CHAPTER 3: BASE COURSE CONSTRUCTION

Now that materials have been hauled to the roadway, the construction process can begin. This Chapter covers in detail the construction steps that were briefly mentioned in Chapter 1 - mixing spreading; compacting; and finishing. These steps will be applied to the three main types of base courses - raw aggregate, stabilized soil and aggregate, and asphaltic concrete.

You learned in Chapter 1 that a base course is constructed in layers, or lifts. The number of lifts used to construct a base course depends on the type of material being used. For example, stabilized base courses are often constructed in one layer, while other base courses are multi-layered.

It is important to remember that prior to any base course being placed the subgrade is to be checked to make sure it is on grade and per plans. This information is to be recorded in a field book. As each lift is constructed, a certain amount of sampling and testing must be done in order to assure a stable and uniform base course. Material that is placed and processed in one lift requires only one passing sample and test for acceptance. (See Georgia Sampling, Testing, and Inspection Manual for frequency).

MONOLITHIC - ONE PASSING SAMPLE & TEST PER ZONE

| 1 LAYER |

In multi-layered construction, where lifts are thick enough to be constructed in separate operations, each lift will be sampled and tested separately.

MULTI-LAYERED - TWO PASSING SAMPLES
AND TESTS PER ZONE

| 4 1/2" |
| 4 1/2" |
FILL IN THE BLANK(S):

3-1 Material that is constructed in one operation requires ______________ passing sample(s) per zone.

3-2 Material constructed in more than one layer, or lift, requires ______________ passing sample(s) per zone.

3-3 The construction of lifts varies according to the ______________ being used.

As each lift is being placed and compacted, it is important to make sure that the top surface of the lift is fairly irregular or rough before placing the next lift. (For all base courses except asphaltic concrete base course). This irregular surface will provide the necessary friction to bond that lift to the lift placed on top of it. Use one course construction only on soil cement.

If the surface of one lift is too smooth, the lift placed on top of it will slide, thus forming a plane of slippage. This is called shifting, and it causes a base course to be unstable and to be off crown. This slippage could cause cracks (or breakage) in one of the lifts and this could cause a failure in the pavement.
FILL IN THE BLANK(S):

3-4 The top surface of a lift should be ____________________ to provide friction for the lifts to bond together.

3-5 If the surface of a lift is too smooth, the lift on top of it will ____________________.

3-6 The sliding of a lift could cause ________________ which would cause ________________ in the pavement.

The Standard Specifications do not specify a minimum length of the subgrade to be in final condition to receive the base course. However, it is desirable that enough roadbed be finished for one-day's run in order to give you time to inspect it. This will also give the contractor enough time to drop back and make necessary corrections or repairs without holding up the construction operation. On the other hand, having too much of the subgrade in final condition would allow traffic to damage it before the base course is placed upon it.

Before construction of any type of base course begins, be sure that you are familiar with the layout and grade control as shown in the project plans and specifications. Ask yourself the following questions:

- Were lab reports, soil surveys, etc., reviewed and do they correlate with job conditions?
- Has the subgrade been stringlined and the results recorded?
- Has the subgrade been inspected and corrected for any deficiencies?
- Is all of the construction equipment properly adjusted and in good working condition?
RAW, UNTREATED BASE COURSES

Depending upon the method used for mixing untreated aggregates, the material will be placed on the subgrade in one of two ways:

If the material has been premixed prior to placement, it will be hauled in from the mixing table or pugmill and then spread.
If the material is not premixed, the components will be hauled in, dumped at regular intervals on the subgrade, spread, windrowed, and spread again.

A mechanical spreader usually spreads material that comes from a mixing table or pugmill. A mechanical spreader is wheel mounted and is usually pushed by a bulldozer. The spreader distributes the material in a uniform layer.

The particular part of the spreader that causes the material to be spread uniformly is called the strike-off bar. The height of the strike-off bar can be adjusted so that it will yield the correct loose thickness of material during spreading. Therefore, since the loose material is to be compacted to a specific depth, the strike-off bar is set at a height that is greater than the required depth of the compacted base course.

If material is to be mixed on the roadway, the components are usually dumped at regular intervals. Dumping in large piles should not be permitted. This results in segregation, non-uniform densities, or hard spots developing at the bottom of the pile.

Coarse components are dumped and spread first, and then the fine components are dumped and spread over the coarse components. The motor grader then mixes the material by windrowing it toward one side of the road and then toward the other.
FILL IN THE BLANK(S):

3-9 ____________ components are spread over ____________ components, and are then mixed by the __________________________.

The process will be repeated until the mixture is well blended. The part of the motor grader that does the mixing is the blade.
If the blade is not in good condition it will be hard to get a well-blended, uniform mixture. The contractor will decide whether to replace the blade. If he can get a good mix by using a worn blade, that's fine. However, you can (and should) suggest that the blade be replaced if the mix is not well blended.

After the mixture is well blended, the motor grader will spread the windrowed material over the surface of the subgrade. No matter which method the contractor uses to spread the base course material, you must make sure that it is spread uniformly.

**FILL IN THE BLANK(S):**

3-10 Material hauled in for an untreated aggregate base course may either be ______________ or mixed- ________________.

3-11 A haul truck, or a haul truck and a ____________________________, may be used to spread premixed material.

3-12 The motor grader mixes the materials by ________________ them from one side of the road to the other.

3-13 No matter which method the contractor uses to spread the base course material, you must make sure that it is spread ________________.

**CIRCLE THE CORRECT ANSWER(S):**

3-14 The strike-off bar is set at a height that is (greater / less) than the required depth of the compacted base course.

3-15 The strike-off bar should be adjusted so that when the loose material is compacted, the (width / depth) of the base course is within tolerance.

3-16 If material is to be mixed-in-place, the motor grader will spread the (fine / coarse) material over the (fine / coarse) material.
The untreated aggregate material that has been mixed must meet certain criteria before compaction. The requirements concern the:

- mixture uniformity
- gradation
- moisture content
- shape of the lifts

As the inspector you have the responsibility of knowing these requirements and seeing that they are met. Let's examine each of the items mentioned above.

**THE MIXTURE**

Each lift must be checked before compaction to make sure that it is mixed uniformly. You should look for any:

- streaks of color
- streaks of moisture
- streaks of coarse or fine particles

A uniform mixture should have none of these things! Inform the contractor if the mixture is not uniform.

**CIRCLE THE CORRECT ANSWER:**

3-17 A mixture that contains streaks of color, moisture, or fine particles (will / might not) obtain maximum density during compaction.

3-18 Untreated aggregate material (must/must not) meet certain criteria.

3-19 Each lift (must/must not) be inspected before compaction.

**GRADATION**

In addition to having a uniform mixture, each lift of loose base material should be graded properly. Gradation is the percentage by weight of different-sized particles in a mixture.

Proper gradation helps a material obtain strength. The strength of a raw aggregate depends partially on the unit weight of the total material. A properly graded material has a higher unit weight after compaction than one that is not properly graded. Look at these two compacted materials. Each material occupies one cubic foot.
The material on the left does not have proper gradation. There are many air voids between the large particles. One cubic foot of this material would weigh less than the same amount of a properly graded material.

The material on the right has proper gradation. It has the same percentage of large particles as the material on the left but the air voids are filled by fine material. One cubic foot of this material would weigh more than the material on the left.

If the materials were mixed-in-place, the total material must be tested by the O M & R, after mixing, to see if the gradation is within tolerance. If gradation tolerance is not met, then recheck samples are taken.

If the recheck samples fail, the material will be remixed, or, if the material being used is pit-run (natural), the mixture will require "sweetening" (the addition of necessary amounts of the deficient component to the base course to bring it within specifications).

Sweetening, resampling, and retesting must continue until the base course material meets specifications, or until new material that meets gradation requirements is brought in. This is the only way to be sure that the material is graded properly.

Remember, whenever a sample is taken by the lab for testing, whether it is the original sample or a resample, a DOT 170 sample card will be included. If it is a resample, the form is filled out as usual except:

The resample is cross-referenced to the original sample.
It should tell what corrective action has been taken in the space reserved for "Remarks."
Using the following information, fill out the appropriate lines on the form:
The original sample was identified as "No. 1 - 3."
The sample failed.
The contractor sweetened the area represented by this sample with 200 pounds per square yard of M10 screenings.
Each time a roadway interval is sampled, or corrected and resampled, O M & R personnel document the sample information in a sample log book:

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>STA. NO.</th>
<th>LIFT NO.</th>
<th>DATE</th>
<th>RESULTS</th>
<th>CROSS REFERENCE</th>
<th>REMARKS</th>
<th>INI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>3</td>
<td>1</td>
<td>4/10/00</td>
<td>Failed on No. 4 Screen</td>
<td>3-1A</td>
<td>see page 68</td>
<td>W.L.J.</td>
</tr>
<tr>
<td>3-1A</td>
<td>3</td>
<td>1</td>
<td>4/10/00</td>
<td>Passed</td>
<td>3-1</td>
<td>W.L.J.</td>
<td></td>
</tr>
</tbody>
</table>

3-21 Document the following information on the sample form that follows:
A sample is taken at Station 3, Lift 1, on August 10, 1997.
Sand-clay-gravel is being sampled.
It fails on the #4 screen.
The area is sweetened with 200 pounds per square yard of M10 screenings.
The area is resampled on August 12, 1997.
The resample fails to conform to specifications.
100 pounds per square yard more of M10 screenings are added.
The area is resampled again on August 14, 1997.
This sample passes.

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>STA. NO.</th>
<th>LIFT NO.</th>
<th>DATE</th>
<th>RESULTS</th>
<th>CROSS REFERENCE</th>
<th>REMARKS</th>
<th>INI.</th>
</tr>
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<td></td>
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</tbody>
</table>

Remarks found on Page 70 - Sample No. 3-1: Added 200 pounds per square yard of M10 screenings and resampled. Sample No. 3-1A: resample for sample 3-1 - Added 100 pounds per square yard of M10 screenings and resampled again. Sample No. 3-1B: resample for sample 3-1A - passed.
MOISTURE CONTENT

In addition to having a uniform mixture and proper gradation, each lift should have a moisture content that is uniform and near optimum. The Standard Specifications state that untreated aggregate based course materials should be brought to the moisture content required for compaction to the required density. The recommended moisture content and theoretical maximum density for raw aggregate materials will be provided by the District Laboratory.

If soil aggregate material is compacted at its optimum moisture content it is easier to obtain the required density during compaction.

The graphs, following, explain why it is important for a material to have the proper moisture content. These are moisture-density curves. The peak of the curve represents theoretical maximum laboratory density at optimum moisture after compaction. Points on the dry side of the curve represent moisture content approaching optimum. Points on the wet side of the curve represent moisture content that has exceeded optimum.

In the following case, the moisture content is not great enough. This material will not reach the maximum density for a given compactive effort.
In this next case too much water has been added. The moisture content is too high - it has gone too far beyond optimum. The material will not reach maximum density for a given compactive effort.

When the proper amount of water has been added to the material it will reach maximum density for a given compactive effort.

Moisture and density are closely related because:

Moisture lubricates soil particles, causing them to slide over each other and form a denser mass.

At the time of compaction, the density of a material increases for a given compactive effort with every increase in moisture content until the optimum moisture content is reached.

If the moisture content is increased beyond optimum at the time of compaction, the soil particles will be displaced by water. This will cause density to decrease, since water weighs less than the materials.

**FILL IN THE BLANK(S):**

3-22 You are more likely to get the required density if you compact an untreated material at or near optimum
A water truck is used to add moisture to an untreated material. The water must be spread evenly and uniformly over the surface of the lift. To spread the water uniformly the truck must travel at a constant rate of speed. If for some reason the truck stops while moistening the lift, they need to make sure the water is turned off.

All of the holes in the spray bar at the back of the water truck must be in good operating condition and unclogged. If the spray bar becomes clogged or too much water is spewing from one hole, stop the truck and notify the contractor.

Moisture tests should be run several times a day, especially on hot days. When moisture is needed it can be added to raw base course material at any time before or during compaction.

**SHAPING THE LIFT**

In addition to being mixed uniformly, having the proper gradation and correct moisture content, each lift must be spread uniformly. The depth should be fairly even with no obvious high or low spots. A relatively uniform depth is easy to obtain if the material is spread with a mechanical spreader. If the material is truck-dumped, the motor grader will be used to level off the loose spread.

Each lift should be shaped roughly to plan grade. This will make it easier to control the grade in the top lift. The material should be spread thick enough to bring the compacted surface slightly above final grade so that fine grading will be a trimming operation rather than a filling operation.

A means of checking for uniform depth is by using a stringline stretched between points of known elevation.
CIRCLE THE CORRECT ANSWER:

3-23 Which of the following lifts (the top / the middle / the bottom) is spread roughly to plan grade?

COMPACCTION OF A RAW, UNTREATED AGGREGATE BASE COURSE

3-22 Moisture content
After a lift of base course is spread, it must be compacted so it will withstand the effects of traffic. Compaction increases the stability of a material. Many types of compaction equipment can be used to obtain the required density. The contractor may use any approved machinery that is in good condition.

One of the most effective pieces of compaction equipment used on materials spread in thick lifts and materials with a high binder (clay) content is the sheepfoot roller.

The sheepfoot roller is a hollow, closed drum with "feet" attached to the rolling surface. The feet on the sheepfoot may be of any shape and length, depending on the type of material being compacted and the thickness of the lift. All of the feet on the roller must be of the same type. None should be missing or excessively worn.
There is an opening in one end of the drum.

The contractor uses this opening to put water and sometimes sand inside the drum. This makes the roller heavier so it can compact with greater force.

**CIRCLE THE CORRECT ANSWER:**

3-24 The weight of the sheepfoot roller (can/cannot) be adjusted.

When the weight of the roller is increased, its compactive effort is increased with the same number of passes.
The feet should be long enough to penetrate to the bottom of the lift without the drum riding on the lift. As compaction is achieved, the roller will begin to "walk out." When properly compacted, a lift will have uniform density throughout its full depth.

Look at this sheepfoot roller. It is not penetrating to the bottom of the lift.

This action results in "bridging." Bridging occurs when the equipment compacts only the top part of a lift, leaving the bottom part uncompacted and loose. If bridging is going to occur it will do so almost immediately (within 2 or 3 passes of the roller). The lift may appear to be uniformly compacted, but the bottom of the lift will not be dense.

CIRCLE THE CORRECT ANSWER:

3-25  Bridging is a sign that the lift (is / is not) uniformly compacted.
Since bridging is not obvious, your first sign of poor compaction will usually be a failing density test.

Probable causes of bridging include:

- feet that are too short
- feet that are worn or broken
- feet that are too large to penetrate
- an improperly loaded drum
- very dry material in the lift

Since feet on the rollers vary in length, shape, and surface areas, the contractor should use the type of roller that is best for the material he is compacting. If a roller has the proper type of feet for the particular material, then the cause for a failing density test could be one of the last two items listed above.

**CIRCLE THE CORRECT ANSWER:**

3-26 For best results, the moisture level for untreated aggregate base course material should be

a. at or near minimum  
b. at or near optimum  
c. 5% of optimum.

A roller should obtain uniform compaction in 6 to 8 passes. (A pass is one coverage over a certain length of roadway by the particular piece of equipment - a sheepfoot roller in this instance). As the number of passes increases, the feet of the roller will penetrate less and less. On the final pass, the feet will hardly penetrate at all, thus the term "walking out"
FILL IN THE BLANK:

As we mentioned earlier, the roller will "___________________" as compaction is achieved.

Each lift should be uniformly compacted to the required density. If a lift has the correct gradation and moisture content, and the contractor uses the proper rollers, a uniformly high density is usually fairly easy to obtain.

Another piece of compaction equipment the contractor might use is the pneumatic roller:

The pneumatic roller is usually used to seal the surface of base course materials. It is not normally used for obtaining compaction. The sheepfoot roller is more efficient for thick lifts because its feet can penetrate to the bottom of the lift.
A pneumatic roller is equipped with rubber tires on the front and rear axles. When the pneumatic roller is operating, the gaps between the front tires are covered by the rear tires.

In this way, the entire area of the pass is covered. The material not covered by the front tires will be covered by the rear tires.

**CIRCLE TRUE OR FALSE**

3-28  True  False  The tires on the pneumatic roller cover the entire surface of the pass.

The tires on the pneumatic roller have no treads. The surface of each tire must be smooth and without nicks or cuts. All of the tires on the pneumatic roller must be equal in diameter, and all must be uniformly inflated.
Pneumatic rollers may either be a larger, self-propelled roller or a smaller roller that is usually towed.

The compactive effort of all pneumatic rollers may be increased by either increasing the tire pressure or by adding weight. If the contractor decides to increase the tire pressure, he will add more air to the tires. You should check to see that all the tires on a pneumatic roller have equal pressure.

3-30 Finish the surface on an untreated aggregate base course
If the contractor decides to increase the compactive effort by adding weight, he will add sand or pieces of concrete to the ballast box. It may be necessary to increase the air pressure of the tires when weight is added. If the air pressure in the tires is not high enough, the only effect adding weight to the ballast box will have is to increase the ground surface covered by each tire.

As the inspector, you can make sure that the pneumatic roller's compactive effort is evenly distributed by seeing that:
- the pressure of all tires is equal
- no tire is flat
- the added weight load is centered
- all tires are equal in diameter

**FILL IN THE BLANK(S):**

3-29 To be able to achieve uniform compaction, the tires of the pneumatic rollers must have equal __________, the weight load must be ________________, all tires must be equal in ________________, and no tire should be ________________.
The waffle-wheel compactor is another piece of equipment used for compacting. It is sometimes used to finish the surface of untreated aggregate base courses.

A waffle-wheel compactor is a self-propelled roller having four wheels, each of which is equipped with spaced metal plates. Be sure to check the metal plates - all of them must be in good condition. None must be broken, missing or badly worn. If you see worn plates on a compactor, notify the contractor. These plates should be replaced before compaction begins.

FILL IN THE BLANK(S):

3-30 A waffle-wheel compactor is sometimes used to _____________________________________________.

This piece of equipment is called the vibratory roller, and is used to compact granular type material.
The vibratory roller compacts material by vibrating the soil particles. Vibration rearranges the particles so they fit together more closely. The following sketches show how soil looks before and after vibration:

**FILL IN THE BLANK(S):**

3-31 View ____________ from previous drawing, shows the denser soil.

3-32 What type of material is the vibratory roller commonly used for?

The vibratory roller should vibrate at a certain frequency. Frequency is the number of vibrations per minute. If the vibratory roller does not have the correct frequency, it will not compact properly. The manufacturer will recommend the best frequency for the vibratory roller.

The contractor is responsible for seeing that the vibratory roller is operating at the proper frequency. You should notify his foreman if the required density is not being reached so that the proper adjustments can be made.

**ANSWER THE QUESTION(S):**

3-33 What is frequency? __________________________.

3-34 The vibratory roller compacts by doing what to the soil particles? __________________________

3-35 What could be wrong with a vibratory roller that does not compact properly?
Now to review the most common uses of the four pieces of compaction equipment we have just talked about. Remember no one piece of equipment is equally suitable for all untreated aggregate materials. Each one is more effective for a certain type of untreated aggregate material. For example:

The sheepsfoot roller is more effective when compacting materials that are spread in thick lifts and materials with a high binder (clay) content.

The pneumatic roller is more effective when compacting materials that are spread in thin (2-inch to 3-inch) lifts and the top of a lift.

The waffle-wheel compactors are commonly used to finish the surface of untreated aggregate base courses. The vibratory roller is more effective when compacting granular materials, such as graded aggregate.

The contractor is usually free to choose which equipment he'll use. However, if the Special Provisions list specific compaction equipment for a job, the contractor is required to use that equipment.

3-36  Label the following pieces of compaction equipment.

A. (picture below) ______________________________

B. (picture above) ______________________________
C. (picture below) ______________________________

D. (picture above) ______________________________

3-31   B
3-32   Granular
3-33   The number of vibrations per minute
3-34   Rearranging
3-35   May be operating at improper frequency
Each lift of a multi-layered base course must be spread and compacted to the required density before the next lift is placed. Each type of base course material has a required density as seen in the appropriate section of the Standard Specifications. Notice that the various untreated aggregate base courses are required to reach 100% of maximum density during compaction. Each lift must meet this required density.

**FILL IN THE BLANK:**

3-37 The density required for an untreated aggregate base course is

**CIRCLE THE CORRECT ANSWER:**

3-38 Each lift must reach required density (before / after) the next lift is placed.

---

An in-place density test determines the percent of theoretical maximum density a roadway has actually reached after compaction. The procedure can be found in the Sampling, Testing, and Inspection Manual. One density test should be taken for every 1500 linear feet per 2 lanes of roadway.

Density tests are taken at random locations. If one particular location is always chosen to run the tests (for example, at centerline) you cannot be sure that the entire area meets density requirements. Even if the centerline meets requirements, the whole roadway may not.

Before a density test is taken:

All areas of the base must have received the same compactive effort.
The base must have a uniform appearance.

The contractor should be required to correct all soft, wet, dry, or yielding spots in the base before random testing begins. The surface is dry enough to be tested when fines do not readily stick to your palm. If fines and moisture remain on your palm after you touch the surface of the lift, wait and give it time to dry.

The results of an in-place density test on an untreated aggregate material are compared to the material's theoretical density as shown on the maximum density curve. O M & R personnel advice construction personnel whether the density fails or passes. All the actual test information is then sent to the Area Engineer.

Actual in-place density should at least equal the theoretical maximum density shown on the maximum density curve.
ANSWER THE QUESTION(S):

3-39 Material A has a theoretical maximum density as shown on the total material curve of 140 pounds per cubic foot. Its in-place density must be at least _________ pounds per cubic foot.

3-40 Material B has a theoretical maximum density as shown on the total material curve of 130 pounds per cubic foot. Its in-place density must be at least _________ pounds per cubic foot.

3-41 Material C has a theoretical maximum density as shown on the total material curve of 110 pounds per cubic foot. Its in-place density must be at least _________ pounds per cubic foot.

If a density test taken shows that in-place density is less than the theoretical maximum density, you have a failing density test. Additional testing will then be done.

FILL IN THE BLANK(S):

3-42 If in-place density is ___________ than theoretical density the test failed.

3-43 If a failing test happens, density tests then must be __________ _______.
After taking two additional tests in the area of a failing test, the average percent compaction for the three tests is reported.

For example: Suppose the theoretical density of a material tested is 130 pounds per cubic foot. The first test fails with 128 pounds per cubic foot. The second test shows a density of 125 pounds per cubic foot, and the third shows 127 pounds per cubic foot. The three are averaged:

\[
\frac{128}{130} = 0.9846 = 98\% \text{ of theoretical density} \\
\frac{125}{130} = 0.9615 = 96\% \text{ of theoretical density} \\
\frac{127}{130} = 0.9769 = 98\% \text{ of theoretical density}
\]

\[
\frac{98 + 96 + 98}{3} = 97.3, \text{ so the average of the three tests is 97\% of theoretical density.}
\]

**FILL IN THE BLANK(S):**

3-44 When running a density test, actual density of the material is compared to its ________ density.

3-45 If the test fails, _______________ tests must be run.

**CIRCLE THE CORRECT ANSWER:**

3-46 You must report the (total / average) of all the tests.

If the average of three density tests in a failing test area is less than theoretical density, the contractor must be notified and he must rework and recompact the failing area until the required density is reached.

Suppose theoretical maximum density for an untreated aggregate base course is 116 pounds per cubic foot. Below are listed actual in-place densities for three zones.

**ANSWER YES OR NO:**

3-47 Which set of densities have an average that meets the density requirements for this base course?

A. 112, 110, and 117 pounds per cubic foot

B. 111, 119, and 118 pounds per cubic foot

C. 117, 104, and 118 pounds per cubic foot
After each density test is taken, the results are written on DOT Form 386 "Report of Compaction Results, Thickness Measurements and/or Samples Taken." As you can see, it fills several tasks. A sample is shown as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample No.</th>
<th>Density</th>
<th>Moisture</th>
<th>Wet Density</th>
<th>Dry Density</th>
<th>Compaction</th>
<th>Wet Compaction</th>
<th>Dry Compaction</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/17</td>
<td>310</td>
<td>140.0</td>
<td>16.9</td>
<td>140.0</td>
<td>130.0</td>
<td>3.8</td>
<td>100%</td>
<td>101.5</td>
<td>F Too dry</td>
</tr>
<tr>
<td>7/17</td>
<td>310</td>
<td>140.0</td>
<td>16.9</td>
<td>140.0</td>
<td>130.0</td>
<td>3.8</td>
<td>100%</td>
<td>101.5</td>
<td>P Recheck</td>
</tr>
</tbody>
</table>

3-39 140
3-40 130
3-41 110
3-42 less
3-43 taken again
The previous sample has been filled out for a Base Compaction Test.

Project Information BLOCK contains basic information about the project. Base is circled because this is a base course sampling. Dates of test(s) are recorded. Item No. & Type Material is explained in the Sampling, Testing and Inspection Manual. Sample Number is based on the District (the first number), the tester's initial (last) and a sequential number, with the numbering system recycling at the beginning of the fiscal year. In this example "Depth Below Top of Subgrade" is N/A for not applicable. Under the Moisture or Voids Content (%) column there is "optimum" and an "actual" block. The "optimum" is taken from the maximum dry density determination and the "actual" is the moisture value of the field sample. The Maximum Dry Density or SP, GR. column has a "Control" and an "In-place" block. The first is the value that has been defined as being the standard for the project and the second is the actual sample value. Under the Per Cent Compaction column, there are two blocks, one for Required percentage and the Actual. Again, the latter is the actual sample percentage. Code Designation refers to the symbols in the bottom left and refers to the types of testing that can be used.

The RESULTS block records whether the sample Passed (P) or Failed (F).

3-48 What kind of device was used in our sample? ___________________________.

3-49 In our example did the first sample Pass or Fail?

3-50 Why was there a second check? ___________________________.

ANSWER THE QUESTION(S):

FINISHING

The last step in constructing a raw aggregate base course is the finishing process, which includes fine-blading, sealing, and finally - applying prime to protect the base course. Let's talk about each of these parts of the finishing process:

After all lifts of the base course have been compacted to the required density, the top lift must be fine bladed. To fine-blade the surface means to shape the base course to the planned dimensions by scraping off a thin layer of excess compacted material. The surface is freed of dips and humps and becomes smooth. The machine used for fine-blading normally is the motor grader.
Fine-blading helps the base course conform to the following:
- plan distance
- plan grade and crown
- plan centerline median
- plan fore slope and back slope

The loose material on the roadway must be brushed away in order for the prime to stick to the base course.
A rotary broom may broom the excess material scraped up during fine-blading off the surface.

The purpose of fine-blading and sealing is to obtain a smooth, uniform surface. You should inspect these operations carefully to be sure all dips and bumps are smoothed out. Visual inspection for irregularities is one of your most important jobs.

**FILL IN THE BLANK:**

3-51 The purpose of fine-blading and sealing is ________________.

**APPLICATION OF PRIME**

The base course must be protected after the surface has been fine-bladed and sealed. An untreated aggregate base course can be protected by applying an asphaltic material called prime. The prime coat serves to:

- keep the base course in finished shape until the surfacing is placed
- bond the surface to the base course
- act as a moisture barrier because it seals out excess moisture while preventing evaporation
- coat the base course and prevent surface fines from being worn away

The type of material used for prime on all types of the base material shall be one of those listed in Section 412 of the Standard Specifications as shown below:

- Cutback Asphalt RC-30, RC-70, RC-250, or MC-30, MC-70, MC-250
- Emulsified Asphalt EAP-1
- Tars RT-2, RT-3
- Cutback Asphalt Emulsion CBAE-2

The contractor may use any of the above materials for prime on any type of base.

Before the contractor applies prime, you should inspect the surface of the base course. The surface of the base must be at optimum moisture and must be free of any loose foreign material. If any loose material exists, the base course should be swept with a rotary broom, but be sure that the contractor does not begin sweeping until the surface is dry. Prior to priming, the surface should be damp.

Besides inspecting the surface, you should also inspect the asphalt distributor before it is put into operation. In order to obtain an even application of prime, the distributor must be in good working condition. Look at the following drawing of a distributor.
An asphalt distributor must be able to prime at a specified rate. The application rate for prime is 0.15 to 0.30 gallons per square yard. In order to apply prime at this rate, the distributor must travel at just the right speed.

The distributor should have certain devices to help you determine the proper speed:

An application chart or table supplied by the manufacturer. Most of these operate like a slide rule and are calibrated to determine the desired truck speed in feet per minute when you know:
- the length of the spray bar
- the pump capacity in gallons
- the required application rate

A tachometer which records actual speed in feet per minute.

A pump gauge which determines the amount of flow by measuring the amount of pressure.
FILL IN THE BLANK(S):

3-52 The application rate for prime is _________ to _________ gallons per square ________.

3-53 To obtain the proper application the asphalt distributor must travel at the proper ________________.

In addition to applying prime at the specified rate, a distributor must be equipped to heat prime to within a specified temperature range. Unheated prime is stiff and viscous, like tar. It can't obtain complete coverage unless it is uniformly heated to a more liquid state.

Prime is heated to the proper temperature by hot oil or gas burners. These burners distribute the heat to flues that run the length of the tank. A pump is used to circulate the prime through the tank. This causes the prime to be heated uniform at all times.

The distributor must also be equipped with a readable thermometer to indicate the temperature of the prime. It will be located on the side of the tank. The temperature range for each type of prime can be found in section 412 of the Standard Specifications. Each time you check the temperature of the prime, it must fall within the specified range.
CIRCLE THE CORRECT ANSWER(S):

3-54  To apply prime at a specified rate, an asphalt distributor must be equipped with which of the following?
   a. a bitumen indicator
   b. a tachometer
   c. a sludge sieve
   d. application charts or tables
   e. a pump gauge

3-55  To apply prime within the specified temperature range, an asphalt distributor must be equipped with
   which of the following?
   a. oil or gas burners
   b. flues
   c. a pump
   d. a readable thermometer

Besides applying prime at a specified rate and temperature range, the distributor must be equipped to maintain con-
stant and uniform pressure on the prime as it passes through the nozzles.
Spray pressure is maintained by a pump. While prime is being "shot," the pump should apply the pressure recommended by the manufacturer's chart for the particular rate of speed.

FILL IN THE BLANK:

3-56 Spray pressure of prime is maintained by a _________ on the asphalt distributor.

The distributor must also be equipped with screens between the tank and the nozzles. Screens are used to strain the prime so foreign material will not clog the nozzles on the spray bar. If you notice that the area covered by the fans from the spray bar is not uniform, have the distributor shut off.

FILL IN THE BLANK:

3-57 An asphalt distributor should be equipped with screens to prevent the ______________________ from clogging.

As an inspector, you need to know the exact amount of prime that is in the tank before and after application in order to determine the amount of prime that was shot. For this purpose, an asphalt distributor should be equipped with a meter or a metal measuring rod. The meter or rod is used to determine the quantity carried in the tank at any given time.
ANSWER THE QUESTION:

3-58 How can you determine the quantity of prime in an asphalt distributor?

Finally, an asphalt distributor is equipped with pneumatic tires.

The tires should be wide enough so that the distributor does not cause ruts or depressions in the base course.

When prime is delivered, it has already been approved by the Laboratory - provided that the type, grade and supplier on the invoice are also shown on the qualified supplier list in QPL-7.
The Shipper's Invoice will show all the points called for in SOP-4.

The Shipper's Invoice should also be dated. It should indicate the quantity of prime in the shipment, the type of asphalt, and the project and contract ID numbers. The invoice serves as the means of acceptance of the prime, so be sure that data on the form conforms to the requirements in SOP-4.

It is not necessary to obtain job control samples of the prime unless questionable material is involved or possible unsatisfactory performance. In these instances, samples should be submitted for testing, and all interested personnel (supplier, contractor, etc.) should be informed.
An approved supplier's shipment invoice should indicate:

- the date
- the gallons of prime in the shipment
- the project and contract ID numbers
- the type and grade of asphalt
- supplier's name
- gross weight of load and not weight of material
- specific gravity at 60°F
- brand name, percentage, and number of gallons of anti-stripping additive
- brand name and amount of silicone (if applicable)

CPW Seal

Invoice and Bill of Lading should be stamped or marked "Certified to meet Department of Transportation Specifications".

The base course has been fine-bladed and sealed and it has the correct moisture for priming. You have inspected the distributor and received the proper forms, but you still aren't ready to begin priming because you haven't checked the outside air temperature. Prime must not be applied when the temperature of the air is less than 40°F in the shade.

As you remember, unheated prime is thick and viscous. To provide good coverage, it must be heated and applied under pressure in a liquid state. If the outside air temperature is below 40°F, the prime will cool while it is being shot. It probably will not obtain good coverage.

**FILL IN THE BLANK:**

3-59 Prime must not be applied when the outside air temperature is below ______________ in the shade.

We mentioned earlier that prime must be spread at a certain rate of application - 0.15 to 0.30 gallons per square yard. Thus, the contractor must spread a minimum of 0.15 gallons per square yard and a maximum of 0.30 gallons per square yard in order to meet specifications. As the inspector, your job is to make sure that the actual amount applied is within this range. The following sections are concerned with determining the actual spread rate.

One of the first steps in determining the actual spread rate is to find the area of the section of base course being primed (Length X Width). To find the width, go to the project plans and find the surface width (not the base course width). Prime is not applied to the entire width of the base course because shoulders of 3 to 10 feet wide will be placed on each side of the surface course. The width of the prime application will be the width of the surface course plus 6 inches on each side.
The Standard Specifications state that prime must be applied 6 inches beyond the width of surfacing shown on the plans. Actually, this means 6 inches on each edge of the plan surface width, or a total of 1 foot must be added.

**FILL IN THE BLANK:**

3-60 Suppose the plan surface width is 20 feet. The total width to be primed is ___________ feet.

To determine length, all you need to do is multiply the number of Stations being primed by 100 feet. For example, Stations 70+00 to 75+00 are being primed; therefore, 5 X 100 feet = 500 feet (total linear feet being primed).

You can now determine the area by multiplying length x width. For example, if the length = 500 feet, and width = 29 feet, then 500 feet X 29 feet = 14,500 square feet. Dividing 14,500 square feet by 9 gives a total of 1,611 square yards.

**ANSWER THE QUESTION:**

3-61 How many square yards are to be primed if the plan width of the surface course is 23 feet and Stations 61+00 to 86+00 are to be primed?

The next step in determining the actual spread rate is to find the number of gallons actually used. This is not difficult. Before the contractor begins to shoot prime, you must record the beginning quantity (in gallons) as indicated on the asphalt distributor's meter or measuring rod. As soon as the application of prime has been made, record the ending quantity. Subtract the ending quantity from the beginning quantity and you'll have the amount of prime actually used.
Prime may be shot at any temperature from 80°F to 180°F, depending on the type. Prime heated over 60°F expands, and more gallons must be used to cover the same area of base. The distributor will have to spread it at a slower rate of speed in order for the base course to be properly covered.

The Standard Specifications set the temperature of pay quantity of prime at 60°F; therefore, if it is shot at another temperature, the gallons used must be converted to liters at 60°F. To convert heated prime to liters at 60°F, it will be necessary to use the correction chart that follows.

This chart is taken from Section IV of the Construction Manual.

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Beginning quantity, ending quantity, and application temperature should be documented in a field book or on the inspector’s report, as these figures are used to compute the actual spread quantity.
The numbers in the temperature column are possible temperatures for prime in consecutive order.
The numbers in the factor column are correction factors for the temperature shown, at certain Specific Gravities.

Go to the temperature column that corresponds to the temperature of prime you are working with. Multiply the correction factor for this temperature by the gallons of prime actually used.

**CALCULATE THE ANSWER:**

3-62 If you shot 1,500 gallons at 115°F with a Specific Gravity of .976, the volume corrected to °F is

_______________________ gallons.

Now, the final step to find the actual rate of application is to divide the number of gallons of prime at 60°F by the number of square yards in the section. The resulting figure should be between 0.15 and 0.30 in order to comply with the rate of application stated in the Standard Specifications.

**FILL IN THE BLANK(S):**

3-63 To find the rate of application per square yard, divide the number of gallons at ________ by the number of __________________ in the section.

3-64 The rate of application must be between _______________ and ___________ gallons per square yard.

3-65 Calculate the actual rate of application of cutback using the following information:
   Prime is shot from Station 45+00 to Station 65+00.
   The width of the plan surface area is 22 feet.
   The gauge on the asphalt distributor tank measures 2,000 gallons before the prime is shot and 500 gallons afterwards.
   The thermometer is on 146°F at the time of application.
   The Specific Gravity of the prime is .966.

   Answer: _______________ gallons per square yard.
Now we're ready for documentation. Below is an example of all the items you may need to document when prime is being shot. This would be in your payment documentation or in a separate field book.

**BASE COURSE - APPLICATION OF PRIME**
- Item # (   )
- Stations Covered
- Linear feet
- Width
- Square yards
- Beginning Quantity
- Ending Quantity
- Gallons Used
- Application Temperature
- Gallons Corrected to 60°F
- Rate of Application
- Haul Ticket Number
- Date

**ANSWER THE FOLLOWING QUESTIONS:**

3-66 Multiply the number of Stations by ____________ to find the number of linear feet covered.

3-67 The width is the width shown on the project plans plus ________________.

3-68 Multiply ________________ by _____________ to find the area covered.

3-69 Beginning and ending quantities of prime in the distributor were taken from the ________________ on the distributor.

3-70 The ________________ minus the ______________ equals the number of gallons actually used.

3-71 The temperature of prime must be between ______________ and ______________ in order to be used.

3-72 Multiply the correction factor by the number of ________________ to find the number of liters at 60°F.

3-73 To find the rate of application divide the number of ________________ by the number of ________________.
MAINTENANCE OF AN UNTREATED AGGREGATE BASE COURSE

If possible, the base course should be closed to traffic until the prime cures. After the prime has cured, the contractor will probably clear the roadway of debris and excess material. He should clean and dress the slopes and ditches as much as possible before the surface course is placed. This prevents possible damage to the completed surface course.

FILL IN THE BLANK:

3-74 The base course should be __________________________ until the prime has cured.

The contractor is responsible for maintaining the completed base course against damage caused by traffic. As an inspector, you should help him out by notifying him of any areas that need repairs. You can check the condition of the base course and prime coat regularly and make a record of all areas where prime is stripped off or where defects are evident in the base course. Be sure to document any corrective action taken.

FILL IN THE BLANK(S):

3-75 You should make a record of all areas where ________________ is stripped off or where ________________ are evident in the base course. You should notify the _____________ of areas that need repair.

If a base course is allowed to stand several months before surfacing, it is possible that raveling will take place. Raveling is a defect that occurs when prime is stripped off and fines are worn away, leaving exposed coarse aggregate. Raveling usually occurs in longitudinal strips on the base surface. The following cross section illustrates raveling:
Where raveling has occurred, the area is usually repaired by removing loose material and applying asphaltic material (hot mix) which is rolled in uniformly with the tandem or pneumatic roller.

**CIRCLE THE CORRECT ANSWER:**

3-76 Raveling usually occurs in (diagonal cross-patterns/longitudinal strips) on the surface of the base course.

**FILL IN THE BLANK:**

3-77 Raveled areas are usually repaired by ___________________.

Shallow, base defects such as depressions (low spots) are repaired by removing to traffic loose material and applying hot mix.
FILL IN THE BLANK:

3-78 ____________________ is used to repair shallow base defects.

Large defective areas in an untreated base course may be reworked, recompacted and reprimed. As an inspector, you are responsible for seeing that the base course is properly maintained until the surfacing is placed.

MATCH THE COLUMNS:

3-79 Match column "A" with column "B" below:

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<th>B</th>
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<td>1. responsible for maintaining and protecting the completed base</td>
<td>A. reworking, recompacting repairing</td>
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<td>2. responsible for seeing that the completed base course is maintained</td>
<td>B. the contractor</td>
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<td>3. usual method of repairing raveled areas</td>
<td>C. the inspector</td>
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<td>4. usual method of repairing small, shallow defects</td>
<td>D. applying hot mix</td>
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106
STABILIZED BASE COURSES

Stabilized base course material may either be premixed through the use of a pugmill, or mixed-in-place on the roadway. Before construction can start on stabilized bases, the outside temperature away from artificial heat and in the shade must be at least 40°F and rising. If construction is underway and the temperature falls to 35°F, construction must be halted. These temperature requirements should be followed unless special permission is granted.

FILL IN THE BLANK(S):

3-80 Construction of stabilized bases may begin when the outside temperature is ________________ and rising, but construction should be halted if the temperature falls to ________________.

PLACEMENT OF STABILIZED MATERIALS

Often the base course materials to be stabilized are materials from an existing roadbed. If this is the case, the existing roadbed must be scarified, pulverized, blended, and shaped before stabilization can begin. Section 301 of the Standard Specifications deals with the "In-Place Cement Stabilized Base Course."

If existing roadbed materials are not present, then the materials to be stabilized are hauled in and placed in the same manner as materials for untreated aggregate bases. The materials are spread and uniformly compacted to the satisfaction of the Project Manager.

FILL IN THE BLANK(S):

3-81 If materials to be stabilized are not present, they must be ____________, placed, and uniformly ____________ prior to stabilization.

Once the material to be stabilized is compacted, cement or lime can be spread and the stabilization process begun. Since cement and lime are spread and cut into the base course materials in the same manner we will discuss only cement. The Central Lab, after testing the materials to be used, will include in their report the percentage of cement needed for proper stabilization as well as the optimum moisture content. It will be up to you to use the information received from the lab properly. If you are in doubt as to how to use the percent of cement go back to Chapter 2 and review.
CALCULATE THE ANSWER:

3-82 Find the cement spread distance if:
Plan depth = 7 inches
Plan width = 23 feet
Proportion of cement = 9%
Weight of cement in transport = 40,000 pounds
Weight of dry soil = 118 pounds per cubic foot

Answer: _______________ linear feet

A cement transport should spread a uniform blanket of cement over the materials to be stabilized utilizing a mechanical cement spreader and by operating at a constant slow rate of speed.

On most roadway materials, only one pass with a single-pass model is needed for a uniform mixture and the required pulverization.
But if material with a high Plasticity Index (P.I.) is deposited on the roadway, a single-pass mixer might have to make several passes over the same section.
**FILL IN THE BLANK(S):**

3-83  A mixer is the single-pass type if it can __________________________.

3-84  A soil condition that might require more than one pass of a single pass mixer is ________________________________.

Another type of mixer is called the multiple-pass mixer. It must usually make several passes over the same section to obtain a uniform mixture and the required pulverization.

The contractor will decide whether to use a single-pass or a multiple-pass mixer. Single-pass models are more efficient, but they are also more expensive. So whenever possible, the contractor will try to use his multiple-pass machines.
CIRCLE TRUE OR FALSE:

3-85  True  False  It is the inspector’s duty to determine the type of mixer used.
3-86  True  False  The most expensive mixer is the multiple-Pass
3-87  True  False  The most efficient mixer is the single-pass
3-88  True  False  Even the single-pass may have to make several passes over the same area.

The part of a mixer that blends and pulverizes the materials is called the cutting box. When a mixer makes a pass over the roadway material, cutting the material, we call that a cutting pass. The cutting box of most mixers is usually less than 12 feet wide.
A mixer must make several cutting passes before the entire width of a roadway is covered.

**PLAN VIEW**

---

**THIRD PASS**

---

**SECOND PASS**

---

**FIRST PASS**

---

**ANSWER THE QUESTION:**

3-89 What is a cutting pass? ____________________________________________.

3-92 The cutting overlap is not the minimum 6 inches

3-93 The 6-inch cutting overlap is not consistent (does not run the entire length of the cutting pass)

You must always inspect the overlap on adjoining cutting passes.

**PLAN VIEW**

---

**THIRD PASS**

---

**SECOND PASS**

---

**FIRST PASS**

---
It is your job to see that each cutting pass overlaps the previous one. The amount of overlap in cut material should be a minimum of 6 inches. This is cutting overlap, not cutting box overlap.

Also, as you can see, the 6-inch overlap should run the entire length of the cutting pass.

**ANSWER THE QUESTION:**

3-90 Why must a mixer make several cutting passes to cover the width of a roadway?

3-91 What two things should you check for on every cutting pass?

_______________________  ________________________
3-92 What is wrong with the cutting pass in View A?

3-93 What is wrong with the cutting pass in View B?

3-94 It contains no clods or streaks of color or moisture
Let's take a closer look at these cutting boxes. This is what you'll see when the box is raised. The single-pass model has three shafts that rotate during a cutting pass. Paddles are attached to each shaft.

The multiple-pass model has only one rotating shaft equipped with tines instead of paddles.

3-90 The cutting box is not wide enough to cover the entire width of the roadway.

3-91 Each cutting pass should overlap the previous one at least 6 inches and the overlap should run the entire length of the cutting pass.
Both paddles and tines can wear down rapidly during cutting operations. If they wear down too far, they can't mix and pulverize the material properly. During heavy cuttings, a shaft of paddles or tines might have to be changed as often as twice a day. There are two ways of determining whether a shaft of paddles or tines needs changing. First, examine the mixture coming out behind the mixer. This mixture is called fluff. Three things you should look for are: a) the uniformity of the fluff, b) the depth of the fluff, and c) the bottom of the fluff down to the subgrade (dig a narrow trench). It should be uniform.

If there are streaks and clods in the fluff after several cutting passes, or if the depth of the cut is too shallow, then paddles or tines probably need to be replaced.
**FILL IN THE BLANK:**

3-94  Stabilized material is mixed uniformly when ________________________________.

The second way to determine whether a shaft of paddles or tines needs to be replaced is by actually looking under the cutting box. If you see broken or worn paddles or tines then they need to be changed.

A box with a lot of broken and worn paddles cannot mix the material properly. One of your duties is to know when tines or paddles need changing. You do this by looking at the fluff and checking depth of cut. But remember, changing tines or paddles is the contractor's option. He may decide to replace those that are worn, or he may try to achieve a good mix by having the stabilizer make more passes. How he gets a specification mix is his business. Your business is inspecting the mix to see that it does meet specifications.
Here's something else to watch out for:

Always make sure that the cutting box on a mixer is equipped with a spray bar. A spray bar is used to add moisture to the mixture when needed. There is a valve that regulates water flow.

**CIRCLE THE CORRECT ANSWER:**

3-95  If the spray bar does not extend across the cutting box, the mixture (will / will not) be moistened uniformly.

3-96  If the spray bar is clogged, the mixture (will / will not) be moistened uniformly.

**FILL IN THE BLANK(S):**

3-97  The overlap on adjoining cutting passes must be at least _____ inches, and it must run the entire ____________ of the cutting pass.

3-98  Fluff material that shows streaks after several passes indicates ____________________________.

3-99  A shallow depth of cut indicates ________________________________.

3-100 The spray bar on the stabilizer must extend ____________________.
The holes must not be __________________________.

**COMPLETE THE DEFINITIONS:**

Write brief definitions to the following:

a. mixer ______________________________________

b. cutting box ________________________________

c. fluff_____________________________________

A stabilized base course that has been mixed-in-place must also meet certain requirements after mixing and at the time of compaction. These requirements involve the following tests:

- width and depth of the cut
- pulverization
- moisture content
- proctor molds

(Testing procedures are not covered in this course, but we will discuss each of the above tests in general.)

**WIDTH AND DEPTH OF CUT**

Measurements of thickness (depth) and width taken at this time - immediately after mixing and prior to compaction - are usually referred to as "construction control measurements." These control measurements are checked as necessary to ensure specified materials.

A minimum of three holes are dug across the roadway.
The width measurements are made at the same locations as depth checks and should be the actual width cut and mixed. To find the outside edge of the base course, dig into the material on each edge and locate the hub that was set for horizontal alignment. A metallic tape can then be used to measure the width from outside edge to outside edge.

**FILL IN THE BLANK(S):**

3-103 Mixed-in-place stabilized bases should be checked for thickness and width ________.

3-104 The initial measurements are taken after the _________ process.

Pulverized material is acceptable if 100% of the material passes the 1½-inch screen and 80% of the material by total weight exclusive of gravel or stone will pass a No. 4 screen. The O M & R perform this test. The testing method for field determination of pulverization of soil bases can be found in the Sampling, Testing, and Inspection Manual.

Documentation of this test should be as follows:

<table>
<thead>
<tr>
<th>STA</th>
<th>LOC</th>
<th>TOTAL WEIGHT</th>
<th>WEIGHT OF #4</th>
<th>% PULV</th>
<th>DATE</th>
<th>INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>16+25</td>
<td>B'RT</td>
<td>5.45</td>
<td>1.16</td>
<td>1/2</td>
<td>7/6</td>
<td>WJF</td>
</tr>
</tbody>
</table>

**FILL IN THE BLANK(S):**

3-105 At least ________ percent of stabilized material must pass a No. ________ screen in order to be acceptable.

---

3-108 The distance from the stringline to the prepared subgrade is measured

3-109 False

3-110 True

3-111 False

3-112 False
The optimum moisture for the mixture is determined by the Laboratory. The actual moisture content should be within 90% to 120% of the specified optimum moisture content at the time of compaction. The method of testing for moisture content can also be found in the Sampling, Testing and Inspection Manual and is also done by the O M & R.

**FILL IN THE BLANK(S):**

3-106 At the time of compaction, the moisture content of a stabilized base must be within __________ percent of the optimum moisture content.

________________________

The next test done by the O m & R is a proctor, which is run on soil in a mold of a given volume. The proctor test is run to find dry weight densities at certain moisture contents. Proctor molds should be taken one per 1,500 feet per 2 lanes.

**ANSWER THE QUESTION:**

3-107 How many proctor molds should be made?

________________________________________

In order to control the thickness of pugmilled material, you must take measurements before spreading it on the subgrade. A straightedge makes these measurements or a stringline stretched between points of known elevation to the prepared subgrade.

3-101 Clogged

3-102 A. A machine with rotating tines or paddles
   B. The piece of equipment which contains the cutting paddles
   C. Material mixed by the stabilizer

3-107 ____________________
After compaction of the pugmilled material another measurement is made to determine the thickness (but we'll cover this a little later on).

**ANSWER THE QUESTION:**

3-108 What step must be taken before spreading to control thickness of pugmilled bases?

You will need to determine when the cement was moist-mixed with the other materials. The construction crew should immediately begin spreading the mixture, as all compaction must be completed within 2 hours after initial mixing of cement with base course materials.

**TRUE OR FALSE:**

3-109 True False Pugmilled materials must be mixed-in-place on the roadway.

3-110 True False Thickness measurements must begin before pugmilled materials are placed.

3-111 True False Measurements are made from a straightedge or stringline to the bottom of the cut made by the stabilizer.

3-112 True False It is not necessary to know the actual time when cement was moist-mixed with other materials in the pugmill.

Procedures for both pugmilled and mixed-in-place materials are the same after the placement step; therefore, for the remainder of Section II we will discuss the procedures for all stabilized materials.

**COMPACITION**

As stated earlier, compaction must be completed within 2 hours after the initial mixing of cement with the base course materials. The steel wheel and vibratory steel wheel roller are normally used to begin compaction. Three to six coverages are usually enough if the moisture content and weight of the roller are sufficient.
The pneumatic roller is also used on stabilized bases to compact, smooth, and tightly seal the material.

After final rolling, density tests are taken by the O M & R and the results documented. Stabilized bases must be compacted to at least 98% of maximum density (This differs from untreated aggregate base courses that had to be compacted to 100% of maximum density).

**FINISHING**

After compaction, fine-blading to crown and grade takes place. The motor grader will be brought in to cut the materials to proper grade, which should be achieved by cutting and not drifting materials into low spots.
Once the contractor's people think the base course is to plan grade and crown, you will need to check it. If the base course, other than soil cement or cement stabilized aggregate, is not within tolerance the contractor must rework the materials. You will learn in the last Chapter of this book what is involved in "checking" or measuring the base course for acceptance and just what the tolerances are.

**CURING**

After a stabilized base course has been compacted and fine bladed, it should be protected against rapid drying for a 7 day curing period. This protection is accomplished by applying an approved grade of prime to the completed base. The curing compound is applied to the section at a minimum rate of 0.15 - 0.30 gallons per square yard.

Traffic and equipment should be kept off of the base during the curing period unless specifically permitted. If permitted, any damage caused by traffic will have to be corrected at the contractor's expense!
3-113 An approved grade of _________ is used to protect a completed stabilized base course.

3-114 The completed base course should be protected against rapid drying for a ___________ day curing period.

3-115 The curing compound is applied at a minimum rate of ______________ gallons per square yard.

3-116 Why should traffic and equipment be kept off the base course during curing?
_______________________________________________.

CONSTRUCTION JOINTS

A construction joint should be cut at the beginning of each day's operation, or at approach slabs or the edge of an existing roadway slab. In the case of cutting into existing soil cement, the contractor should cut back (usually with a motor grader) approximately 2 feet or more into the existing material to form the construction joint. In the case of joining an existing concrete slab (when cutting in place), the material should be moved away from the slab by means of a motor grader, mixed, and then bladed back into place.

The construction joint has two purposes:

It assures a good bond between cuts.
It assures continuous soil cement base with no unstabilized material between the end of one cut and the beginning of another.

FILL IN THE BLANK:

3-117 To form a construction joint, cut back into an existing soil cement base at least ___________.

125
ASPHALTIC CONCRETE BASE COURSES

Asphaltic concrete base course construction is similar to asphaltic concrete paving with the exception of the type of mixture used. (Remember: Asphaltic Concrete Base or Sand Asphalt Base is used for base course construction). In this section we will present the basic operational information; however, for more detailed information about the equipment and the paving procedures, refer to the Asphalt Paving Inspection course.

To begin construction of an asphaltic concrete base course, the air temperature in the shade away from artificial heat must be in accordance with the following table because in cold weather asphalt base mixture cools quickly.

<table>
<thead>
<tr>
<th>Thickness (inches)</th>
<th>Minimum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 – 3</td>
<td>35°F</td>
</tr>
<tr>
<td>3.1 – 4</td>
<td>30°F</td>
</tr>
<tr>
<td>4.1 – 8</td>
<td>Contractor’s Discretion</td>
</tr>
</tbody>
</table>

**FILL IN THE BLANK:**

3-118 Construction of a 2½-inch layer is halted if the descending air temperature falls below ____________.

**PLACEMENT**

As the inspector you should keep an eye out for mixture deficiencies which may lead to rejection of a truckload of asphaltic concrete. Some of these deficiencies are:

- overheated mix - blue smoke rising from mix
- cold mixture - stiff appearance or improper coating of larger aggregate particles
- excess asphalt cement in mixture - material lies flat and has extremely shiny appearance; soupy
- too little asphalt cement in mixture - granular appearance or improper coating of aggregate
- excess coarse aggregate - coarse and rough textured appearance
- excess fine aggregate - lean, dull brown with fine textured appearance
- excess moisture - steam rising from mix as it's being dumped into paver; may be bubbling as if boiling and may look soupy
- segregation - fine aggregates lumped together, and coarse aggregates lumped together
CHOOSE THE BEST ANSWER(S):

3-119 A mix with a dull brown appearance may have:
   a. too much asphalt
   b. excess fine aggregates
   c. contamination

3-120 A mix with improper coating of large aggregates and a stiff appearance may be:
   a. an overheated mixture
   b. a mixture with too much asphalt
   c. a cold mixture

3-121 Blue smoke rising from the truck may indicate:
   a. an overheated mix
   b. a segregated mix
   c. a cold mix

3-122 A mix with excess moisture might:
   a. bubble and pop as if boiling
   b. appear soupy
   c. steam as it's dumped into the paver

3-123 A mixture with too much asphalt cement might:
   a. have a dull brown appearance
   b. have a very shiny appearance and lie flat
   c. have a granular appearance

3-113 Prime
3-114 7
3-115 0.15
3-116 To avoid any damage to the completed base course
3-117 2 feet or more
The tractor portion of the paver receives the hot mix and feeds the mix onto the "augers" which spread the mix across the roadway.

The screed unit of the paver presses down and smoothes the mix. An electronic screed system automatically controls the grade and slope of the base through the use of a "sensor" attached to one of the tow arms.

**FILL IN THE BLANK(S):**

3-124 The two units of the paver are the ________________ unit and the ________________ unit.

The mixture spread by the paver, commonly called the "mat", is spread thicker than the plan thickness to allow for compaction. The contractor is responsible for obtaining the plan thickness, so normally he will spread a mat which is about 20% greater than plan thickness. For example, if the plan thickness of the base is 8 inches, then $20\% \times 8\text{ inches} = 1.6\text{ inch}$; therefore, the laydown thickness is 9.6 inches. You learned in Chapter 2 the method for computing the amount by weight of asphaltic concrete needed.

**FILL IN THE BLANK(S):**

3-125 The contractor will usually spread about ________________ percent more mix than plan thickness to allow for compaction.
When you inspect the mat after placement, you should look for several things:

- The surface should be black, even, and without any holes.
- The texture should appear uniform - not slick in some areas and granular in others.
- The coarse aggregates should be evenly distributed.
- There should be no oily spots.

**COMPACtion**

Compaction of asphaltic concrete is achieved by rolling. Three stages of rolling have traditionally been employed: breakdown rolling, intermediate rolling, and finish rolling. The first two stages achieve the compaction, and the final stage is actually for smoothing the surface of the mat. Until recent years, different rollers were used in each stage of compaction.

Breakdown rolling was achieved by using either a three-wheel roller, or a tandem roller.

3-119   b. Excess fine aggregates
3-120   c. A cold mixture
3-121   a. An overheated mix
3-122   a., b., and c., (All are correct)
3-123   b. Have a very shiny appearance and lie flat
Intermediate rolling was achieved by using a pneumatic roller.

Finish rolling was achieved by using a tandem roller as shown previously.

In recent years; however, the use of one steel wheel roller to achieve the required density has increased, and in particular, the vibratory roller.

The vibratory roller is not only economical to use since only one type of roller is necessary, but it is also efficient. Some models are designed specifically for asphaltic concrete and the problems which can occur with this type of pavement. This roller can also revert to a static mode from the vibratory mode, which is important when changing directions.
The Standard Specifications allow for either the traditional method of using the different rollers to achieve compaction or the more recent method of using one type of rollers-whichever method is sufficient to achieve the required density and surface smoothness. All rollers used shall be self-propelled, in good condition, and capable of maintaining the pace of the paver.

**ANSWER THE QUESTION:**

3-126 What are some requirements for rollers?

1. _______________________________________________________
2. _______________________________________________________
3. _______________________________________________________

Breakdown rolling should begin as soon as the mat will carry the roller without distorting the mix. The rolling pattern described in the following discussion is one which has traditionally been used with the tandem or three wheel roller; however, suitable rolling patterns may vary, depending on such factors as temperature, properties of the mix, climatic conditions, and the type of job. Control strips are used to try out the contractor’s proposed rolling procedures. The Office of Materials and Research usually sets these procedures.

On the first lane, the roller should work from the outside of the mat toward the centerline of the roadway. To begin with the roller should actually overhang the edge of the mix by 2 to 3 inches. One pass in one direction followed by a return pass on the same coverage.
**ANSWER THE QUESTION(S):**

3-127 On the first pass of breakdown rolling, always work from the ____________ edge to the ____________.

3-128 The roller should overhang the edge of the mix by

3-129 Where is the second pass made?

The third pass should overlap the previous pass by 6 inches, and the fourth pass is made over the same material as pass three. This pattern is continued until the entire width has been rolled. The final passes should overhang the edge of the mat by 2 to 3 inches.

**FILL IN THE BLANK(S):**

3-130 The third and fourth passes made are made

3-131 The final pass should overhang the edge of the mat by ____________________________________.
To get the roller back to the uncompacted mat just placed by the paver, pass seven should cut diagonally across the points where the roller has stopped.

Notice that the places where the roller stops on its passes are staggered. This is done to avoid a continuous dip across the entire width of the mat. By rolling diagonally on pass seven, the dips caused by reversal of the roller on each pass are ironed out.

ANSWER THE QUESTION:

3-132 Where is pass seven made?

Intermediate rolling is done to obtain maximum density. When the pneumatic roller is used for this stage it should start from the outside edge and work in, but it must be kept about 6 inches away from the centerline if only one lane is in place. When both lanes are down, the joint should be overlapped at least 6 inches.

FILL IN THE BLANK(S):

3-133 The highest densification compaction is achieved during ____________ rolling.

3-134 If one lane is in place, the pneumatic roller (if used) should be about ______ from the centerline, but if both lanes are down the roller should ___________ the centerline about ______.
The pneumatic roller may take from 7 to 17 passes to cover a lane, but must not over roll the mix. (Vibratory rolling generally requires a fewer number of passes than static rolling). Each pass overlaps the previous pass, but no two passes are in the exact path as was done in breakdown rolling. Notice how these passes overlap.

**Answer the Question:**

3-135 What is the general pattern of intermediate rolling?

Finish rolling is necessary to obtain surface smoothness and should be carried out when the mix is still workable enough. A rolling pattern similar to that of the intermediate rolling pattern is used. When vibratory rollers are used instead of tandem rollers, the roller will be switched to a static mode for finish rolling.

3-136 The purpose of finish rolling is ________________.

Some rules to follow to obtain good results at rolling are:

- Perform compaction at a suitable temperature range.
- Change directions slowly and smoothly (and with vibrations off if a vibratory roller is used).
- Do not allow roller to stand on the hot mat.
- Avoid stopping the roller in the same transverse location after each stop.
- Avoid abrupt turns.
You remember that with unstabilized aggregate and stabilized base courses, certain density requirements have to be met after compaction. The same is true for asphaltic concrete base courses. Upon completion of all rolling procedures, samples are taken for density testing. As the inspector you should be present while this sampling takes place.

The linear feet of asphaltic base course laid each day is subdivided into five sections of equal length, and one sample is taken from each section. The size of each sample should be approximately 4 inches in diameter.

FILL IN THE BLANK(S):

3-137 ______________ samples are taken each day, each of which is ______________ inches in diameter.

According to the Standard Specifications, the average of the five tests must be a minimum of 97.5% of the control strip density. The control strip density must equal or exceed 94% of the voidless mix density when the mix is tested by AASHTO: T-245 (Marshall Specimens).

FILL IN THE BLANK(S):

3-138 The ______________ of five samples must be at least __________ percent of _________________.

You should receive the results of your samples the day they are taken. All results should be documented in your field book just as for soil aggregate and stabilized bases. Any section that is deficient should be corrected or replaced, and the corrective action documented.
FINISHING - APPLYING THE TACK COAT

Upon completion, an asphaltic concrete base course shall be coated with tack, which is also a bituminous material. The tack coat may be viscosity grade AC-10, AC-20 or AC-3Q; or cationic emulsified asphalt grade CRS-2h or CRS-3 may be used.

FILL IN THE BLANK(S):

3-139 An asphaltic concrete base course is finished by applying a __________________________ coat that is a __________________________ material.

Some rules concerning the application of tack are:

Never apply tack to a dirty, wet or frozen surface.
Apply emulsified asphalt tack only when the temperature is above 40°F.
Any time asphalt concrete can be placed in accordance with Table 400.05B of Standard Specifications, Asphalt Cement tack may also be applied.

TABLE 400.05B

<table>
<thead>
<tr>
<th>Lift Thickness</th>
<th>Minimum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch or less</td>
<td>55°F</td>
</tr>
<tr>
<td>1.1 inches to 2 inches</td>
<td>45°F</td>
</tr>
<tr>
<td>2.1 inches to 3 inches</td>
<td>35°F</td>
</tr>
<tr>
<td>3.1 inches to 4 inches</td>
<td>30°F</td>
</tr>
<tr>
<td>4.1 inches to 8 inches</td>
<td>Contractor's Discretion</td>
</tr>
</tbody>
</table>

FILL IN THE BLANK(S):

3-140 You should never apply tack to a ___________ surface, when the temperature is below __________ for emulsified asphalt. Asphalt Cement tack may be applied ________________.
Tack should be uniformly spread by an asphalt distributor at a rate established by the Engineer, according to the ranges set forth in the Specification Book. Too much tack may cause the surface course to slide instead of bond to the base course. Also, if the asphaltic base course absorbs extra tack, the base could lose stability.

The measurement of gallons per square yard is converted to liters at 60°F. We will not go into detail again here on conversion.

**FILL IN THE BLANK:**

3-141 If too much tack is applied to the base course ________________________________.

3-142 The rate of application of tack is established ________________________________.

3-143 The gallons of tack used is converted to gallons at __________ degrees Fahrenheit.

You will need to document the information dealing with tack coat in either a field book or on the source documentation. Do this in the same manner as you documented a prime coat.

**CONSTRUCTION JOINTS**

At the end of the day's operations you will need to inspect the construction of the transverse joint at which the next day's operations will begin. You can get a more detailed description of the procedure in the Asphalt Paving Inspection course, but here are the basics:

Kraft paper is laid along all the top and face of the vertical joint
The remainder of the mix from the paver is run out over the piece of Kraft paper in front of the vertical face of the joint.
The mix is then tapered to the subgrade and compacted.
At the start of the base course construction the next day you will inspect the following procedures:

The paper and tapered mix are removed and a butt joint 90° with the pavement surface should be left. Make sure that the surface of the mat is smooth and parallel to the surface.
The edge of the mat and the joint face is coated with tack.
The screed of the paver is placed above the compacted mix to a height that will compact even with the previous day's work.
Spreading is begun.

FILL IN THE BLANK(S):

3-144 Let the mix run out on the ________________.
3-145 Taper mix to ________________ and compact.
3-146 Cut a butt joint __________ to the pavement surface and remove the taper and paper.
3-147 Coat the edge of the mat with ________.
3-148 Place the ________ parallel to the pavement surface at a height that will compact to the same height as the previous day's work.
3-149 Begin ________.

SHOULDER CONSTRUCTION

Depending on the project plans and specifications, the shoulder bases will either be constructed at the same time as the base course or after the base course has been completed. Monolithic construction is the term used when the shoulders and the base course are constructed at the same time and form one unit.
**FILL IN THE BLANK(S):**

3-150  _________________ construction refers to the construction of shoulders and base course as one unit.

Separate construction refers to the construction of the shoulders after the base course has been completed. Generally, the shoulder material that is placed will be premixed and deposited with a shoulder spreader off the edge of the base course.

Then the shoulder material will be compacted and finished to conform to plan typical section.

3-141  The surface course will slide
3-142  By the Engineer
3-143  60
FILL IN THE BLANK(S):

3-151 Construction of the shoulders after the base course, in separate operations, is termed ________________________.

3-152 Usually the shoulder material will have been ________________ and ready for placement.

The shoulder spreader as mentioned previously operates by running on top of the base course depositing shoulder material off the edge.

3-161 a. Sheepfoot roller
3-162 c. Bridging
3-163 c. Vibratory roller
3-164 d. 100%
3-165 b. 5 feet
3-166 b. Raveling

FILL IN THE BLANK(S):

3-153 The ____________________________ is used for placement of shoulder material.

3-154 Monolithic construction is ____________________________.

140
Separate construction is ____________________________

CHAPTER 3 REVIEW

CIRCLE THE CORRECT ANSWER:

3-156 Construction of a base course in one lift is termed:
   a. single operation
   b. separate construction
   c. monolithic construction
   d. multi-layered construction

3-157 The process of one lift sliding after being placed upon a lift that is too smooth can cause:
   a. breakage
   b. shifting
   c. sliding
   d. separation

3-158 The minimum amount of prepared subgrade that should be in final condition to receive the base course is:
   a. 500 feet
   b. 1,000 feet
   c. 1,500 feet
   d. 300 feet
   e. none specified

3-159 The piece of equipment used for mixing untreated aggregates on the roadway is the:
   a. spreader box
   b. haul truck
   c. grade-all
   d. motor grader

3-160 Which of the following items have certain requirements which an untreated aggregate mixture must meet
after being mixed:
   a. mixture uniformity
   b. gradation
   c. moisture content
   d. shape of the lifts

3-150 Monolithic
3-161 One of the most effective pieces of equipment used to compact materials spread in thick lifts is the:
   a. sheepfoot roller
   b. pneumatic roller
   c. vibratory roller
   d. waffle-wheel roller

3-162 Equipment which does not penetrate to the bottom of a lift leaving it uncompacted and loose is causing:
   a. shifting
   b. planing
   c. bridging
   d. separation

3-163 The piece of equipment often used to compact granular material is the:
   a. pneumatic roller
   b. sheepfoot roller
   c. vibratory roller
   d. waffle-wheel roller

3-164 Untreated aggregate base courses must reach what percentage of maximum density?
   a. 95%
   b. 98%
   c. 85%
   d. 100%

3-165 If a failing density test occurs, two additional tests should be taken within what radius of the failing test?
   a. 2 feet
   b. 5 feet
   c. 8 feet
   d. 10 feet

3-166 The defect which occurs when prime is stripped off and fines are worn away is called:
   a. bridging
   b. raveling
   c. separation
   d. planing
To begin construction of a stabilized base, the ascending (rising) air temperature must be:
- a. 35°F
- b. 40°F
- c. 45°F
- d. 50°F

The piece of equipment used to mix cement with untreated aggregate on the roadway is the:
- a. motor grader
- b. pugmill
- c. mixer
- d. pneumatic roller

At the time of compaction the actual moisture content of the stabilized base course should not vary from the specified optimum moisture content by more than:
- a. 100 - 120%
- b. 90 - 120%
- c. 90 - 100%
- d. 80 - 50%

Stabilized base courses must reach what percentage of maximum density?
- a. 100%
- b. 98%
- c. 95%
- d. 93%

A stabilized base course should be protected against rapid drying by applying an emulsified or cutback asphalt for a curing period of:
- a. 24 hours
- b. 43 hours
- c. 72 hours
- d. 7 days

To begin construction of an asphaltic concrete base course, the air temperature in the shade must be above:
- a. 35°F
- b. 40°F
- c. 45°F
- d. 50°F

Construction of the shoulders after the base course has been completed.
- c. Monolithic construction
- c. Sliding
- e. None specified
- d. Motor grader
- a. Mixture uniformity
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 3-173 | A deficiency of an asphaltic concrete mixture in which fine aggregates are lumped together and coarse aggregates are lumped together is called:  
| a. separation  
| b. segregation  
| c. contamination  
| d. bridging |
| 3-174 | Which of the following items are good rules to observe in rolling asphaltic concrete?  
| a. Rollers should change directions slowly and smoothly.  
| b. Abrupt turns should be avoided.  
| c. Rollers should be stopped in approximately the same transverse location after each pass.  
| d. Vibrators of vibratory rollers should always be "on" during rolling. |
| 3-175 | Intermediate rolling is done to obtain:  
| a. surface smoothness  
| b. maximum density  
| c. the breaking down of the mixture |
| 3-176 | To apply a tack coat, the measurement of gallon per square yard is converted to gallons at:  
| a. 50°F  
| b. 60°F  
| c. 70°F  
| d. 80°F |
| 3-177 | Construction of shoulders and base course in one operation is called:  
| a. monolithic construction  
| b. single unit construction  
| c. separate construction  
| d. continuous construction |
| 3-178 | The procedure for determining random locations for testing is found in the:  
| c. Sampling, Testing and Inspection Manual  
| d. Field Construction Manual |
3-179 The recommended moisture content and theoretical maximum density for the particular base course material are provided by the:
a. Project Manager
b. Central Laboratory
c. Design Engineer
d. Headquarters

ARRANGE THESE IN ORDER BY PLACING THE APPROPRIATE NUMBERS IN THE BLANK:

3-180

__________ A The mixture is sweetened.
__________ B Pit-run material is dumped and spread on the roadway.
__________ C The material meets specifications and is accepted.
__________ D The material is sampled and tested after necessary amounts of deficient materials have been added.
__________ E The material is sampled and tested to see if gradation is within tolerance. The sample fails.
__________ F Check samples are taken, but the check samples fail.

CALCULATE THE ANSWER:

3-181

The width of the plan surface = 25 feet
Prime is to be shot from Station 85+00 to Station 90+00
Beginning Quantity = 2,000 gallons
Ending Quantity = 1,618 gallons
Approximate temperature = 136°F (The conversion factor for this temperature = 0.9701).

Answer ____________________________ gallons per square yard
CHAPTER 4: BASE COURSE ACCEPTANCE

DIMENSIONAL MEASUREMENTS

When a base course is completed it should conform to plan typical section, and the way we determine this is by measuring. We have again designated the section divisions as the main base course types, but under each type of base course, the following topics are discussed:

- thickness and width requirements
- methods of measurement
- documentation

Thickness and width requirements are based on the appropriate base specification of the Standard Specifications. The methods and documentation are explained in detail in the Sampling, Testing, and Inspection Manual, Volume 1.

As the roadway inspector, you will not actually be taking acceptance measurements, as the District Lab does this; however, you should be familiar with all processes concerning the base course. The District Lab is measuring a base course that you have inspected.

RAW, UNTREATED AGGREGATE BASE COURSES

For any individual thickness test, the tolerance amount for under thickness of untreated aggregate base courses is ⅛-inch. Over thickness of untreated aggregate base courses is waived at no additional cost to the Department. The average of individual tests in any 3,000-foot section of a base must not be less than ⅛-inch of the thickness shown on the plans.

FILL IN THE BLANK(S):

4-1 For an individual test, an untreated aggregate base course must not exceed a tolerance of _________ for under thickness. The average of tests in any ________________ section of the completed base must not be less than ________________ of plan thickness.
If an area shows an under thickness deficiency beyond the ½-inch, the contractor must correct the area by furnishing, placing, and compacting additional materials as required to bring the area to plan dimension. This must be done at no additional cost to the Department.

4-2 If the plan thickness of a raw base is 7 inches, which of the following measurements are within the tolerance?
   a. 6 inches
   b. 6½ inches
   c. 6¾ inches

An untreated aggregate base course should not vary from plan width in excess of 6 inches. Over widths are waived at no additional cost to the Department. Under widths in excess of the tolerance are corrected at the contractor's expense by placing, shaping, and compacting additional base course material as needed.

CIRCLE THE CORRECT ANSWER(S):

4-3 The plan width of an untreated aggregate base course is 24 feet. If the actual width is 24 feet 7½ inches, the base (is/is not) acceptable. If the actual width is 23½ feet, the base (is/is not) acceptable. However, if the actual width is 23 feet, the base (is/is not) acceptable.

The thickness of an untreated aggregate base course must be measured at random locations to represent each 1,500-foot section of completed base. The thickness is determined from holes dug through the base to the sub-grade. Three holes are dug across the roadway as indicated below:
The depth of these holes is then checked by means of a straightedge and measuring stick as shown below.

**FILL IN THE BLANK(S):**

4-4 _______________ holes are dug across the base to measure the _______________. A _______________ is inserted to the bottom of the base, and a _______________ is placed across the top of the hole.

The width of an untreated aggregate base course should be checked at the same time and in the same location that thickness determinations are made. Measurements are taken by stretching a metallic tape from outside edge to outside edge of the compacted base.

**FILL IN THE BLANK(S):**

4-5 Width measurements are made by ________________________________
DOCUMENTING ACCEPTANCE MEASUREMENTS

All measurements of thickness will be recorded to the nearest ¼-inch, and all measurements of width will be recorded to the nearest inch. The following illustration is an example of documenting measurements of thickness and width.

<table>
<thead>
<tr>
<th>STA.</th>
<th>LOC.</th>
<th>THEO. THICK</th>
<th>ACT. THICK</th>
<th>THEO. WIDTH</th>
<th>ACT. WIDTH</th>
<th>DATE</th>
<th>INL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>B 2A</td>
<td>8”</td>
<td>8 1/8”</td>
<td>22’</td>
<td>22’</td>
<td>8-10-77</td>
<td>1/8H</td>
</tr>
<tr>
<td>16</td>
<td>E</td>
<td>8”</td>
<td>8 1/8”</td>
<td>22’</td>
<td>22’</td>
<td>8-10-77</td>
<td>1/8H</td>
</tr>
<tr>
<td>16</td>
<td>B 17</td>
<td>8”</td>
<td>8 1/8”</td>
<td>22’</td>
<td>22’</td>
<td>8-10-77</td>
<td>1/8H</td>
</tr>
</tbody>
</table>

Just as an untreated aggregate base course has to meet certain requirements for acceptance, a stabilized base course must also meet certain specifications before being approved. Let's talk about these requirements.

STABILIZED BASE COURSE

For any individual thickness test the tolerance amount for under thickness of stabilized bases is ½-inch. The allowance for over thickness is ½-inch. The average of individual tests in any ½-mile section of a base must not vary in excess of ½-inch from the thickness shown on the plans.

FILL IN THE BLANK(S):

4-6 For an individual thickness test, a stabilized base course must not exceed a tolerance of ____________ for under thickness. A stabilized base must not exceed a tolerance of ____________ for over thickness.

If areas show deficiencies beyond the tolerances, the contractor must correct them at no additional costs to the Department. If the Engineer will not permit any grade adjustments, the areas must be removed to the full depth of the course and reconstructed to the required thickness.

If the Engineer does permit grade adjustments, the contractor may correct thickness deficiencies by furnishing and placing a supplemental layer of asphaltic concrete instead of removing and replacing the deficient base course.
FILL IN THE BLANK(S):

4-7 If the Engineer does not allow grade adjustments to correct deficiencies, the areas must be
_______________________ with material meeting the required specifications.

4-8 If the Engineer does allow grade adjustments, the area is corrected by
__________________________________________________________.

Stabilized bases should not vary from the plan width in excess of 6 inches. Over widths of pugmilled materials (in
excess of the tolerance) if paid for by the square yard are waived; however, over widths of mixed-in-place materi-
als must be corrected. If grade adjustments are not permitted the full depth and width of the base course in the
area of the over width shall be removed and replaced with the same type of base course. If grade adjustments are
permitted, the contractor will correct the over width deficiency by placing supplemental layer of asphaltic concrete
to the entire width of the section.

Under widths in excess of the tolerance shall be corrected to plan width by placing additional materials (one of the
materials listed above). The width of the widening materials shall not be less than 12 inches.

You learned from Chapter 3 in the section on stabilized bases that control measurements of thickness (depth) and
width are taken either:

prior to compaction if the materials are mixed-in-place, or
prior to placement if pugmilled materials are used.

The District Lab takes the acceptance measurements within 7 days after completion of the base course. The meas-
urements are taken at random locations to represent each 1,500-foot section of the completed base.

Thickness is checked by digging three randomly spaced holes across the base to the subgrade. Three measure-
ments are taken within each hole, evenly spaced around the perimeter.
The average of these measurements within a hole is the reported depth measurement. Using chemicals that turn dark red on contact with materials of high calcium content can also check thickness. (Cement has high calcium content).

Three holes are dug to the subgrade across the compacted base. The sides of each hole are scraped clean, and all loose material is removed. The chemical is squirted into the hole by means of a squirt bottle, starting at the bottom of the hole to the top in three different places, approximately 120° apart.

**FILL IN THE BLANK(S):**

4-9 Certain chemicals turn __________________ upon contact with materials of high __________________ content.
A measuring stick is inserted into the hole to the point where the color change begins. A measurement is then taken by placing a straightedge across the hole. Each of the three lines of the chemical is measured, and the average of the three measurements is documented as the actual depth at that point.

4-10 The actual measurement of thickness after applying the chemical is done by ________________________.

4-11 The measurement recorded is an average of ____________________________.

One method of measuring the width of the completed base is by using the same process used for control measurements; that is, locating the outside edges of the base and using a metallic tape to measure the width. You will probably have to cut into the outside edges of the base to locate the point where the fully stabilized base begins.

FILL IN THE BLANK(S):

Their color and hardness can be used to recognize stabilized materials. This method of measuring width is not as reliable as the method described that follows.
The same type of chemical used to measure depth should be used to measure width. The outside edges of the compacted base course materials are cut away until the complete depth of the base course is exposed. (These must be vertical cuts.) The chemical is squirted on the edges from the bottom up. If the color change does not indicate that the base is stabilized to the proper depth at that point, you must cut further into the base until the chemical indicates that you have located the edge of the fully stabilized material. Once you have located the outside edges of the stabilized materials, use a metallic tape to measure from side to side.

**GIVE THE INFORMATION:**

4-12 Two ways of determining the width of a stabilized base are:

A. 

B. 

**DOCUMENTING ACCEPTANCE MEASUREMENTS**

The following is an example of documenting measurements of thickness and width.

<table>
<thead>
<tr>
<th>STA.</th>
<th>LOC.</th>
<th>THEO. THICK</th>
<th>ACT. THICK</th>
<th>THEO. WIDTH</th>
<th>ACT. WIDTH</th>
<th>% CEMENT</th>
<th>DATE</th>
<th>INI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>6'2&quot;</td>
<td>6&quot;</td>
<td>6'2&quot;</td>
<td></td>
<td></td>
<td>8%</td>
<td>6/9/77</td>
<td>R28</td>
</tr>
<tr>
<td>21</td>
<td>8&quot;</td>
<td>6'2&quot;</td>
<td>22'</td>
<td>22'</td>
<td>6&quot;</td>
<td>8%</td>
<td>6/9/77</td>
<td>R28</td>
</tr>
<tr>
<td>21</td>
<td>6'1&quot;</td>
<td>6&quot;</td>
<td>6'2&quot;</td>
<td></td>
<td></td>
<td>8%</td>
<td>6/9/77</td>
<td>R28</td>
</tr>
</tbody>
</table>
Notice that the only difference between documenting raw and stabilized bases is that the percentage of cement is added for stabilized bases.

**ANSWER THE QUESTION:**

**4-13**  Are the actual thickness and width in tolerance? (See Part 1: Dimensional Requirements, if you are not sure).

The District Lab takes acceptance measurements within 7 days after completion of the base course. The measurements are checked at random locations to represent each 1,500-foot section.

The first step in determining the thickness of stabilized base courses is to dig three holes across the roadway down to the subgrade. Then, using a measuring stick and a straightedge, check the depth in three different places in each hole, approximately 120° apart.

The average of the three measurements within the same hole is the actual measurement documented.

**FILL IN THE BLANK(S):**

**4-14**  The measurement documented as the thickness of the stabilized base is actually the _____________ of the three measurements taken within each hole.

Using a metallic measuring tape, measure the complete width of the roadway from outside edge to outside edge.

**DOCUMENTING ACCEPTANCE MEASUREMENTS**

Document the acceptance measurements for stabilized base courses just as you would an untreated aggregate base.

<table>
<thead>
<tr>
<th>STA.</th>
<th>LGR.</th>
<th>THEO. THICK</th>
<th>ACT. THICK</th>
<th>THEO. WIDTH</th>
<th>ACT. WIDTH</th>
<th>DATE</th>
<th>INS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8&quot;</td>
<td>8'2&quot;</td>
<td>8'12&quot;</td>
<td>22'</td>
<td>22'</td>
<td>8-10-77</td>
<td>2114</td>
</tr>
<tr>
<td>10</td>
<td>8&quot;</td>
<td>8'2&quot;</td>
<td>8'12&quot;</td>
<td>22'</td>
<td>22'</td>
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<tr>
<td>10</td>
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<td>8'12&quot;</td>
<td>22'</td>
<td>22'</td>
<td>8-10-77</td>
<td>2114</td>
</tr>
</tbody>
</table>

154
Thickness measurements on shoulders are generally taken in the same manner as are measurements for a normal section; however, it is necessary only to dig one or two holes across the shoulder, depending on the width.

The width of the shoulder base should not vary from plan width in excess of 3 inches. Width is checked by using a metallic measuring tape.

4-15 The tolerance for shoulder width is ________________________________.

CHAPTER 4 REVIEW

ANSWER THE QUESTION:

4-16 Who is responsible for taking acceptance measurements?

4-17 Over thickness of untreated aggregate base courses are waived. What must be done for under thickness beyond the tolerance?

4-18 How are thickness and width of an untreated aggregate base course measured for acceptance?

4-12 A. Determine by color and hardness the point where the fully stabilized base begins; then measure with a metallic tape

   B. Use a chemical to determine the point where stabilization begins; then measure with a metallic tape
<table>
<thead>
<tr>
<th>Page</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-19</td>
<td>The treatment of over widths varies, depending on whether or not grade adjustments are permitted. Under widths; however, must be corrected by</td>
</tr>
<tr>
<td>4-20</td>
<td>How are chemicals used to determine thickness of stabilized base courses?</td>
</tr>
<tr>
<td>4-21</td>
<td>How are over thickness' of stabilized base courses treated?</td>
</tr>
<tr>
<td>4-22</td>
<td>What procedure is used to measure thickness on shoulders?</td>
</tr>
</tbody>
</table>
4-15 3 inches

4-16 The Central Lab

4-17 The contractor must furnish, place, and compact additional materials to bring the area to plan dimension.

4-18 A. Three holes are dug across the roadway down to the sub-grade. The depth is then checked by means of a straightedge and measuring stick.

B. A metallic tape is stretched from outside edge to outside edge of the compacted base.