 7.5 | 5.1 | 7.5 | 8.0 | 7.5 | 7.5 |

| | Westbound Roadway - Percent (2nd. Lift) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | 1W | 2W | 3W | 4W | 5W | 6W | 7W | 8W | 9W | 10W |
| Bin 1 (Coarse & Fine Sand) | 55 | 70 | 67 | 67 | 67 | 55 | *72 | *72 | 72 | 62 |
| Bin 2 (Expanded Clay) | - | 30 | 30 | 30 | 30 | - | 25 | 25 | 35 | 35 |
| Bin 2 (Crushed Gravel) | 39.5 | - | - | - | - | 39.5 | - | - | - | - |
| Mineral Filler | 5.5 | 0 | 3 | 3 | 3 | 5.5 | 3 | 3 | 3 | 3 |
| Asphalt Content | 5.1 | 7.0 | 7.0 | 8.0 | 7.5 | 5.1 | 7.5 | 8.0 | 7.5 | 8.0 |

| | Westbound Roadway - Percent (1st. Lift) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | 1W | 2W | 3W | 4W | 5W | 6W | 7W | 8W | 9W | 10W |
| Bin 1 (Coarse & Fine Sand) | 55 | 70 | 67 | 67 | 62 | 55 | *72 | *72 | 72 | 62 |
| Bin 2 (Expanded Clay) | - | 30 | 30 | 30 | 35 | - | 25 | 25 | 35 | 35 |
| Bin 2 (Crushed Gravel) | 39.5 | - | - | - | - | 39.5 | - | - | - | - |
| Mineral Filler | 5.5 | 0 | 3 | 3 | 3 | 5.5 | 3 | 3 | 3 | 3 |
| Asphalt Content | 5.1 | 8.0 | 7.0 | 8.0 | 7.5 | 5.1 | 7.5 | 8.0 | 7.5 | 8.0 |

* Bin 1 includes 10 percent minus No. 4 Expanded Clay.

## APPENDIX "D"

## EXTRACTED GRADATIONS FOR THE VARIOUS TEST SECTIONS
## TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS
## (CONTROL AND EXPANDED CLAY SECTIONS)

TABLE 4

EXTRACTED GRADATIONS FOR THE VARIOUS TEST SECTIONS

Westbound Roadway
Bottom Lift
Inside Lane

| Test Section U. S. Sieve | 1W Control | | 2W | 3W | 4W | 5W Percent Passing | 6W Control | | 7W | 8W | 9W | | 10W | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/4" | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | 100.0 | |
| 1/2" | 99.1 | 98.4 | 98.3 | 97.6 | 94.1 | 88.9 | 99.8 | 98.9 | 99.0 | 98.2 | 99.0 | | 99.5 | |
| 3/8" | 90.2 | 92.8 | 88.3 | 87.5 | 82.3 | 76.8 | 93.1 | 90.6 | 91.2 | 91.1 | 94.7 | | 94.9 | |
| No. 4 | 62.6 | 67.0 | 70.0 | 72.7 | 74.1 | 67.2 | 62.7 | 63.5 | 79.2 | 79.7 | 67.8 | | 68.4 | |
| No. 10 | 48.4 | 51.2 | 61.5 | 64.4 | 67.5 | 61.1 | 46.6 | 45.5 | 70.0 | 67.8 | 58.2 | | 59.1 | |
| No. 40 | 29.1 | 32.0 | 35.3 | 40.3 | 46.0 | 39.5 | 28.5 | 28.0 | 37.5 | 36.8 | 32.3 | | 33.9 | |
| No. 80 | 11.4 | 14.4 | 8.3 | 14.0 | 18.8 | 15.7 | 11.0 | 12.8 | 10.2 | 11.6 | 11.4 | | 12.3 | |
| No. 200 | 6.9 | 9.0 | 3.2 | 7.0 | 8.2 | 7.1 | 6.5 | 8.2 | 4.8 | 5.8 | 6.3 | | 7.2 | |
| Asphalt | 5.0 | 4.9 | 7.5 | 6.8 | 8.3 | 7.2 | 5.0 | --- | 7.1 | 7.5 | 7.5 | | 8.0 | |
| | | | | | | Outside | | | | | | | | |
| 3/4" | 100.0 | 100.0 | | 100.0 | 100.0 | | | | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1/2" | 98.0 | 98.4 | Same | 97.8 | 93.0 | Same | Same | | Same | 98.8 | 98.2 | 99.6 | 99.1 | 96.6 |
| 3/8" | 91.5 | 90.5 | as | 86.3 | 79.8 | as | as | | as | 87.6 | 90.0 | 94.2 | 83.7 | 81.7 |
| No. 4 | 64.8 | 64.8 | Inside | 72.5 | 73.4 | Inside | Inside | | Inside | 73.6 | 65.5 | 67.0 | 67.9 | 68.6 |
| No. 10 | 48.2 | 49.0 | Lane | 64.2 | 66.6 | Lane | Lane | | Lane | 64.4 | 57.4 | 57.1 | 60.3 | 61.9 |
| No. 40 | 28.8 | 31.2 | | 41.2 | 42.4 | | | | | 35.3 | 32.5 | 33.2 | 37.0 | 38.0 |
| No. 80 | 13.0 | 13.5 | | 14.4 | 15.3 | | | | | 10.1 | 11.4 | 11.5 | 12.5 | 13.3 |
| No. 200 | 7.9 | 7.7 | | 7.1 | 7.3 | | | | | 5.1 | 5.8 | 6.5 | 5.9 | 6.8 |
| Asphalt | 5.1 | ----- | | 7.5 | 7.9 | | | | | 7.5 | 7.5 | 7.5 | 7.7 | 7.7 |
| | | | | | | Top Lift Inside Lane | | | | | | | | |
| 3/4" | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1/2" | 99.1 | 98.4 | 97.9 | 98.6 | 98.7 | 95.4 | 99.8 | 98.9 | 97.7 | 98.8 | 98.2 | 99.6 | 99.1 | 96.6 |
| 3/8" | 90.2 | 92.8 | 87.4 | 88.4 | 88.5 | 84.3 | 93.1 | 90.6 | 89.8 | 87.6 | 90.0 | 94.2 | 83.7 | 81.7 |
| No. 4 | 62.6 | 67.0 | 73.0 | 73.5 | 72.0 | 70.8 | 62.7 | 63.5 | 72.8 | 73.6 | 65.5 | 67.0 | 67.9 | 68.6 |
| No. 10 | 48.4 | 51.2 | 63.7 | 64.7 | 63.2 | 63.0 | 46.6 | 45.5 | 65.7 | 64.4 | 57.4 | 57.1 | 60.3 | 61.9 |
| No. 40 | 29.1 | 32.0 | 40.5 | 41.0 | 36.8 | 35.2 | 28.5 | 28.0 | 35.6 | 35.3 | 32.5 | 33.2 | 37.0 | 38.0 |
| No. 80 | 11.4 | 14.4 | 11.5 | 14.4 | 13.5 | 11.6 | 11.0 | 12.8 | 11.2 | 10.1 | 11.4 | 11.5 | 12.5 | 13.3 |
| No. 200 | 6.9 | 9.0 | 4.2 | 7.2 | 6.9 | 5.4 | 6.5 | 8.2 | 5.9 | 5.1 | 5.8 | 6.5 | 5.9 | 6.8 |
| Asphalt | 5.0 | 4.9 | 6.4 | 6.9 | 7.5 | | 5.0 | ---- | 7.1 | 7.5 | 7.5 | 7.5 | 7.7 | 7.7 |
| | | | | | | Outside | | | | | | | | |
| 3/4" | 100.0 | 100.0 | | | | | | | | | | | | |
| 1/2" | 98.0 | 98.4 | | | | | | | 100.0 | 100.0 | 100.0 | | 100.0 | |
| 3/8" | 91.5 | 90.5 | Same | Same | Same | Same | Same | | 99.4 | 99.5 | 98.1 | | 97.2 | |
| No. 4 | 64.8 | 64.8 | as | as | as | as | as | | 92.3 | 90.5 | 85.2 | | 86.2 | |
| No. 10 | 48.2 | 49.0 | Inside | Inside | Inside | Inside | Inside | | 79.0 | 75.4 | 67.0 | | 70.7 | |
| No. 40 | 28.8 | 31.2 | Lane | Lane | Lane | Lane | Lane | | 65.7 | 63.9 | 59.3 | | 61.0 | |
| No. 80 | 13.0 | 13.5 | | | | | | | 34.4 | 36.7 | 35.6 | | 38.5 | |
| No. 200 | 7.9 | 7.7 | | | | | | | 13.2 | 11.6 | 12.4 | | 18.6 | |
| Asphalt | 5.1 | ----- | | | | | | | 6.2 | 6.4 | 6.1 | | 13.9 | |
| | | | | | | | | | 7.0 | 7.5 | 7.1 | | 7.7 | |

TABLE 4 CONTINUED

EXTRACTED GRADATIONS FOR THE VARIOUS TEST SECTIONS

Eastbound Roadway
Top Lift
Inside Lane

| Test Section U.S. Sieve | 1E | | 2E | 3E | 4E | 5E | 6E | | 7E | 8E | 9E | 10E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Percent Passing | | | | | | |
| 3/4" | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1/2" | 98.9 | 98.0 | 98.4 | 97.2 | 99.3 | 97.1 | 98.9 | 98.0 | 98.4 | 98.3 | 99.0 | 97.3 |
| 3/8" | 91.4 | 88.6 | 86.9 | 86.2 | 87.4 | 86.4 | 91.4 | 88.6 | 88.2 | 89.8 | 90.0 | 87.3 |
| No. 4 | 63.9 | 59.9 | 71.3 | 72.9 | 71.6 | 71.9 | 63.9 | 59.9 | 73.8 | 79.2 | 75.0 | 75.0 |
| No. 10 | 48.5 | 45.7 | 63.2 | 65.4 | 64.6 | 63.7 | 48.5 | 45.7 | 65.2 | 69.5 | 67.8 | 68.2 |
| No. 40 | 30.5 | 28.4 | 36.5 | 37.2 | 39.4 | 38.2 | 30.5 | 28.4 | 42.2 | 40.8 | 42.2 | 40.8 |
| No. 80 | 12.8 | 10.9 | 11.5 | 11.0 | 14.3 | 13.7 | 12.8 | 10.9 | 18.8 | 13.9 | 14.9 | 12.0 |
| No. 200 | 7.8 | 6.3 | 5.8 | 6.5 | 7.1 | 7.4 | 7.8 | 6.3 | 7.1 | 6.7 | 5.9 | 5.4 |
| Asphalt Content | 5.3 | 4.9 | 7.0 | 6.9 | 7.6 | 7.6 | 5.3 | 4.9 | 7.6 | 7.9 | 7.5 | 7.5 |

Outside Lane

| Test Section U.S. Sieve | 1E | 2E | 3E | 4E | 5E | 6E | 7E | 8E | 9E | 10E |
|---|---|---|---|---|---|---|---|---|---|---|
| 3/4" | Same as Inside Lane | Same as Inside Lane | Same as Inside Lane | Same as Inside Lane | 100.0 | 100.0 | 100.0 | 100.0 | Same as Inside Lane | 100.0 |
| 1/2" | | | | | 97.9 | 99.1 | 97.0 | 98.3 | | 97.3 |
| 3/8" | | | | | 87.2 | 90.2 | 83.1 | 87.0 | | 85.3 |
| No. 4 | | | | | 72.0 | 62.6 | 70.1 | 75.3 | | 75.5 |
| No. 10 | | | | | 55.9 | 48.4 | 63.1 | 67.4 | | 67.7 |
| No. 40 | | | | | 38.9 | 29.1 | 39.5 | 40.6 | | 39.8 |
| No. 80 | | | | | 15.6 | 11.4 | 13.8 | 14.0 | | 13.0 |
| No. 200 | | | | | 7.1 | 6.9 | 5.8 | 6.5 | | 6.2 |
| Asphalt Content | | | | | 7.2 | 5.0 | 7.3 | 8.1 | | 7.5 |

TABLE 5

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE CONTROL TEST SECTIONS

Control Sections (Type 1 Gravel Mixes)

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content - % By Weight | Asphalt Content - % By Volume | Voids - % | V.F.A. | Density lbs./cu/ft. | Marshall Stability | Flow |
|---|---|---|---|---|---|---|---|---|---|
| | 340 | 2.326 | | | | | | 1475 | 7 |
| | 340 | 2.330 | | | | | | 1453 | 7 |
| | 330 | 2.321 | | | | | | 1547 | 8 |
| 1W (inside lane - Bottom Lift) | 330 | 2.318 | | Theoretical Gravity - 2.444 | | | | 1593 | 8 |
| 6W (inside & outside lane - | 320 | 2.333 | | Date 11/21/67 | | | | 1492 | 7 |
| Bottom Lift) | 320 | 2.333 | | | | | | 1523 | 6 |
| 6E (outside lane - Top Lift) | 325 | 2.345 | | | | | | 1569 | 10 |
| | 325 | 2.336 | | | | | | 1523 | 8 |
| | 335 | 2.334 | | | | | | 1532 | 8 |
| | 335 | 2.339 | | | | | | 1655 | 8 |
| | 325 | 2.345 | | | | | | 1650 | 9 |
| | 325 | 2.337 | | | | | | 1731 | 10 |
| Average | 329 | 2.333 | 5.1 | 11.55 | 4.5 | 72.0 | 145.6 | 1562 | 8 |
| | 310 | 2.331 | | | | | | 1454 | 12 |
| | 300 | 2.332 | | | | | | 1424 | 12 |
| | 310 | 2.331 | | | | | | 1540 | 8 |
| | 310 | 2.334 | | | | | | 1659 | 9 |
| 1E (inside & outside lane - | 320 | 2.325 | | Theoretical Gravity - 2.444 | | | | 1380 | 11 |
| Top Lift) | 315 | 2.333 | | Date 11/20/67 | | | | 1496 | 11 |
| 6E (inside lane - Top Lift) | 320 | 2.338 | | | | | | 1569 | 10 |
| | 320 | 2.333 | | | | | | 1457 | 9 |
| | 305 | 2.331 | | | | | | 1565 | 10 |
| | 305 | 2.327 | | | | | | 1396 | 9 |
| | 320 | 2.332 | | | | | | 1586 | 10 |
| | 315 | 2.325 | | | | | | 1584 | 10 |
| Average | 313 | 2.331 | 5.1 | 11.54 | 4.6 | 71.5 | 145.5 | 1509 | 10 |
| | 310 | 2.342 | | | | | | 1650 | 8 |
| | 305 | 2.332 | | | | | | 1507 | 8 |
| 1W (outside lane - Bottom & | 315 | 2.334 | | Theoretical Gravity - 2.444 | | | | 1565 | 12 |
| Top Lift) | 315 | 2.339 | | Date 11/22/67 | | | | 1613 | 12 |
| 1W (inside lane - Top Lift) | 320 | 2.334 | | | | | | 1508 | 12 |
| | 315 | 2.329 | | | | | | 1411 | 11 |
| | 315 | 2.316 | | | | | | 1475 | 10 |
| | 310 | 2.321 | | | | | | 1396 | 9 |
| Average | 313 | 2.331 | 5.1 | 11.54 | 4.6 | 71.5 | 145.5 | 1516 | 10 |
| | 340 | 2.331 | | | | | | 1650 | 9 |
| 1W (outside lane - Top Lift) | 335 | 2.329 | | Theoretical Gravity - 2.444 | | | | 1605 | 10 |
| 6W (inside & outside lanes - | 310 | 2.342 | | Date 11/27/67 | | | | 1380 | 10 |
| Top Lift) | 300 | 2.336 | | | | | | 1459 | 10 |
| | 320 | 2.339 | | | | | | 1609 | 10 |
| | 315 | 2.344 | | | | | | 1784 | 10 |
| Average | 320 | 2.337 | 5.1 | 11.57 | 4.4 | 72.4 | 145.8 | 1581 | 10 |

TABLE 6

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE EXPANDED CLAY TEST SECTIONS

Westbound Roadway

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content By Weight | Marshall Stability | Flow |
|---|---|---|---|---|---|
| 2W (inside & outside lane) | 300 | 1.598 | | 1638 | 6 |
| | 300 | 1.587 | | 1557 | 6 |
| Bottom Lift | 310 | 1.657 | | 865 | 6 |
| | 305 | 1.614 | | 1352 | 13 |
| | 300 | 1.656 | | 913 | 5 |
| | 290 | 1.629 | | 1051 | 5 |
| **Average** | 301 | 1.624 | 8.0 | 1229 | 7 |
| | 345 | 1.731 | | 1033 | 6 |
| 2W (inside & outside lane) | 340 | 1.744 | | 760 | 4 |
| Top Lift | 320 | 1.741 | | 940 | 4 |
| | 315 | 1.725 | | 950 | 4 |
| | 325 | 1.686 | | 1096 | 4 |
| | 315 | 1.654 | | 1205 | 4 |
| | 350 | 1.734 | | 820 | 2 |
| | 345 | 1.679 | | 1036 | 3 |
| Average | 332 | 1.712 | 7.0 | 980 | 4 |
| | 325 | 1.688 | | 1275 | 6 |
| 3W (inside lane - Bottom Lift) | 320 | 1.717 | | 1247 | 6 |
| | 320 | 1.699 | | 1793 | 6 |
| | 315 | 1.731 | | 1775 | 11 |
| | 310 | 1.688 | | 1523 | 6 |
| | 305 | 1.711 | | 1675 | 7 |
| **Average** | 316 | 1.706 | 7.0 | 1548 | 7 |
| 3W (outside lane - Bottom Lift) | 325 | 1.728 | | 1539 | 4 |
| | 320 | 1.726 | | 1440 | 4 |
| Average | 323 | 1.725 | 7.0 | 1490 | 4 |
| | 345 | 1.738 | | 1606 | 2 |
| 3W (inside & outside lane) | 340 | 1.733 | | 1850 | 4 |
| Top Lift | 370 | 1.717 | | 1584 | 5 |
| | 360 | 1.722 | | 1367 | 10 |
| | 330 | 1.724 | | 1662 | 4 |
| | 330 | 1.686 | | 1544 | 5 |
| Average | 346 | 1.720 | 7.0 | 1602 | 5 |
| | 330 | 1.721 | | 1391 | 9 |
| 4W (inside lane - Bottom Lift) | 325 | 1.722 | | 1428 | 8 |
| Binder Course Mix | 330 | 1.717 | | 1286 | 8 |
| | 325 | 1.713 | | 1459 | 8 |
| Average | 328 | 1.718 | 8.0 | 1391 | 8 |
| 4W (outside lane - Bottom Lift) | 345 | 1.744 | | 1396 | 9 |
| Binder Course Mix | 340 | 1.736 | | 1187 | 8 |
| | 330 | 1.774 | | 1352 | 9 |
| | 325 | 1.746 | | 1244 | 8 |
| | 330 | 1.766 | | 1587 | 11 |
| | 330 | 1.740 | | 1479 | 7 |
| Average | 333 | 1.751 | 8.0 | 1374 | 9 |
| | 355 | 1.751 | | 1750 | 7 |
| 4W (inside & outside lane) | 350 | 1.716 | | 1890 | 8 |
| Top Lift | 370 | 1.710 | | 1790 | 11 |
| Wearing Course Mix | 355 | 1.683 | | 1813 | 6 |
| | 290 | 1.777 | | 1606 | 8 |
| | 290 | 1.756 | | 1492 | 5 |
| Average | 335 | 1.732 | 8.0 | 1724 | 8 |

TABLE 6 CONTINUED

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE EXPANDED CLAY TEST SECTIONS

Westbound Roadway

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content By Weight | Marshall Stability | Flow |
|---|---|---|---|---|---|
| | 335 | 1.719 | | 2157 | 7 |
| 5W (inside & outside lane) | 335 | 1.684 | | 2247 | 5 |
| Bottom Lift | 340 | 1.716 | | 2100 | 8 |
| | 335 | 1.742 | | 2180 | 7 |
| | 340 | 1.707 | | 2500 | 5 |
| | 335 | 1.723 | | 2101 | 7 |
| Average | 337 | 1.715 | 7.5 | 2214 | 7 |
| | 355 | 1.751 | | 1767 | 4 |
| 5W (inside & outside lane) | 350 | 1.765 | | 1606 | 5 |
| Top Lift | 340 | 1.723 | | 1823 | 7 |
| | 340 | 1.735 | | 1610 | 12 |
| | 345 | 1.734 | | 1700 | 7 |
| | 335 | 1.745 | | 1817 | 6 |
| Average | 344 | 1.742 | 7.5 | 1721 | 7 |
| | 345 | 1.718 | | 1084 | 5 |
| 7W (inside & outside lane) | 340 | 1.684 | | 1371 | 7 |
| Bottom Lift | 355 | 1.735 | | 880 | 5 |
| | 345 | 1.718 | | 980 | 6 |
| | 345 | 1.732 | | 1586 | 4 |
| | 340 | 1.734 | | 1667 | 6 |
| | 315 | 1.682 | | 1294 | 4 |
| | 305 | 1.689 | | 1310 | 3 |
| Average | 336 | 1.712 | 7.5 | 1272 | 5 |
| 7W (inside lane - Top Lift) | 340 | 1.670 | | 2132 | 7 |
| | 335 | 1.642 | | 2096 | 8 |
| | 325 | 1.695 | | 1842 | 7 |
| | 320 | 1.725 | | 1807 | 4 |
| Average | 330 | 1.683 | 7.5 | 1969 | 6 |
| | 415 | 1.619 | | 2687 | 7 |
| 7W (outside lane - Top Lift) | 405 | 1.614 | | 2204 | 4 |
| | 335 | 1.644 | | 1220 | 5 |
| | 330 | 1.626 | | 1039 | 6 |
| Average | 371 | 1.626 | 7.5 | 1788 | 6 |
| 8W (inside lane - Bottom Lift) | 300 | 1.761 | | 1325 | 5 |
| | 295 | 1.748 | | 1406 | 7 |
| Average | 298 | 1.755 | 8.0 | 1366 | 6 |
| | 370 | 1.674 | | 1942 | 7 |
| 8W (outside lane - Bottom Lift) | 365 | 1.699 | | 1935 | 7 |
| | 330 | 1.671 | | 2075 | 7 |
| | 325 | 1.696 | | 1532 | 8 |
| | 305 | 1.687 | | 1507 | 5 |
| | 300 | 1.660 | | 1538 | 6 |
| Average | 333 | 1.681 | 8.0 | 1755 | 7 |
| | --- | 1.677 | | 2239 | 6 |
| | --- | 1.672 | | 2171 | 6 |
| | 345 | 1.651 | | 1650 | 6 |
| 8W (inside & outside lane) | 335 | 1.624 | | 1683 | 5 |
| Top Lift | 350 | 1.658 | | 2276 | 7 |
| | 345 | 1.666 | | 1477 | 7 |
| | 345 | 1.698 | | 1523 | 4 |
| | 345 | 1.659 | | 1569 | 6 |
| | 300 | 1.706 | | 1158 | 5 |
| | 295 | 1.678 | | 1406 | 5 |
| Average | 333 | 1.669 | 8.0 | 1715 | 6 |

TABLE 6 CONTINUED

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE EXPANDED CLAY TEST SECTIONS

**Westbound Roadway**

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content By Weight | Marshall Stability | Flow |
|---|---|---|---|---|---|
| | 350 | 1.877 | | 1980 | 6 |
| 9W (inside lane - Bottom Lift) | 345 | 1.855 | | 1622 | 9 |
| | 355 | 1.900 | | 1827 | 7 |
| | 355 | 1.871 | | 1714 | 7 |
| | 325 | 1.926 | | 1249 | 11 |
| | 320 | 1.925 | | 1477 | 12 |
| Average | 342 | 1.892 | 7.5 | 1645 | 9 |
| | 320 | 1.854 | | 1902 | 6 |
| | 315 | 1.847 | | 1894 | 8 |
| 9W (outside lane - Bottom Lift) | 335 | 1.889 | | 1922 | 7 |
| | 330 | 1.884 | | 2064 | 7 |
| | 330 | 1.917 | | 1828 | 7 |
| | 325 | 1.888 | | 1894 | 6 |
| Average | 326 | 1.880 | 7.5 | 1917 | 7 |
| | 360 | 1.920 | | 1934 | 5 |
| | 350 | 1.899 | | 1997 | 4 |
| 9W (inside lane - Top Lift) | 340 | 1.919 | | 1492 | 6 |
| | 340 | 1.893 | | 1578 | 8 |
| | 330 | 1.904 | | 1875 | 6 |
| | 325 | 1.911 | | 1731 | 6 |
| Average | 341 | 1.908 | 7.5 | 1768 | 6 |
| | 335 | 1.652 | | 1615 | 9 |
| | 330 | 1.623 | | 1569 | 7 |
| 9W (outside lane - Top Lift) | 310 | 1.622 | | 2065 | 5 |
| | 305 | 1.598 | | 2109 | 5 |
| | 325 | 1.653 | | 2474 | 6 |
| | 320 | 1.659 | | 2344 | 7 |
| Average | 321 | 1.635 | 7.5 | 2029 | 7 |
| | 335 | 1.907 | | 1821 | 14 |
| 10W (inside lane - Bottom Lift) | 335 | 1.918 | | 1699 | 16 |
| | 360 | 1.884 | | 1667 | 7 |
| | 355 | 1.852 | | 1875 | 8 |
| Average | 346 | 1.890 | 8.0 | 1766 | 11 |
| | 360 | 1.654 | | 1734 | 5 |
| 10W (outside lane - Bottom Lift) | 355 | 1.638 | | 2036 | 6 |
| | 315 | 1.659 | | 1745 | 12 |
| | 310 | 1.641 | | 2000 | 5 |
| | 300 | 1.686 | | 1979 | 4 |
| | 295 | 1.602 | | 1848 | 6 |
| Average | 323 | 1.647 | 8.0 | 1890 | 6 |
| | 335 | 1.631 | | 2100 | 9 |
| 10W (inside lane - Top Lift) | 330 | 1.643 | | 2234 | 8 |
| | 355 | 1.678 | | 1610 | 10 |
| | 350 | 1.608 | | 2067 | 9 |
| | 325 | 1.660 | | 1584 | 4 |
| | 320 | 1.613 | | 1918 | 6 |
| Average | 336 | 1.639 | 8.0 | 1919 | 8 |
| | 355 | 1.632 | | 2225 | 8 |
| | 350 | 1.647 | | 2240 | 9 |
| 10W (outside lane - Top Lift) | 305 | 1.659 | | 1630 | 11 |
| | 305 | 1.647 | | 1722 | 8 |
| | 300 | 1.609 | | 1917 | 6 |
| | 295 | 1.618 | | 1917 | 8 |
| Average | 302 | 1.635 | 8.0 | 1942 | 8 |

TABLE 7

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE EXPANDED CLAY TEST SECTIONS

Eastbound Roadway

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content By Weight | Marshall Stability | Flow |
|---|---|---|---|---|---|
| | 400 | 1.679 | | 1947 | 8 |
| | 400 | 1.668 | | 1820 | 11 |
| 2E (inside & outside lanes) | 295 | 1.711 | | 913 | 7 |
| Top Lift | 290 | 1.609 | | 1063 | 6 |
| | 345 | 1.735 | | 1453 | 8 |
| | 345 | 1.700 | | 1523 | 6 |
| Average | 346 | 1.684 | 7.5 | 1453 | 8 |
| | 320 | 1.739 | | 1457 | 5 |
| | 320 | 1.680 | | 1475 | 5 |
| 3E (inside & outside lanes) | 335 | 1.698 | | 1635 | 4 |
| Top Lift | 330 | 1.692 | | 1673 | 7 |
| | 330 | 1.733 | | 1477 | 7 |
| | 330 | 1.678 | | 1587 | 5 |
| Average | 328 | 1.703 | 7.0 | 1551 | 6 |
| | 295 | 1.687 | | 1662 | 7 |
| | 290 | 1.668 | | 1606 | 5 |
| 4E (inside & outside lanes) | 345 | 1.697 | | 1523 | 7 |
| Top Lift | 340 | 1.672 | | 1502 | 9 |
| | 290 | 1.718 | | 1523 | 6 |
| | 290 | 1.707 | | 1610 | 8 |
| | 308 | 1.690 | 8.0 | 1571 | 7 |
| 5E (inside - Top Lift) | 295 | 1.705 | | 1340 | 5 |
| | 290 | 1.712 | | 1277 | 6 |
| | 280 | 1.691 | | 1850 | 8 |
| | 275 | 1.675 | | 1650 | 10 |
| Average | 285 | 1.696 | 7.5 | 1529 | 7 |
| | 305 | 1.668 | | 1596 | 13 |
| 5E (outside lane - Top Lift) | 300 | 1.636 | | 1621 | 7 |
| | 280 | 1.685 | | 1187 | 8 |
| | 275 | 1.681 | | 1544 | 7 |
| Average | 290 | 1.668 | 7.5 | 1487 | 9 |
| | 320 | 1.678 | | 1846 | 9 |
| 7E (inside lane - Top Lift) | 305 | 1.671 | | 1768 | 10 |
| | 345 | 1.661 | | 1381 | 5 |
| | 340 | 1.635 | | 1297 | 5 |
| | 325 | 1.715 | | 1565 | 8 |
| | 320 | 1.704 | | 1639 | 8 |
| Average | 326 | 1.677 | 7.5 | 1583 | 8 |
| | 345 | 1.718 | | 1823 | 7 |
| | 345 | 1.679 | | 1523 | 8 |
| 7E (outside lane - Top Lift) | 325 | 1.719 | | 1673 | 6 |
| | 320 | 1.690 | | 1563 | 9 |
| Average | 329 | 1.702 | 7.5 | 1646 | 8 |
| | 295 | 1.710 | | 904 | 7 |
| | 290 | 1.690 | | 973 | 7 |
| 8E (inside lane - Top Lift) | 345 | 1.651 | | 1368 | 8 |
| | 340 | 1.686 | | 1832 | 7 |
| | 360 | 1.699 | | 1236 | 8 |
| | 350 | 1.704 | | 1584 | 8 |
| Average | 330 | 1.690 | 8.0 | 1316 | 8 |
| | 345 | 1.720 | | 1569 | 8 |
| | 340 | 1.720 | | 1683 | 8 |
| 8E (outside lane - Top Lift) | 340 | 1.713 | | 1347 | 5 |
| | 335 | 1.672 | | 1333 | 7 |
| | 320 | 1.728 | | 1768 | 12 |
| | 320 | 1.728 | | 1157 | 7 |
| Average | 333 | 1.714 | 8.0 | 1476 | 8 |

TABLE 7 CONTINUED

TEST RESULTS OF PLANT MIXED MARSHALL SPECIMENS FOR THE EXPANDED CLAY TEST SECTIONS

Eastbound Roadway

| Test Sections Represented | Temperature of Briquette °F | Specific Gravity | Asphalt Content By Weight | Marshall Stability | Flow |
|---|---|---|---|---|---|
| | 330 | 1.718 | | 1322 | 6 |
| 9E (inside lane - Top Lift) | 325 | 1.673 | | 1063 | 6 |
| | 340 | 1.695 | | 1523 | 8 |
| | 335 | 1.735 | | 1447 | 7 |
| Average | 333 | 1.705 | 7.5 | 1339 | 7 |
| | 290 | 1.770 | | 1127 | 9 |
| | 285 | 1.761 | | 1066 | 6 |
| 9E (outside lane - Top Lift) | 320 | 1.806 | | 890 | 7 |
| | 315 | 1.766 | | 1036 | 6 |
| Average | 303 | 1.776 | 7.5 | 1030 | 7 |
| | 310 | 1.800 | | 1464 | 7 |
| | 305 | 1.754 | | 1324 | 7 |
| 10E (inside lane - Top Lift) | 315 | 1.771 | | 1377 | 9 |
| | 310 | 1.768 | | 1084 | 6 |
| Average | 310 | 1.773 | 7.5 | 1312 | 7 |
| | --- | 1.752 | | 1220 | 7 |
| | --- | 1.735 | | 1269 | 8 |
| 10E (outside lane - Top Lift) | 335 | 1.734 | | 1138 | 8 |
| | 330 | 1.732 | | 1128 | 8 |
| | 305 | 1.693 | | 1274 | 6 |
| | 300 | 1.676 | | 1292 | 10 |
| Average | 318 | 1.720 | 8.5 | 1220 | 8 |

# APPENDIX "E"

## TEST RESULTS FOR LABORATORY MADE SPECIMENS (LABORATORY CURVES 1, 2 AND 3)

TABLE 8

TEST RESULTS FOR LABORATORY MADE SPECIMENS - LAB CURVE 1

Asphalt Content 7.5%
75 Blow Marshall Hammer

| Briquette Number | Expanded Clay Extracted From Briquettes-% | Specific Gravity | Theoretical Gravity | Asphalt Content By Volume | Voids-% | V.M.A.% | V.F.A.% | Density Lbs/cu.ft. |
|---|---|---|---|---|---|---|---|---|
| 1 | 32.0 | 1.605 | 1.737 | 11.69 | 7.6 | 19.29 | 60.6 | 100.2 |
| 2 | 32.0 | 1.612 | 1.737 | 11.74 | 7.2 | 18.94 | 62.0 | 100.6 |
| 3 | 31.0 | 1.642 | 1.751 | 11.96 | 6.2 | 18.16 | 65.9 | 102.6 |
| 4 | 31.0 | 1.633 | 1.751 | 11.89 | 6.7 | 18.59 | 64.0 | 101.9 |
| 5 | - | - | - | - | - | - | - | - |
| 6 | 30.0 | 1.659 | 1.766 | 12.08 | 6.1 | 18.18 | 66.4 | 103.5 |
| 7 | 29.0 | 1.678 | 1.780 | 12.22 | 5.7 | 17.92 | 68.2 | 104.7 |
| 8 | 29.0 | 1.646 | 1.780 | 11.99 | 7.5 | 19.49 | 61.5 | 102.7 |
| 9 | 28.0 | 1.673 | 1.795 | 12.18 | 6.8 | 18.98 | 64.2 | 104.4 |
| 10 | 28.0 | 1.667 | 1.795 | 12.14 | 7.1 | 19.24 | 63.1 | 104.0 |
| 11 | 27.0 | 1.692 | 1.809 | 12.32 | 6.5 | 18.82 | 65.5 | 105.6 |
| 12 | 27.0 | 1.677 | 1.809 | 12.21 | 7.3 | 19.51 | 62.6 | 104.6 |
| 13 | 26.0 | 1.685 | 1.824 | 12.27 | 7.6 | 19.87 | 61.8 | 105.1 |
| 14 | 26.0 | 1.672 | 1.824 | 12.17 | 8.3 | 20.47 | 59.5 | 104.3 |
| 15 | 25.0 | 1.700 | 1.845 | 12.38 | 7.9 | 20.28 | 61.0 | 106.1 |
| 16 | 25.0 | 1.709 | 1.845 | 12.45 | 7.4 | 19.85 | 62.7 | 106.6 |

TABLE 9

TEST RESULTS FOR LABORATORY MADE SPECIMENS - LAB CURVE 2

Asphalt Content - 7.5%
75 Blow Marshall Hammer

| Briquette Number | Expanded Clay Extracted From Briquettes -% | Specific Gravity | Theoretical Gravity | Asphalt Content By Volume | Voids-% | V.M.A. % | V.F.A. -% | Density Lbs/cu.ft. |
|---|---|---|---|---|---|---|---|---|
| 1 | 34.0 | 1.555 | 1.707 | 11.32 | 8.9 | 20.22 | 56.0 | 97.0 |
| 2 | 33.7 | 1.606 | 1.712 | 11.70 | 6.2 | 17.90 | 65.4 | 100.2 |
| 3 | 31.8 | 1.604 | 1.740 | 11.68 | 7.8 | 19.48 | 60.0 | 100.2 |
| 4 | 31.0 | 1.631 | 1.751 | 11.87 | 6.9 | 18.77 | 63.2 | 101.8 |
| 5 | 30.3 | 1.623 | 1.762 | 11.82 | 7.9 | 19.72 | 60.0 | 101.3 |
| 6 | 30.8 | 1.642 | 1.754 | 11.96 | 6.4 | 18.36 | 65.1 | 102.5 |
| 7 | 29.0 | 1.659 | 1.780 | 12.08 | 6.8 | 18.88 | 64.0 | 103.5 |
| 8 | 29.2 | 1.703 | 1.777 | 12.40 | 4.2 | 16.60 | 74.7 | 106.3 |
| 9 | 27.5 | 1.670 | 1.802 | 12.17 | 7.3 | 19.47 | 62.5 | 104.2 |
| 10 | 28.1 | 1.668 | 1.793 | 12.15 | 7.0 | 19.15 | 63.4 | 104.1 |
| 11 | 27.2 | 1.681 | 1.807 | 12.24 | 7.0 | 19.24 | 63.6 | 104.9 |
| 12 | 26.9 | 1.698 | 1.811 | 12.37 | 6.2 | 18.57 | 66.6 | 106.0 |
| 13 | 26.7 | 1.708 | 1.814 | 12.44 | 5.8 | 18.24 | 68.2 | 106.6 |
| 14 | 26.1 | 1.719 | 1.822 | 12.51 | 5.7 | 18.21 | 68.7 | 107.3 |
| 15 | 26.8 | 1.648 | 1.812 | 12.00 | 9.1 | 21.10 | 56.9 | 102.8 |
| 16 | 28.1 | 1.714 | 1.793 | 12.49 | 4.4 | 16.89 | 73.9 | 107.0 |

## TABLE 10

## COMPARISON OF TEST RESULTS FOR LABORATORY CURVES 1 AND 2

| % of Expanded Clay | Specific Gravity Curve 1 | Specific Gravity Curve 2 | Density #/cu.ft. Curve 1 | Density #/cu.ft. Curve 2 | Difference in Density #/cu.ft. |
|---|---|---|---|---|---|
| 25 | 1.703 | 1.725 | 106.3 | 107.6 | 1.3 |
| 26 | 1.692 | 1.708 | 105.6 | 106.6 | 1.0 |
| 27 | 1.680 | 1.692 | 104.8 | 105.6 | 0.8 |
| 28 | 1.667 | 1.676 | 104.0 | 104.6 | 0.6 |
| 29 | 1.656 | 1.659 | 103.3 | 103.5 | 0.2 |
| 30 | 1.644 | 1.644 | 102.6 | 102.6 | 0.0 |
| 31 | 1.632 | 1.628 | 101.8 | 101.6 | 0.2 |
| 32 | 1.620 | 1.611 | 101.1 | 100.5 | 0.6 |
| 33 | 1.608 | 1.594 | 100.3 | 99.5 | 0.8 |

TABLE 11

TEST RESULTS FOR LABORATORY MADE SPECIMENS - LAB CURVE 3

Asphalt Content - 8.0%
75 Blow Marshall Hammer

| Briquette Number | Expanded Clay Extracted From Briquettes - % | Specific Gravity | Theoretical Gravity | Asphalt Content By Volume | Voids-% | V. M.A. % | V.F.A. -% | Density Lbs/cu.ft. |
|---|---|---|---|---|---|---|---|---|
| 1 | 30.8 | 1.683 | 1.748 | 13.07 | 3.7 | 16.77 | 77.9 | 105.0 |
| 2 | 30.6 | 1.633 | 1.751 | 12.68 | 6.7 | 19.38 | 65.4 | 101.9 |
| 3 | 31.8 | 1.631 | 1.734 | 12.67 | 6.0 | 18.67 | 67.9 | 101.8 |
| 4 | 31.8 | 1.625 | 1.734 | 12.62 | 6.3 | 18.92 | 66.7 | 101.4 |
| 5 | 34.6 | 1.559 | 1.693 | 12.23 | 7.9 | 20.13 | 60.8 | 97.3 |
| 6 | 34.0 | 1.573 | 1.701 | 12.21 | 7.5 | 19.71 | 61.9 | 98.2 |
| 7 | 40.9 | 1.484 | 1.611 | 11.52 | 7.9 | 19.42 | 59.3 | 92.6 |
| 8 | 38.2 | 1.515 | 1.646 | 11.77 | 8.0 | 19.77 | 59.5 | 94.5 |
| 9 | 39.2 | 1.492 | 1.632 | 11.59 | 8.6 | 20.19 | 57.4 | 93.1 |
| 10 | 39.5 | 1.507 | 1.629 | 11.71 | 7.5 | 19.21 | 61.0 | 94.0 |
| 11 | 44.0 | 1.436 | 1.573 | 11.16 | 8.7 | 19.86 | 56.2 | 89.6 |
| 12 | 41.7 | 1.466 | 1.601 | 11.39 | 8.4 | 19.79 | 57.6 | 91.5 |

# APPENDIX "F"

## TEST RESULTS OF ROADWAY CORES IMMEDIATELY AND 12 MONTHS AFTER CONSTRUCTION (CONTROL, 3W, 4W, 5W AND EXTRA TEST SECTION)

TABLE 12

TEST RESULTS OF ROADWAY SPECIMENS FOR CONTROL MIXES IMMEDIATELY AFTER CONSTRUCTION

Westbound Roadway

| Station | | Asphalt Content-% By Weight | Asphalt Content-% By Volume | Specific Gravity | Voids-% | V.M.A.-% | V.F.A.-% | Density lbs./cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Section 1 Sta. 1018-1048 | | | | | |
| Top Lift | | | | | | | | | |
| 1023 | I | 5.1 | 11.28 | 2.279 | 6.8 | 18.08 | 62.4 | 142.2 | 97.8 |
| 1023 | O | | 11.28 | 2.279 | 6.8 | 18.08 | 62.4 | 142.2 | 97.8 |
| 1027 | I | | 11.35 | 2.293 | 6.2 | 17.55 | 64.7 | 143.1 | 98.4 |
| 1027 | O | | 11.22 | 2.267 | 7.2 | 18.42 | 60.6 | 141.5 | 97.3 |
| 1033 | I | | 11.34 | 2.290 | 6.3 | 17.64 | 64.3 | 142.9 | 98.2 |
| 1033 | O | | 11.23 | 2.269 | 7.2 | 18.43 | 60.9 | 141.6 | 97.1 |
| 1039 | I | | 11.39 | 2.300 | 5.9 | 17.29 | 65.9 | 143.5 | 98.7 |
| 1039 | O | | 11.07 | 2.235 | 8.6 | 19.67 | 56.3 | 139.5 | 95.6 |
| 1045 | I | | 11.41 | 2.305 | 5.7 | 17.11 | 62.3 | 143.8 | 98.9 |
| 1045 | O | | 11.20 | 2.261 | 7.5 | 18.70 | 59.9 | 141.1 | 96.7 |
| Bottom Lift | | | | | | | | | |
| 1023 | I | 5.1 | 11.39 | 2.301 | 5.9 | 17.29 | 65.9 | 143.6 | 98.6 |
| 1023 | O | | 11.19 | 2.259 | 7.6 | 18.79 | 59.6 | 141.0 | 96.9 |
| 1027 | I | | 11.22 | 2.266 | 7.3 | 18.52 | 60.6 | 141.4 | 97.1 |
| 1027 | O | | 11.09 | 2.240 | 8.3 | 19.39 | 57.2 | 139.8 | 96.7 |
| 1033 | I | | 11.28 | 2.278 | 6.8 | 18.08 | 62.4 | 142.2 | 97.6 |
| 1033 | O | | 11.19 | 2.282 | 6.6 | 17.79 | 62.9 | 142.4 | 97.9 |
| 1039 | I | | 11.39 | 2.300 | 5.9 | 17.29 | 65.9 | 143.5 | 98.6 |
| 1039 | O | | 10.95 | 2.212 | 9.5 | 20.45 | 53.5 | 138.0 | 94.9 |
| 1045 | I | | 11.20 | 2.263 | 7.4 | 18.60 | 60.2 | 141.2 | 97.0 |
| 1045 | O | | 11.23 | 2.268 | 7.2 | 18.43 | 60.9 | 141.5 | 97.3 |
| | | | | Section 6 Sta. 1115-1139 | | | | | |
| Top Lift | | | | | | | | | |
| 1117 | I | 5.1 | 11.24 | 2.271 | 7.1 | 18.34 | 61.3 | 141.7 | 97.2 |
| 1117 | O | | 11.22 | 2.268 | 7.2 | 18.42 | 60.9 | 141.5 | 97.0 |
| 1122 | I | | 11.27 | 2.277 | 6.8 | 18.07 | 62.4 | 142.1 | 97.4 |
| 1122 | O | | 11.38 | 2.298 | 6.2 | 17.58 | 64.7 | 143.4 | 98.3 |
| 1127 | I | | 11.23 | 2.268 | 7.2 | 18.43 | 64.4 | 141.5 | 97.0 |
| 1127 | O | | 11.33 | 2.288 | 6.6 | 17.93 | 63.2 | 142.8 | 97.9 |
| 1132 | I | | 11.18 | 2.258 | 7.6 | 18.78 | 59.6 | 140.9 | 96.6 |
| 1132 | O | | 11.42 | 2.306 | 5.6 | 17.02 | 67.1 | 143.9 | 98.7 |
| 1137 | I | | 11.13 | 2.247 | 8.1 | 19.23 | 57.9 | 140.2 | 96.1 |
| 1137 | O | | 11.33 | 2.289 | 6.3 | 17.63 | 64.3 | 142.8 | 97.9 |
| Bottom Lift | | | | | | | | | |
| 1117 | I | 5.1 | 11.07 | 2.235 | 8.6 | 19.66 | 56.3 | 139.5 | 95.8 |
| 1117 | O | | 11.17 | 2.256 | 7.7 | 18.87 | 59.2 | 140.8 | 96.7 |
| 1122 | I | | 11.40 | 2.293 | 6.2 | 17.60 | 64.8 | 143.1 | 98.3 |
| 1122 | O | | 11.20 | 2.263 | 7.4 | 18.60 | 60.2 | 141.2 | 97.0 |
| 1127 | I | | 11.25 | 2.272 | 7.0 | 18.25 | 61.6 | 141.8 | 97.4 |
| 1127 | O | | 11.27 | 2.277 | 6.9 | 18.17 | 62.0 | 142.1 | 97.6 |
| 1132 | I | | 11.24 | 2.270 | 7.1 | 18.34 | 61.3 | 141.6 | 97.3 |
| 1132 | O | | 11.94 | 2.261 | 7.5 | 19.44 | 61.4 | 141.1 | 96.9 |
| 1137 | I | | 11.07 | 2.235 | 8.6 | 19.67 | 56.3 | 139.5 | 95.8 |
| 1137 | O | | 11.21 | 2.265 | 7.3 | 18.51 | 60.6 | 141.3 | 97.1 |

## TABLE 12 CONTINUED

## TEST RESULTS OF ROADWAY SPECIMENS FOR CONTROL MIXES IMMEDIATELY AFTER CONSTRUCTION

### Eastbound Roadway

| Station | | Asphalt Content-% By Weight | Asphalt Content-% By Volume | Specific Gravity | Voids-% | V.M.A.-% | V.F.A.-% | Density lbs./cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|---|
| **Section 1 Sta. 1018-1048** | | | | | | | | | |
| Top Lift | | | | | | | | | |
| 1021 | I | 5.1 | 11.22 | 2.266 | 7.3 | 18.52 | 60.6 | 141.4 | 97.2 |
| 1021 | O | | 11.14 | 2.249 | 8.0 | 19.14 | 58.2 | 140.3 | 96.5 |
| 1027 | I | | 11.27 | 2.277 | 6.8 | 18.07 | 62.4 | 142.1 | 97.7 |
| 1027 | O | | 11.25 | 2.273 | 7.0 | 18.25 | 61.6 | 141.8 | 97.5 |
| 1033 | I | | 11.38 | 2.298 | 6.0 | 17.38 | 65.5 | 143.4 | 98.6 |
| 1033 | O | | 10.95 | 2.212 | 9.5 | 20.45 | 53.5 | 138.0 | 94.9 |
| 1039 | I | | 11.27 | 2.277 | 6.8 | 18.07 | 62.4 | 142.1 | 97.7 |
| 1039 | O | | 11.19 | 2.261 | 7.5 | 18.69 | 59.9 | 141.1 | 97.0 |
| 1045 | I | | 11.08 | 2.238 | 8.4 | 19.48 | 56.9 | 139.7 | 96.0 |
| 1045 | O | | 11.00 | 2.224 | 9.0 | 20.00 | 55.0 | 138.8 | 95.4 |
| **Section 6 Sta. 1115-1139** | | | | | | | | | |
| Top Lift | | | | | | | | | |
| 1117 | I | | 11.19 | 2.261 | 7.5 | 18.69 | 59.9 | 141.1 | 97.0 |
| 1122 | I | | 11.20 | 2.263 | 7.4 | 18.60 | 60.2 | 141.2 | 97.1 |
| 1127 | I | | 11.29 | 2.280 | 6.7 | 17.99 | 62.8 | 142.3 | 97.8 |
| 1132 | I | | 11.20 | 2.263 | 7.4 | 18.60 | 60.2 | 141.2 | 97.1 |
| 1137 | I | | 11.06 | 2.233 | 8.6 | 19.66 | 56.3 | 139.3 | 95.8 |

TABLE 13

TEST RESULTS OF ROADWAY SPECIMENS FOR CONTROL MIXES 12 MONTHS AFTER CONSTRUCTION

| Station | Asphalt Content - % By Weight | Asphalt Content - % By Volume | Specific Gravity | Voids-% | V.M.A.% | V.F.A.% | Density Lbs/cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|
| **Westbound Roadway - Wearing Course** | | | | | | | | |
| **Section 1 Sta. 1018 - 1048** | | | | | | | | |
| 1023 I | 5.1 | 11.50 | 2.323 | 5.0 | 16.50 | 70.0 | 145.0 | 99.7 |
| 1023 O | | 11.53 | 2.328 | 4.7 | 16.23 | 71.0 | 145.3 | 99.9 |
| 1027 I | | 11.57 | 2.336 | 4.4 | 15.97 | 74.4 | 145.8 | 100.2 |
| 1027 O | | 11.66 | 2.354 | 3.7 | 15.36 | 75.9 | 146.9 | 101.0 |
| 1033 I | | 11.46 | 2.315 | 5.3 | 16.76 | 68.4 | 144.5 | 99.3 |
| 1033 O | | 11.55 | 2.332 | 4.6 | 16.15 | 71.5 | 145.5 | 100.0 |
| 1039 I | | 11.54 | 2.331 | 4.6 | 16.14 | 71.5 | 145.5 | 100.0 |
| 1039 O | | 11.54 | 2.330 | 4.7 | 16.24 | 71.1 | 145.4 | 100.0 |
| 1045 I | | 11.61 | 2.344 | 4.1 | 15.71 | 73.9 | 146.3 | 100.6 |
| 1045 O | | 11.56 | 2.334 | 4.5 | 16.06 | 72.0 | 145.6 | 100.1 |
| **Section 6 Sta. 1115 - 1139** | | | | | | | | |
| 1117 I | 5.1 | 11.50 | 2.322 | 5.0 | 16.50 | 71.0 | 144.9 | 99.6 |
| 1117 O | | 11.47 | 2.317 | 5.2 | 16.67 | 68.8 | 144.6 | 99.3 |
| 1122 I | | 11.48 | 2.318 | 5.2 | 16.68 | 68.8 | 144.6 | 99.4 |
| 1122 O | | 11.54 | 2.330 | 4.7 | 16.24 | 71.1 | 145.4 | 99.8 |
| 1127 I | | 11.37 | 2.296 | 6.1 | 17.47 | 65.1 | 143.3 | 98.5 |
| 1127 O | | 11.62 | 2.347 | 4.0 | 15.62 | 74.4 | 146.5 | 100.6 |
| 1132 I | | 11.39 | 2.301 | 5.9 | 17.29 | 65.9 | 143.6 | 98.7 |
| 1132 O | | 11.57 | 2.336 | 4.4 | 15.97 | 72.4 | 145.8 | 100.1 |
| 1137 I | | 11.39 | 2.300 | 5.9 | 17.29 | 65.9 | 143.5 | 98.7 |
| 1137 O | | 11.51 | 2.325 | 4.9 | 16.41 | 70.1 | 145.1 | 98.5 |
| **Eastbound Roadway - Wearing Course** | | | | | | | | |
| **Section 1 Sta. 1018 - 1048** | | | | | | | | |
| 1021 I | 5.1 | 11.49 | 2.321 | 5.0 | 16.49 | 69.7 | 144.8 | 99.6 |
| 1021 O | | 11.61 | 2.344 | 4.1 | 15.71 | 73.9 | 146.3 | 100.6 |
| 1027 I | | 11.46 | 2.314 | 5.3 | 16.76 | 68.4 | 144.4 | 99.3 |
| 1027 O | | 11.54 | 2.331 | 4.6 | 16.14 | 71.5 | 145.5 | 100.0 |
| 1033 I | | 11.55 | 2.333 | 4.5 | 16.05 | 72.0 | 145.5 | 100.0 |
| 1033 O | | 11.50 | 2.322 | 5.0 | 16.50 | 70.0 | 144.9 | 99.6 |
| 1039 I | | 11.45 | 2.313 | 5.4 | 16.85 | 68.0 | 144.3 | 99.2 |
| 1039 O | | 11.60 | 2.343 | 4.1 | 15.71 | 73.9 | 146.2 | 100.5 |
| 1045 I | | 11.43 | 2.308 | 5.6 | 17.03 | 67.1 | 144.0 | 99.0 |
| 1045 O | | 11.59 | 2.340 | 4.3 | 15.89 | 72.9 | 146.0 | 100.4 |
| **Section 6 Sta. 1115 - 1139** | | | | | | | | |
| 1117 I | | 11.51 | 2.325 | 4.9 | 16.41 | 70.1 | 145.1 | 99.7 |
| 1117 O | | 11.47 | 2.316 | 5.2 | 16.67 | 68.8 | 144.5 | 99.3 |
| 1122 I | | 11.40 | 2.303 | 5.8 | 17.20 | 66.3 | 143.7 | 98.8 |
| 1122 O | | 11.57 | 2.336 | 4.4 | 15.97 | 72.4 | 145.8 | 100.1 |
| 1127 I | | 11.51 | 2.324 | 4.9 | 16.41 | 70.1 | 145.0 | 99.7 |
| 1127 O | | 11.60 | 2.324 | 4.2 | 15.82 | 73.4 | 146.1 | 100.4 |
| 1132 I | | 11.37 | 2.297 | 6.0 | 17.37 | 65.5 | 143.3 | 98.5 |
| 1132 O | | 11.51 | 2.325 | 4.9 | 16.41 | 70.1 | 145.1 | 99.7 |
| 1137 I | | 11.38 | 2.299 | 5.9 | 17.28 | 65.9 | 143.5 | 98.6 |
| 1137 O | | 11.53 | 2.328 | 4.7 | 16.23 | 71.0 | 146.3 | 99.8 |

TABLE 14

TEST RESULTS ON WEARING COURSE ROADWAY SPECIMENS IMMEDIATELY AFTER CONSTRUCTION

Westbound Roadway

| Station | Expanded Clay Extracted From Core - % | Specific Gravity of Core | Lab. Gravity from Curve 2 | Theoretical Gravity | Asphalt Content by Volume | Voids % | V.M.A.% | V.F.A.% | Density Lbs/cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Section 3W 7.0% AC | | | | | |
| 1094 I* | 31.3 | 1.652 | 1.622 | 1.754 | 11.22 | 5.8 | 17.02 | 65.9 | 103.1 | 101.8 |
| 1099 I | 32.9 | 1.585 | 1.596 | 1.730 | 10.78 | 8.4 | 19.18 | 56.2 | 98.9 | 99.3 |
| 1104 I | 29.1 | 1.676 | 1.658 | 1.787 | 11.39 | 6.2 | 17.59 | 64.8 | 104.6 | 101.1 |
| 1109 I | 28.5 | 1.666 | 1.668 | 1.796 | 11.32 | 7.2 | 18.52 | 61.1 | 104.0 | 99.9 |
| 1112 I | 30.0 | 1.638 | 1.643 | 1.773 | 11.14 | 7.6 | 18.74 | 59.4 | 102.2 | 99.7 |
| 1094 O* | 27.8 | 1.702 | 1.679 | 1.806 | 11.57 | 5.8 | 17.37 | 66.6 | 106.2 | 101.4 |
| 1104 O | 31.1 | 1.620 | 1.625 | 1.757 | 11.02 | 7.8 | 18.82 | 58.6 | 101.1 | 99.7 |
| 1109 O | 32.0 | 1.646 | 1.611 | 1.743 | 11.19 | 5.6 | 16.79 | 66.6 | 102.7 | 102.2 |
| 1112 O | 28.8 | 1.667 | 1.663 | 1.791 | 11.34 | 6.9 | 18.24 | 62.2 | 104.0 | 100.2 |
| | | | | | Section 4W 8.0% AC | | | | | |
| 1144 I | 32.9 | 1.594 | 1.596 | 1.717 | 12.39 | 7.2 | 19.59 | 63.2 | 99.5 | 99.9 |
| 1147 I | 33.0 | 1.576 | 1.594 | 1.716 | 12.25 | 8.2 | 20.45 | 59.9 | 98.3 | 98.9 |
| 1152 I | 30.4 | 1.684 | 1.637 | 1.754 | 13.08 | 4.0 | 17.08 | 76.6 | 105.1 | 102.9 |
| 1156 I | - | 1.683 | - | - | - | - | - | - | - | - |
| 1161 I | 30.7 | 1.660 | 1.632 | 1.750 | 12.90 | 5.1 | 18.00 | 71.7 | 103.6 | 101.7 |
| 1144 O | - | 1.702 | - | - | - | - | - | - | - | - |
| 1147 O | 33.7 | 1.599 | 1.583 | 1.706 | 12.42 | 6.3 | 18.72 | 66.3 | 99.8 | 101.0 |
| 1152 O | 31.6 | 1.639 | 1.617 | 1.737 | 12.74 | 5.6 | 18.34 | 69.5 | 102.8 | 101.4 |
| 1156 O | 27.9 | 1.699 | 1.678 | 1.791 | 13.20 | 5.1 | 18.30 | 72.1 | 106.0 | 101.3 |
| 1161 O | 29.4 | 1.685 | 1.654 | 1.769 | 13.09 | 4.7 | 17.79 | 73.6 | 105.1 | 101.9 |
| | | | | | Section 5W 7.5% AC | | | | | |
| 1175 I | 30.4 | 1.656 | 1.637 | 1.760 | 12.06 | 5.9 | 17.96 | 67.1 | 103.3 | 101.2 |
| 1179 I | 33.0 | 1.663 | 1.594 | 1.722 | 12.11 | 3.4 | 15.51 | 78.1 | 103.8 | 104.3 |
| 1183 I | 31.1 | 1.662 | 1.625 | 1.750 | 12.10 | 5.0 | 17.10 | 70.8 | 103.7 | 102.3 |
| 1187 I | 30.7 | 1.618 | 1.632 | 1.756 | 11.78 | 7.9 | 19.68 | 59.9 | 101.0 | 99.1 |
| 1190 I | 32.7 | 1.671 | 1.599 | 1.726 | 12.16 | 3.2 | 15.36 | 79.2 | 104.3 | 104.5 |
| 1175 O | 21.4 | 1.777 | 1.784 | 1.905 | 12.94 | 6.7 | 19.64 | 65.9 | 110.9 | 99.6 |
| 1179 O | 31.0 | 1.600 | 1.627 | 1.751 | 11.65 | 8.6 | 20.25 | 57.5 | 99.8 | 98.3 |
| 1183 O | - | 1.677 | - | - | - | - | - | - | - | - |
| 1187 O | 33.5 | 1.505 | 1.586 | 1.715 | 10.96 | 12.2 | 23.16 | 47.3 | 93.9 | 94.9 |
| 1190 O | 30.8 | 1.633 | 1.631 | 1.754 | 11.89 | 6.9 | 18.79 | 63.3 | 101.9 | 100.1 |

*I - Inside Lane
*O - Outside Lane

Note: These are the corrected physical properties for test sections 3W, 4W, 5W. All of the remaining expanded clay test sections were not corrected due to the large amount of time consumed in extracting each core and therefore, their properties are not listed.

TABLE 15

TEST RESULTS ON WEARING COURSE ROADWAY SPECIMENS 12 MONTHS AFTER CONSTRUCTION

Westbound Roadway

| Station | Expanded Clay Extracted From Core - % | Specific Gravity of Core | Lab. Gravity from Curve 2 | Theoretical Gravity | Asphalt Content by Volume | Voids % | V.M.A. % | V.F.A. % | Density Lbs/cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Section 3W 7.0% AC | | | | | | |
| 1094 I* | 29.6 | 1.682 | 1.650 | 1.779 | 11.43 | 5.5 | 16.93 | 67.5 | 105.0 | 101.9 |
| 1099 I | 31.0 | 1.640 | 1.627 | 1.758 | 11.15 | 6.7 | 17.85 | 62.5 | 102.3 | 100.8 |
| 1104 I | 31.7 | 1.691 | 1.616 | 1.748 | 11.50 | 3.3 | 14.80 | 77.7 | 105.5 | 104.6 |
| 1109 I | 31.7 | 1.649 | 1.616 | 1.748 | 11.20 | 5.7 | 16.90 | 66.3 | 102.9 | 102.0 |
| 1112 I | 29.1 | 1.708 | 1.658 | 1.787 | 11.61 | 4.4 | 16.01 | 72.5 | 106.6 | 103.0 |
| 1094 O* | 30.8 | 1.704 | 1.631 | 1.761 | 11.58 | 3.2 | 14.78 | 78.3 | 106.3 | 104.5 |
| 1099 O | 30.8 | 1.693 | 1.631 | 1.761 | 11.50 | 3.9 | 15.40 | 74.7 | 105.6 | 103.8 |
| 1104 O | 30.5 | 1.709 | 1.635 | 1.766 | 11.61 | 3.2 | 14.81 | 78.4 | 106.6 | 104.5 |
| 1109 O | 30.6 | 1.728 | 1.634 | 1.764 | 11.75 | 2.0 | 13.75 | 85.5 | 107.8 | 105.8 |
| 1112 O | 32.1 | 1.660 | 1.609 | 1.742 | 11.28 | 4.7 | 15.98 | 70.6 | 103.6 | 103.2 |
| | | | | Section 4W 8.0% AC | | | | | | |
| 1144 I | 32.4 | 1.650 | 1.604 | 1.725 | 12.82 | 4.3 | 17.12 | 74.9 | 103.0 | 102.9 |
| 1147 I | 33.8 | 1.658 | 1.581 | 1.704 | 12.87 | 2.7 | 15.57 | 82.7 | 103.5 | 104.9 |
| 1152 I | 30.4 | 1.696 | 1.637 | 1.754 | 13.17 | 3.3 | 16.47 | 80.0 | 105.8 | 103.6 |
| 1156 I | 32.3 | 1.670 | 1.606 | 1.726 | 12.97 | 3.2 | 16.17 | 80.2 | 104.2 | 104.0 |
| 1161 I | 33.6 | 1.662 | 1.584 | 1.707 | 12.91 | 2.6 | 15.51 | 83.2 | 103.7 | 104.9 |
| 1144 O | 28.2 | 1.734 | 1.673 | 1.786 | 13.47 | 2.9 | 16.37 | 82.3 | 108.2 | 103.6 |
| 1147 O | 33.2 | 1.687 | 1.591 | 1.713 | 13.11 | 1.5 | 14.61 | 89.7 | 105.3 | 106.0 |
| 1152 O | 30.7 | 1.713 | 1.632 | 1.750 | 13.30 | 2.1 | 15.40 | 86.4 | 106.9 | 105.0 |
| 1156 O | 25.9 | 1.793 | 1.710 | 1.823 | 13.92 | 1.6 | 15.52 | 89.7 | 111.9 | 104.9 |
| 1161 O | 29.3 | 1.757 | 1.655 | 1.770 | 13.65 | 0.7 | 14.35 | 95.1 | 109.6 | 106.2 |
| | | | | Section 5W 7.5% AC | | | | | | |
| 1175 I | 29.0 | 1.711 | 1.660 | 1.780 | 12.46 | 3.9 | 16.36 | 76.2 | 106.8 | 103.1 |
| 1179 I | 33.6 | 1.652 | 1.584 | 1.713 | 12.03 | 3.6 | 15.63 | 77.0 | 103.1 | 104.3 |
| 1183 I | 32.3 | 1.676 | 1.606 | 1.732 | 12.20 | 3.2 | 15.40 | 79.2 | 104.6 | 104.4 |
| 1187 I | 32.6 | 1.683 | 1.601 | 1.728 | 12.25 | 2.6 | 14.58 | 82.5 | 105.0 | 105.1 |
| 1190 I | 36.9 | 1.643 | 1.530 | 1.668 | 11.96 | 1.5 | 13.46 | 88.9 | 102.5 | 107.4 |
| 1175 O | 33.7 | 1.682 | 1.583 | 1.712 | 12.25 | 1.8 | 14.05 | 87.2 | 105.0 | 106.3 |
| 1179 O | 38.8 | 1.594 | 1.499 | 1.643 | 11.61 | 3.0 | 14.61 | 79.5 | 99.5 | 106.3 |
| 1183 O | 33.2 | 1.663 | 1.591 | 1.719 | 12.11 | 3.3 | 15.41 | 78.6 | 103.8 | 104.5 |
| 1187 O | 32.5 | 1.694 | 1.603 | 1.729 | 12.34 | 2.0 | 14.34 | 86.1 | 105.7 | 105.7 |
| 1190 O | 32.7 | 1.675 | 1.599 | 1.726 | 12.19 | 3.0 | 15.19 | 80.3 | 104.5 | 104.8 |

* I - Inside Lane
* O - Outside Lane

Note: These are the corrected physical properties for test sections 3W, 4W, 5W. All of the remaining expanded clay test sections were not corrected due to the large amount of time consumed in extracting each core and therefore, their properties are not listed.

TABLE 16

TEST RESULTS OF ROADWAY SPECIMENS FOR EXPANDED CLAY MIXES - EXTRA TEST SECTIONS

Eastbound Roadway - Asphalt Content 8.0% By Weight

| Station | Expanded Clay Extracted From Core - % | Specific Gravity of Core | Lab Gravity From Curve 3 | Theoretical Gravity | Asphalt Content By Volume | Voids-% | V.M.A.% | V.F.A.% | Density Lbs./cu.ft. | %Compaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Original Cores - Outside Lane | | | | | | |
| 1245 O | 28.5 | 1.640 | 1.679 | 1.782 | 12.74 | 8.0 | 20.74 | 61.4 | 102.3 | 97.7 |
| 13 Passes (Pneumatic) | 28.0 | 1.650 | 1.687 | 1.789 | 12.82 | 7.8 | 20.62 | 62.2 | 103.0 | 97.8 |
| | 28.3 | 1.628 | 1.682 | 1.785 | 12.64 | 8.8 | 21.44 | 59.0 | 101.6 | 96.8 |
| AVERAGE | | | | | | | | | | 97.4 |
| 1247 O | 29.6 | 1.606 | 1.661 | 1.766 | 12.48 | 9.1 | 21.58 | 57.8 | 100.2 | 96.7 |
| 15 Passes | 28.2 | 1.626 | 1.684 | 1.786 | 12.63 | 9.0 | 21.63 | 58.4 | 101.5 | 96.6 |
| | 30.1 | 1.600 | 1.654 | 1.758 | 12.43 | 9.0 | 21.43 | 58.0 | 99.8 | 96.7 |
| AVERAGE | | | | | | | | | | 96.7 |
| 1249 O | 30.9 | 1.615 | 1.641 | 1.747 | 12.54 | 7.6 | 20.14 | 62.3 | 100.8 | 98.4 |
| 17 Passes | 32.1 | 1.597 | 1.621 | 1.729 | 12.41 | 7.6 | 20.01 | 62.0 | 99.7 | 98.5 |
| | 29.1 | 1.640 | 1.670 | 1.773 | 12.74 | 7.5 | 20.24 | 62.9 | 102.3 | 98.2 |
| AVERAGE | | | | | | | | | | 98.4 |
| 1255 O | 28.6 | 1.623 | 1.677 | 1.780 | 12.60 | 8.8 | 21.40 | 58.9 | 101.3 | 96.8 |
| 19 Passes | 31.2 | 1.596 | 1.636 | 1.742 | 12.40 | 8.4 | 20.80 | 59.6 | 99.6 | 97.6 |
| | 30.4 | 1.620 | 1.649 | 1.754 | 12.58 | 7.6 | 20.18 | 62.3 | 101.1 | 98.2 |
| AVERAGE | | | | | | | | | | 97.5 |
| | | | | 12 Months Cores - Outside Lane | | | | | | |
| 1245 O | 29.8 | 1.651 | 1.658 | 1.763 | 12.83 | 6.1 | 19.23 | 66.7 | 103.0 | 99.6 |
| 13 Passes | 23.4 | 1.688 | 1.762 | 1.864 | 13.11 | 9.5 | 22.61 | 58.0 | 105.3 | 95.8 * |
| AVERAGE | | | | | | | | | | 99.6 |
| 1247 O | 31.9 | 1.621 | 1.624 | 1.732 | 12.59 | 6.4 | 18.99 | 66.3 | 101.2 | 99.8 |
| 15 Passes | 29.2 | 1.653 | 1.668 | 1.772 | 12.83 | 6.7 | 19.53 | 65.7 | 103.1 | 99.1 |
| AVERAGE | | | | | | | | | | 99.5 |
| 1249 O | 28.8 | 1.687 | 1.674 | 1.778 | 13.11 | 5.1 | 18.21 | 72.0 | 105.3 | 100.8 |
| 17 Passes | 30.7 | 1.614 | 1.644 | 1.750 | 12.53 | 7.8 | 20.33 | 61.6 | 100.7 | 98.2 |
| AVERAGE | | | | | | | | | | 99.5 |
| 1255 O | 31.6 | 1.635 | 1.629 | 1.737 | 12.70 | 5.9 | 18.60 | 68.3 | 102.0 | 100.4 |
| 19 Passes | 30.3 | 1.639 | 1.650 | 1.756 | 12.73 | 6.7 | 19.43 | 65.5 | 102.3 | 99.3 |
| AVERAGE | | | | | | | | | | 99.9 |

Compaction Sequence

Three Wheel Roller - 5 Passes

Pneumatic Roller - Varied as designated

Tandem Roller - Passes required to eliminate roller marks

* This value not averaged

TABLE 16 CONTINUED

TEST RESULTS OF ROADWAY SPECIMENS FOR EXPANDED CLAY MIXES - EXTRA TEST SECTIONS

Eastbound Roadway - Asphalt Content 8.0% By Weight

| Station | Expanded Clay Extracted From Core - % | Specific Gravity of Core | Lab. Gravity From Curve 3 | Theoretical Gravity | Asphalt Content By Volume | Voids-% | V.M.A.% | V.F.A.% | Density Lbs./cu.ft. | % Compaction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Original Cores - Inside Lane | | | | | | |
| 1245 I | 26.7 | 1.669 | 1.709 | 1.808 | 12.96 | 7.7 | 20.66 | 62.7 | 104.1 | 97.7 |
| 13 Passes | 29.0 | 1.655 | 1.671 | 1.775 | 12.85 | 6.8 | 19.65 | 65.4 | 103.3 | 99.0 |
| (Pneumatic) | 27.9 | 1.668 | 1.689 | 1.791 | 12.95 | 6.9 | 19.85 | 65.2 | 104.1 | 98.8 |
| AVERAGE | | | | | | | | | | 98.5 |
| 1247 I | 28.2 | 1.653 | 1.684 | 1.786 | 12.83 | 7.5 | 20.33 | 63.1 | 103.1 | 98.2 |
| 15 Passes | 28.7 | 1.647 | 1.676 | 1.779 | 12.80 | 7.4 | 20.20 | 63.4 | 102.8 | 98.3 |
| | 30.0 | 1.626 | 1.655 | 1.760 | 12.63 | 7.6 | 20.23 | 62.4 | 101.5 | 98.2 |
| AVERAGE | | | | | | | | | | 98.2 |
| 1249 I | 28.5 | 1.636 | 1.679 | 1.782 | 12.71 | 8.2 | 20.91 | 60.8 | 102.1 | 97.4 |
| 17 Passes | 28.5 | 1.645 | 1.679 | 1.782 | 12.78 | 7.7 | 20.48 | 62.4 | 102.6 | 98.0 |
| | 29.8 | 1.623 | 1.658 | 1.763 | 12.60 | 7.9 | 20.50 | 61.5 | 101.3 | 97.9 |
| AVERAGE | | | | | | | | | | 97.8 |
| 1255 I | 28.6 | 1.641 | 1.678 | 1.780 | 12.75 | 7.8 | 20.55 | 62.0 | 102.4 | 97.8 |
| 19 Passes | 31.2 | 1.621 | 1.636 | 1.742 | 12.59 | 6.9 | 19.49 | 64.6 | 101.2 | 99.1 |
| | 30.0 | 1.644 | 1.655 | 1.760 | 12.77 | 6.6 | 19.37 | 65.9 | 102.6 | 99.3 |
| AVERAGE | | | | | | | | | | 98.7 |
| | | | | 12 Months Cores - Inside Lane | | | | | | |
| 1245 I | 28.7 | 1.675 | 1.676 | 1.779 | 13.01 | 5.9 | 18.91 | 68.8 | 104.5 | 99.9 |
| 13 Passes | 29.0 | 1.682 | 1.671 | 1.775 | 13.07 | 5.2 | 18.27 | 71.5 | 105.0 | 100.6 |
| AVERAGE | | | | | | | | | | 100.3 |
| 1247 I | 30.5 | 1.678 | 1.647 | 1.753 | 13.03 | 5.7 | 18.73 | 69.6 | 104.7 | 101.9 |
| 15 Passes | 30.6 | 1.659 | 1.646 | 1.751 | 12.88 | 4.7 | 17.58 | 73.3 | 103.5 | 100.8 |
| AVERAGE | | | | | | | | | | 101.4 |
| 1249 I | 29.6 | 1.674 | 1.661 | 1.766 | 13.00 | 4.8 | 17.80 | 73.0 | 104.5 | 100.8 |
| 17 Passes | 30.7 | 1.641 | 1.644 | 1.750 | 12.75 | 3.8 | 16.55 | 77.0 | 102.4 | 99.8 |
| AVERAGE | | | | | | | | | | 100.3 |
| 1255 I | 30.1 | 1.674 | 1.654 | 1.759 | 13.00 | 4.8 | 17.80 | 73.0 | 104.5 | 101.2 |
| 19 Passes | 30.0 | 1.662 | 1.644 | 1.760 | 12.91 | 5.6 | 18.51 | 69.7 | 103.7 | 101.1 |
| AVERAGE | | | | | | | | | | 101.2 |

Compaction Sequence

Three Wheel Roller - 3 passes
Pneumatic Roller - Varied as designated
Tandem Roller - Number of passes required to eliminate roller marks

# APPENDIX "G"

## AVERAGE SKID RESISTANCE VALUES FOR ALL TEST SECTIONS AT VARIOUS TIME INTERVALS
## AVERAGE LONGITUDINAL GROOVES 12 MONTHS AFTER CONSTRUCTION
## ROUGHNESS RESULTS IMMEDIATELY AND 12 MONTHS AFTER CONSTRUCTION
## PRESENT SERVICEABILITY INDEX - 12 MONTH RESULTS

TABLE 18

AVERAGE LONGITUDINAL GROOVES ONE YEAR AFTER CONSTRUCTION

Eastbound Roadway

* Average Grooves - mm.

| Test Section | Inside Lane | | Outside Lane | |
|---|---|---|---|---|
| | Rt.Wheelpath | Lt. Wheelpath | Rt. Wheelpath | Lt. Wheelpath |
| 1 (Control) | 0 | 1 | 1 | 3 |
| 2 | 0 | 0 | 2 | 2 |
| 3 | 1 | 1 | 3 | 4 |
| 4 | 0 | 1 | 2 | 3 |
| 5 | 1 | 0 | 3 | 4 |
| 6 (Control) | 1 | 1 | 2 | 4 |
| 7 | 0 | 0 | 2 | 2 |
| 8 | 0 | 0 | 2 | 4 |
| 9 | 3 | 1 | 2 | 3 |
| 10 | 3 | 1 | 4 | 3 |
| Average | 1 | 1 | 3 | 4 |
| Extra Test Section | 0.9 | 0.6 | 2.3 | 3.2 |

Westbound Roadway

| Test Section | Inside Lane Rt. Wheelpath | Inside Lane Lt. Wheelpath | Outside Lane Rt. Wheelpath | Outside Lane Lt. Wheelpath |
|---|---|---|---|---|
| 1 (Control) | 0 | 0 | 1 | 3 |
| 2 | 0 | 1 | 1 | 4 |
| 3 | 1 | 2 | 2 | 5 |
| 4 | 2 | 3 | 5 | 8 |
| 5 | 0 | 1 | 2 | 5 |
| 6 (Control) | 1 | 2 | 2 | 5 |
| 7 | 0 | 2 | 2 | 4 |
| 8 | 0 | 2 | 4 | 6 |
| 9 | 0 | 1 | 1 | 4 |
| 10 | 2 | 4 | 3 | 6 |
| Average | 0.6 | 1.8 | 2.3 | 5.0 |

* Each value is an average of 25 readings taken throughout the test sections.

TABLE 19

ROUGHNESS RESULTS ON THE VARIOUS TEST SECTIONS IMMEDIATELY AFTER CONSTRUCTION AND AFTER 12 MONTHS OF SERVICE

Roughness - Inches Per Mile

| Section | Inside Lane | | | | Outside Lane | | | |
|---|---|---|---|---|---|---|---|---|
| | Left Wheel Path | | Right Wheel Path | | Left Wheel Path | | Right Wheel Path | |
| | Orig. | 12 mo. | Orig. | 12 mo. | Orig. | 12 mo. | Orig. | 12 mo. |
| 1W | 95 | 93 | 84 | 95 | 85 | 97 | 84 | 86 |
| 2W | 100 | 94 | 100 | 105 | 89 | 98 | 93 | 90 |
| 3W | 98 | 105 | 92 | 109 | 106 | 103 | 106 | 88 |
| 6W | 81 | 89 | 86 | 83 | 83 | 88 | 72 | 83 |
| 4W | 97 | 92 | 81 | 90 | 95 | 100 | 90 | 85 |
| 5W | 98 | 87 | 89 | 91 | 89 | 88 | 92 | 85 |
| 7W | 91 | 102 | 99 | 104 | 94 | 96 | 94 | 100 |
| 8W | 100 | 106 | 105 | 99 | 100 | 102 | 92 | 111 |
| 9W | 95 | 108 | 89 | 100 | 99 | 94 | 95 | 89 |
| 10W | 93 | 95 | 81 | 92 | 93 | 90 | 89 | 78 |
| 1E | 79 | 87 | 77 | 94 | 80 | 83 | 82 | 89 |
| 2E | 110 | 127 | 101 | 90 | 131 | 120 | 73 | 108 |
| 3E | 97 | 131 | 94 | 96 | 130 | 116 | 66 | 111 |
| 6E | 84 | 86 | 71 | 90 | 73 | 89 | 82 | 90 |
| 4E | 110 | 103 | 102 | 90 | 106 | 115 | 78 | 122 |
| 5E | 101 | 83 | 97 | 85 | 74 | 108 | 74 | 124 |
| 7E | 125 | 96 | 131 | 82 | 86 | 129 | 74 | 150 |
| 8E | 120 | 114 | 138 | 105 | 109 | 124 | 94 | 152 |
| 9E | 108 | 107 | 91 | 108 | 96 | 109 | 93 | 118 |
| 10E | 102 | 111 | 91 | 108 | 96 | 103 | 100 | 103 |

TABLE 20

PRESENT SERVICEABILITY INDEX - 12 MONTH RESULTS

Eastbound Roadway

| Test Section | Inside Lane | * Outside Lane |
|---|---|---|
| 1 | 2.5 | 2.3 |
| 2 | 2.6 | 2.4 |
| 3 | 2.8 | 2.4 |
| 4 | 2.4 | 2.3 |
| 5 | 2.7 | 2.2 |
| 6 | 2.8 | 2.3 |
| 7 | 2.8 | 2.3 |
| 8 | 2.2 | 2.0 |
| 9 | 2.2 | 2.1 |
| 10 | 2.2 | 2.2 |
| AVERAGE | 2.5 | 2.3 |

Westbound Roadway

| Test Section | Inside Lane | * Outside Lane |
|---|---|---|
| 1 | 2.6 | 2.5 |
| 2 | 2.6 | 2.3 |
| 3 | 2.5 | 2.6 |
| 4 | 2.5 | 2.2 |
| 5 | 2.6 | 2.2 |
| 6 | 2.4 | 2.6 |
| 7 | 2.5 | 2.4 |
| 8 | 2.3 | 2.4 |
| 9 | 2.4 | 2.5 |
| 10 | 2.0 | 2.9 |
| AVERAGE | 2.4 | 2.5 |

* The outside lane of the Eastbound Roadway includes the widening which is cracked and pumping.

# APPENDIX "H"

# TEST PROCEDURES FOR DETERMINING SPECIFIC GRAVITY OF AGGREGATES

Method of Test for
# DETERMINATION OF SPECIFIC GRAVITY OF COARSE LIGHTWEIGHT AGGREGATE
LDH DESIGNATION TR - 312-69

## SCOPE

1. This method of test is intended to determine the specific gravity of coarse lightweight aggregate.

## APPARATUS

2. (a) A balance having a capacity of 1,000 grams, sensitive to 0.1 gram.

(b) Oven, hot-plate or burner.

(c) Vacuum pump.

(d) Pot, stirring spoon, 1/2 gallon mason jar with cap, etc.

## SAMPLES

3. (a) The samples shall be representative of the material to be used in construction. The materials shall be tested in triplicate and averaged. The material shall be screened on a No. 4 mesh sieve and the portion retained on the No. 4 sieve used in this procedure. The material shall be dried prior to its preparation for the gravity determination.

(b) A quart sample of asphalt cement of the same source and grade to be used during construction should be obtained if possible. If not available, an asphalt cement of similar physical characteristics may be used.

## PROCEDURE

4. (a) Heat the dried screened aggregate and asphalt cement to 300°F - 325°F.

(b) Weigh out and record approximately 250 grams of aggregate and place in a clean enameled pot or mixing bowl.

(c) Weigh into the pot 10 to 15 percent asphalt cement as based on the aggregate weight. The trial and error method shall be used to determine the correct percentage of asphalt cement necessary to thoroughly coat the aggregate.

(d) Mix the aggregate and asphalt cement until each aggregate particle is completely and uniformly coated. During mixing it may be necessary to hold the pot over a bunsen burner for just a few minutes while mixing to enable a uniform coating.

(e) Spread the mixture on a clean surface and allow to cool to room temperature.

(f) The cooled mixture shall then be weighed in air, and the weight recorded.

(g) Calculate the exact percentage of asphalt in the mix, being very careful not to lose any of the coated particles.

$$C = \frac{B-A}{B} (100)$$

A = Weight of the dry aggregate
B = Weight of the dry mixture
C = Per Cent of asphalt in the mixture

(h) Fill the 1/2 gallon mason jar with water until the water is over the brim of the jar. Carefully place the cap onto the jar in a manner not to create any unnecessary air pockets between the cap and the water. Screw the cap on tightly and dry the outside of the jar with a clean cloth. Weigh the water filled jar and record the weight.

(i) Pour approximately half of the water out of the jar and replace with the asphalt aggregate mixture. Replace as much water as needed to cover the mixture, and place under vacuum for 10 minutes. Agitate jar to release entrapped air.

(j) Remove from vacuum and fill the jar as described in paragraph (h). Some of the lighter particles may float; however, after applying the cap these particles will become submerged into the water. Note: (It is permissible to have a small removable screen set into the neck of the jar to keep the lighter particles from coming above the top of the jar. If so the screen should be weighed with the jar whenever a weight is recorded). After the cap is tightly screwed onto the jar, the jar shall be dried with a clean cloth and the weight recorded.

(k) Calculate the combined specific gravity of the mixture as follows:

$$F = \frac{B}{D+B-E}$$

B = Weight of the dry mixture
D = Weight of the jar and water
E = Weight of the jar, water and mixture
F = Combined Specific Gravity of the mixture

(l) After obtaining the specific gravity of the mixture F calculate the specific gravity of the lightweight aggregate as follows:

$$G = \frac{X}{\frac{100}{F} - \frac{C}{H}}$$

G = Specific gravity of the lightweight aggregate
X = Percent of aggregate in the mix
F = Combined specific gravity of the mixture
C - Percent of asphalt in the mixture
H - Specific gravity of the asphalt cement

Normal Testing Time - 4 hours

Method of Test for

# APPARENT SPECIFIC GRAVITY OF FINE AGGREGATE AND MINERAL FILLER FOR BITUMINOUS MIXTURES

LDH DESIGNATION: TR 301-67

## Scope

1. This method is intended for the determination of the apparent specific gravity of mineral filler and fine aggregate (fraction passing a No. 4 mesh sieve) showing a water absorption of less than 2.5%, for use in bituminous mixtures.

## Apparatus

2. The apparatus shall consist of the following:

(a) *Balance* - A balance having a capacity of 1 Kilogram or more and sensitive to 0.1 gram or less.

(b) *Flask* - A volumetric flask of 500 milliliter capacity, calibrated to 0.15 milliliter at 77° F (25° C).

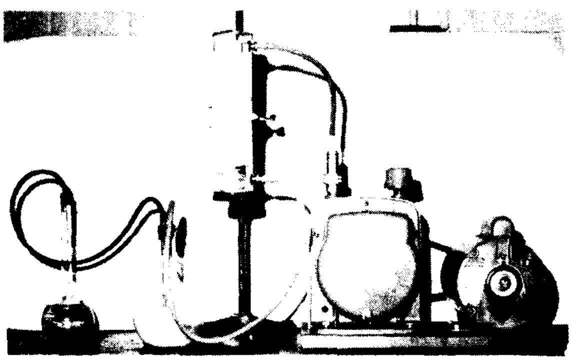


**FIGURE I**

*Fine Aggregate Under Vacuum*

## Procedure

3. (a) 1000 gram portion of the fine aggregate will be placed in a suitable container and dried at a temperature not to exceed 235° F. Note: For dry bin samples obtain 200-300 grams by splitting or quartering the 1000 gram sample.

(b) The sample will be cooled to room temperature and then poured into the tared volumetric flask (100 - 125 grams should be used for mineral fillers).

(c) The flask and contents will be weighed and the flask filled with water to a level approximately 1 inch above the surface of the fine aggregate.

(d) The flask will be left at room temperature for 24 hours. After this time it will be placed under vacuum for 15-30 minutes.

(e) The water level will be brought to slightly above the calibration mark and placed in a water bath at 77°F (25°C) for 1 hour.

(f) Then the water level will be adjusted so that the bottom of the meniscus will be at the same level with the calibration line.

(g) The flask and contents will be weighed and the weight recorded.

(h) The apparent specific gravity will be computed by use of the following formula:

$$\text{Apparent Specific Gravity} = \frac{A - B}{D - C + A}$$

where:

A = weight of flask plus dry sample in grams
B = weight of flask in grams
C = weight of flask plus sample plus water in grams
D = calibrated volume of flask at 77°F (25°C)

## Precautions:

500 milliliter volumetric flasks are generally calibrated at 60°F; therefore, they should be recalibrated at 77°F.

Normal testing time –26 hours.

## References:

AASHO Designation: T 84
ASTM Designation: C 128