Base Course Inspection

Georgia Department of Transportation

FORWARD

Base Course Inspection has become a complex and highly technical task. It is necessary for today's inspector to be thoroughly knowledgeable about all materials, tests, machinery, processes, and the sequence of operations involved in base course inspection. A vital quality demanded of the inspector is the ability to make accurate decisions based on knowledge of his field and sound judgment.

TO THE STUDENT...

This study course is designed to provide the background knowledge which, when coupled with experience in the field, is needed to properly inspect base course construction in Georgia.
This is a self-instructional study course, which allows you to proceed at your own speed. The course is constructed in a logical sequence, so that at each point, in the course you will have been given all the information needed to understand what is being discussed.

The idea behind this method is for you to read and study the information, actively participate by writing or checking off answers to questions, then find out immediately if you are correct. This method reinforces what you have read and enables you to retain what you have learned for a longer period of time. The retention of information from a self-instructional study course should be far greater than from a lecture or textbook.

To get the most from this course, start at the beginning. Read each section as it comes; preparing you for the next section. To make reading easier, the information is divided into frames. At the end of some frames, you will find questions. By answering these questions, you will be able to retain what you have just read longer than by lecture or discussion.

The answers to these questions are as follows: If the questions are on an odd page, look on the following odd page. If the questions are on an even page, turn that page back and look at the preceding even page. To explain further, the answers to questions on page four can be found on page two.

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CHAPTER 1: OVERVIEW

INTRODUCTION TO BASE COURSE

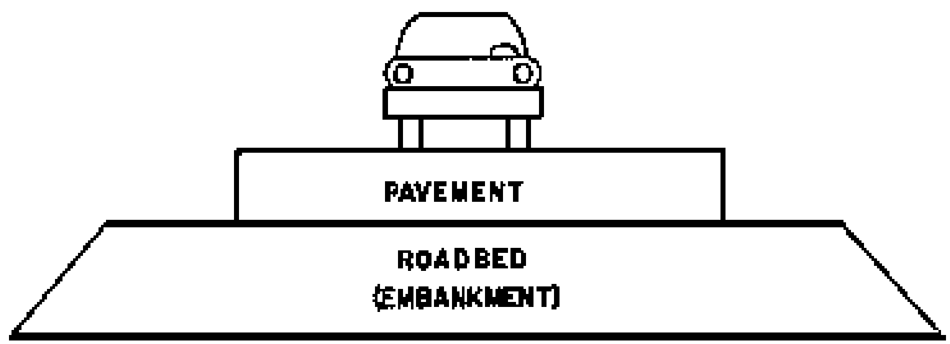
In this introductory Chapter, you should get a general idea of what base course construction is all about and the various types of base courses that are constructed in Georgia. The second Chapter deals with the procedures that must take place before the base course is actually constructed and your role as the inspector. In Chapter 3, we will discuss the actual construction procedures that take place after all of the preliminary steps have been taken. Some of the procedures from Chapter 2 and Chapter 3 may actually take place at the same time. For example, after a sufficient amount of the roadbed has been prepared for placement of the base course, construction on that portion will begin. Meanwhile, the contractor is preparing another section at the same time. Chapter 4, which is the final Chapter, covers the acceptance of the completed base course. You have an important role as the inspector in each phase of base course construction, so let's begin now with the elements of a roadway.

1-2. sometimes

The Elements of a Roadway

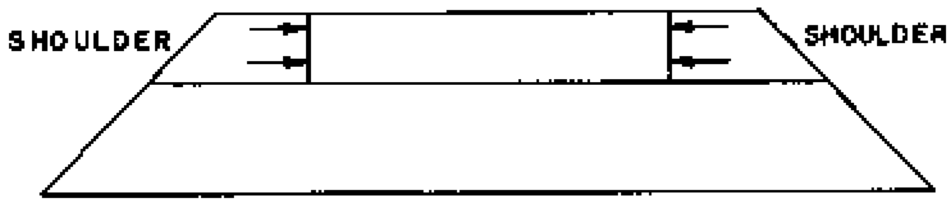
1-3. 1. pavement
2. shoulder
3. base course

The base course is actually a part of the pavement that is the finished cover or riding surface of the roadway. It bears the weight of the traffic load, and evenly distributes the weight to the foundation of the road.



The second part of the roadway is the roadbed, or embankment. It is the foundation, and it provides support for the pavement.

The shoulders are the third main part of the roadway. Shoulders provide safety and lateral (side) support for the pavement.



1-1 MATCH THE PARTICULAR PART OF THE ROADWAY WITH ITS FUNCTION.

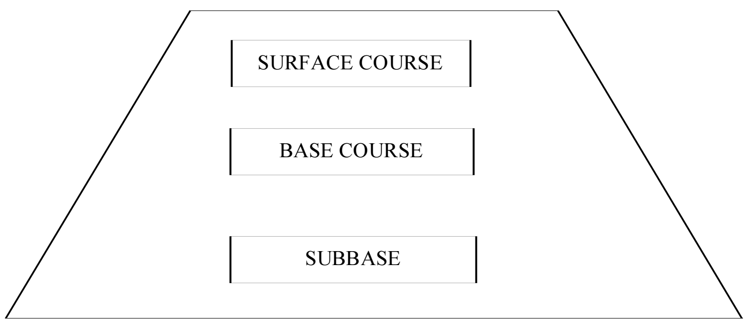
____ 1. Pavement A. To provide lateral support and safety

____ 2. Shoulders B. To bear and distribute the weight of the traffic load.

____ 3. Roadbed C. To support the pavement and shoulders

Pavement is constructed in separate layers. The top layer is called the surface course. It takes all the wear and tear of the traffic load. The second layer is the base course. This is the layer that you will be inspecting. The bottom layer of pavement is called the subbase. Since the subbase is built and inspected just like the base course, we will only discuss base course inspection. The traffic load on a particular road may not necessitate all three courses.

Pavements that carry a heavy traffic load usually contain a surface course, base course, and one or more subbases. Pavements that carry a light traffic load contain only a surface course and base course.

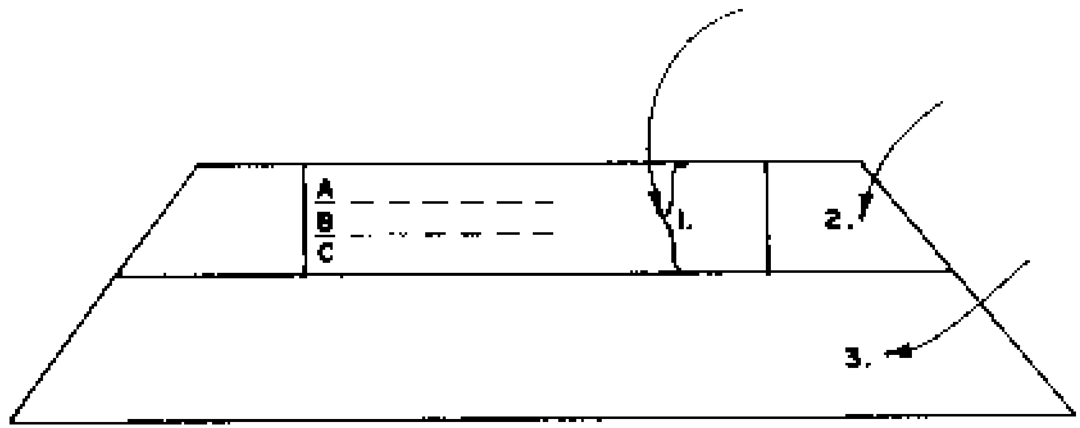


1-5. 1-Yes
2-Yes
3-No
4-No
5-Yes

CHOOSE THE CORRECT ANSWER:

1-2 It is (sometimes / always) necessary to have a subbase.

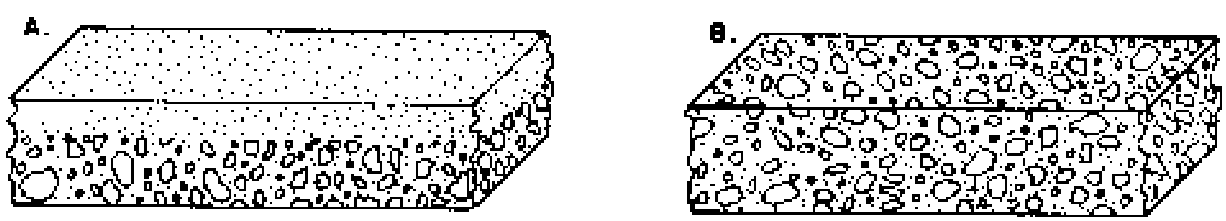
1-3 Label the three main parts of a road and the three layers of pavement on the diagram below.



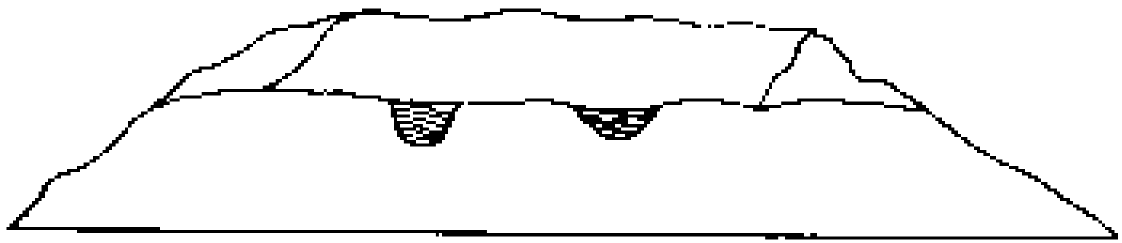
Basics of Constructing a Stable Roadway

For a road to be stable, each part that we have just discussed must be stable in itself. There are four main procedures that help us in constructing a stable roadway. We will discuss each one of the procedures in detail in Chapter 3 which deals specifically with base course construction; however, let's take a general look at these procedures now.

We mix the roadway materials to obtain a uniform mixture of particles. Which material below is mixed properly?



We need a uniform mixture of particles to help prevent a road from developing failures and looking like this:



1-4 Match column "A" picture:

Column A Column B

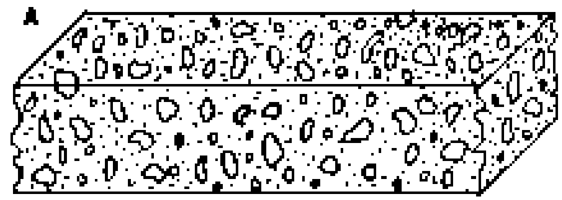
________ 1. A pavement failure

________ 2. Non-uniform particle distribution

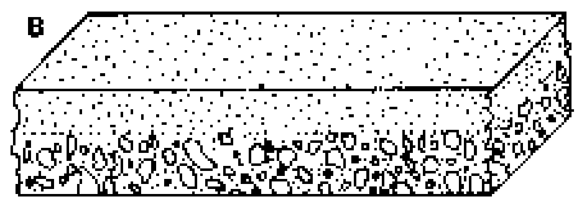
________ 3. Cross-section of stable roadway

________ 4. Uniform particle mixture

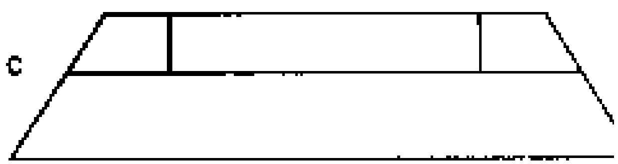
A



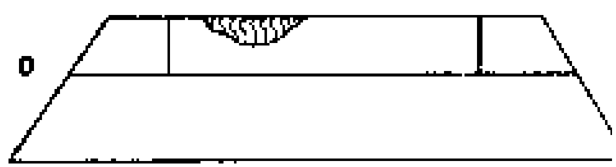
B



C



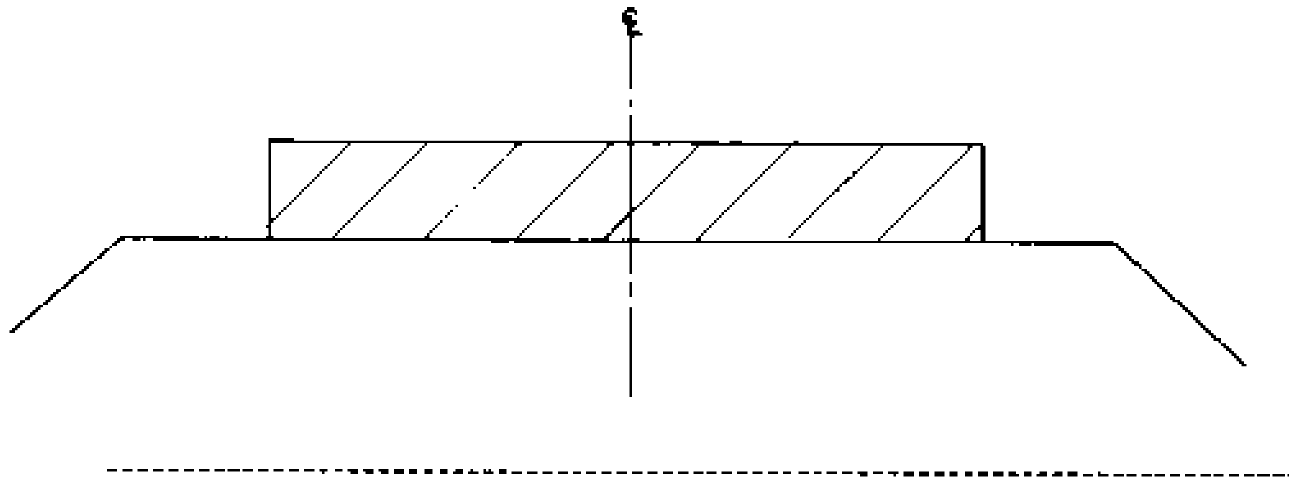
D



1-1. 1-B
2-A
3-C

Roadway materials are spread in layers, or lifts. Each lift should have dimensions that are uniform and conform to plan typical section.

Here is a cross-section of a single lift:



1-8. The elevation difference between shoulder and centerline

1-9. The slope from centerline to shoulder

1-10. The plan typical section

Each lift should have uniform thickness and width before we can say that it is spread properly. No lift should be spread on top of a non-uniform lift.

ANSWER YES OR NO:

1-5 Which three of the following five reasons are why loose roadway mixtures should be spread uniformly.

_____1. To obtain uniform thickness and width

_____2. To prevent failures

_____3. To obtain proper proportioning

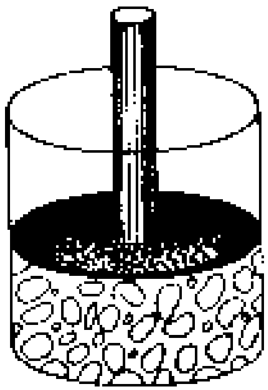
_____4. To obtain maximum gradation

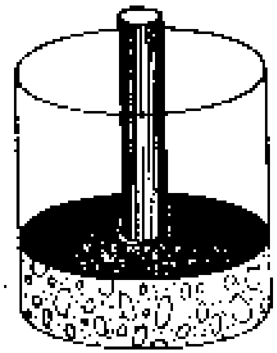
_____5. To obtain stability

Material that is compacted (dense) will support more weight than uncompacted material.

ANSWER THE QUESTION:

1-6 Which sketch below shows material that is compacted?

A. 

B. 

Each lift of roadway material is compacted so that it will be dense. Each lift should have the required density as set forth in the appropriate section for bases of the Standard Specifications for Roads and Bridges. Required density is usually 100%.

ANSWER THE QUESTION:

1-7 What will probably happen to a lift that is not compacted to its required density?

_____ Nothing will happen.

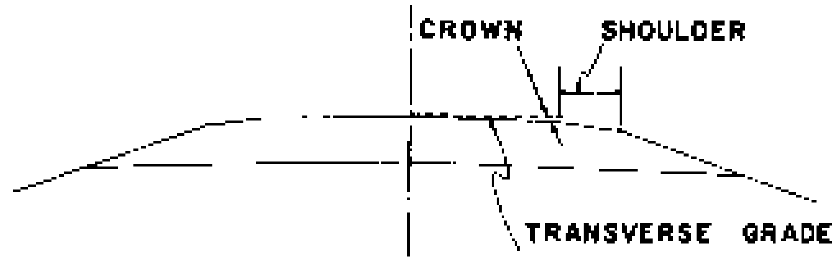
_____ The lift could be unstable.

_____ The lift could develop failures.

_____ The lift could weaken any lift(s) placed above it.

1-4. 1-D
2-B
3-C
4-A

A properly finished road must conform to plan typical section. It must have the same crown and grade as the plans.



The crown is the elevation difference between the centerline of the road and the shoulder.
The transverse grade is the slope of the road from the centerline to the shoulder.

FILL IN THE BLANK(S):

1-8 The crown of a road is ____

1-9 The transverse grade of a road is ____

1-10 A properly finished road must have the same crown and grade as ________________________________

One way in which the proper grade and crown are achieved is by fine-blading, which is the scraping off of excess compacted material in order to trim the roadway to the planned dimensions. (Fine blading should be a trimming operation - not a filling operation.)

FILL IN THE BLANK(S):

1-11 Fine-blading is part of the ___________________ operation.

1-12 Fine-blading is the _________________________ of excess compacted material.

After fine-blading, the loose material must be brushed away with a special piece of equipment so that the asphaltic material that is sprayed on the completed base course will stick.Depending on the type of base course, the asphaltic material used can either be an emulsion, a prime coat, or a tack coat. (We will go into more detail later as to when the different materials are used). The main purpose for spraying asphaltic material on the completed base course is to protect the base course until surfacing is applied.

FILL IN THE BLANK(S):

1-13 Loose material remaining after fine-blading must be___________ so that ___________ will stick to the completed base course.

1-14 Three types of asphaltic materials used to protect the base course are __________, __________, and __________.

Another step in the construction of a base course is the construction of the shoulder base. At times, the base course is extended into the shoulder area forming one continuous unit. Another method requires a special piece of equipment that deposits material off the base course edge then the shoulder base material is shaped, compacted, fine-bladed, and is protected with asphaltic material.

1-15 Put these base course construction steps in their usual order:

________ a. applying the asphaltic materials
________ b. brooming the surface
________ c. fine-blading
________ d. compacting the base course
________ e. completing the shoulders

1-6. B

1-7. B

Special equipment is used for each construction procedure that we have talked about; we will discuss the equipment required as each procedure is covered in detail in Chapter 3. This portion of the manual is to familiarize you with general concepts and practices.

TYPES OF BASE COURSES

There are four general types of base courses:

raw, untreated soil or soil aggregate
raw, untreated aggregate
stabilized soil and aggregate
asphaltic concrete

1-16. graded aggregate

The "multi-layered" base course is a combination of these four types.

1-17. sand-clay

Raw, Untreated Aggregate Base Course

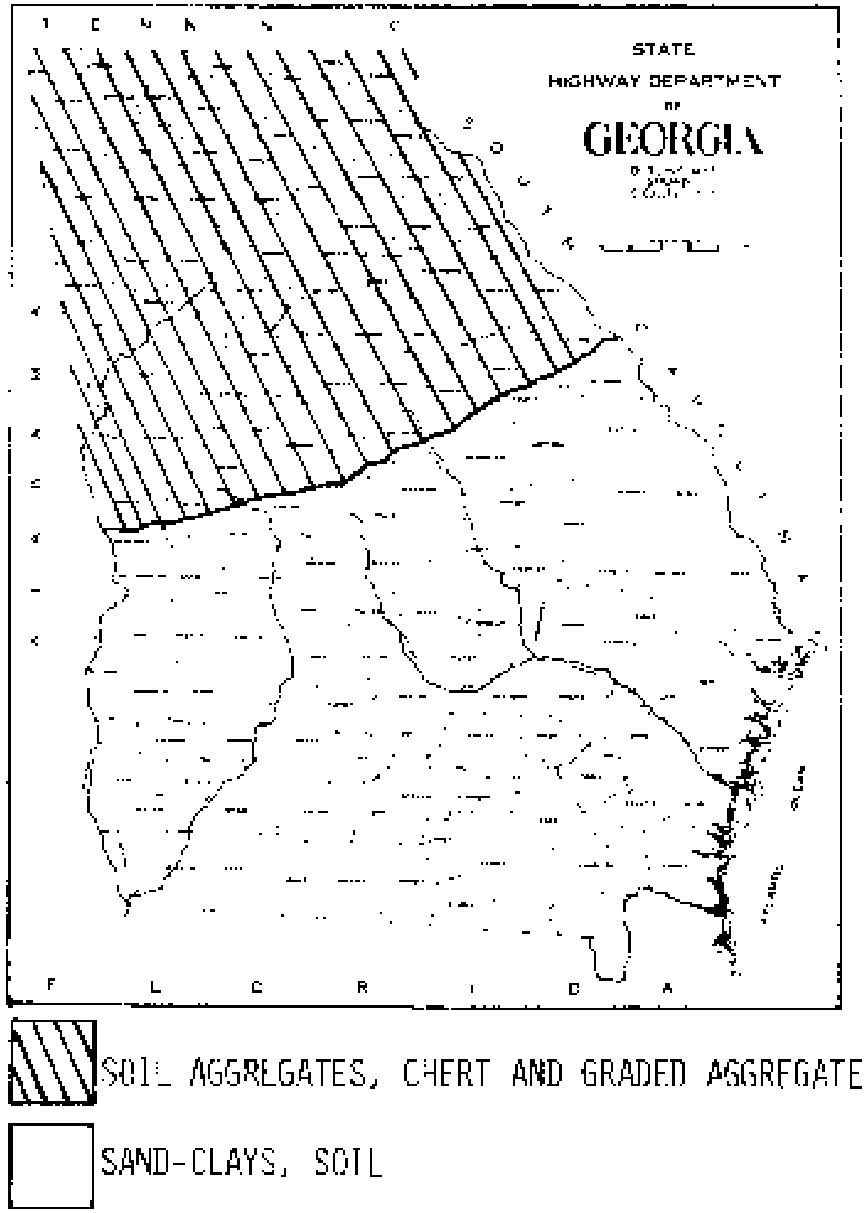
Raw means that no chemicals have been added to the aggregate. The three types of aggregate materials that can be used for base courses in Georgia are:

1-18. components
measuring

- sand, clay or soil aggregate
- chert
- graded aggregate

1-19. sands
25%

This map illustrates the materials common to the northern and southern parts of Georgia.



1-11. Trimming

1-12. Scraping off

1-13. Brushed away
Asphaltic material

1-14. Emulsion
Prime
Tack

1-15. A. 4
B. 3-
C. 2-
D. 1-
E. 5-

1-20. Add enough of the material that it lacks to bring it to specifications.

1-21. 1-PR
2-A
3-PR
4-A
5-B
6-B

1-22. Components must contain particles of specific sizes and a certain proportion of each size.

1-23. Sieving

ANSWER THE QUESTION(S):

1-16 Which raw aggregate do you suppose is most commonly used in north Georgia?

1-17 How about the raw aggregates most common to the coastal (southern) counties?

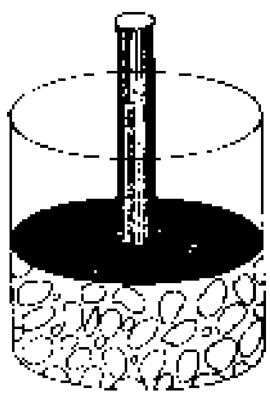
Each raw aggregate material is made up of components. For example, the base course material, graded aggregate, is made up of two components: coarse and fine aggregate. The mixture of various aggregate components is not a random process, but rather a measured, calculated one. The Standard Specifications provide information for mixing the various components. See Sections 814, 815 and 816 for the gradation ranges.

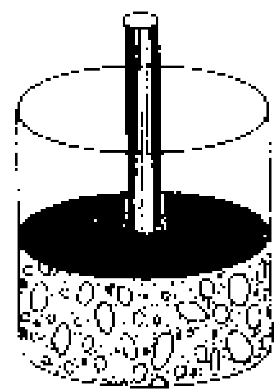
FILL IN THE BLANK(S)

1-18 Raw aggregate base courses are made up of _______________ which have been mixed by _______________ a certain amount of each aggregate.

1-19 Topsoil/sand-clay base courses are composed predominantly of _______________ with up to __________ clay.

Look at these base course materials:

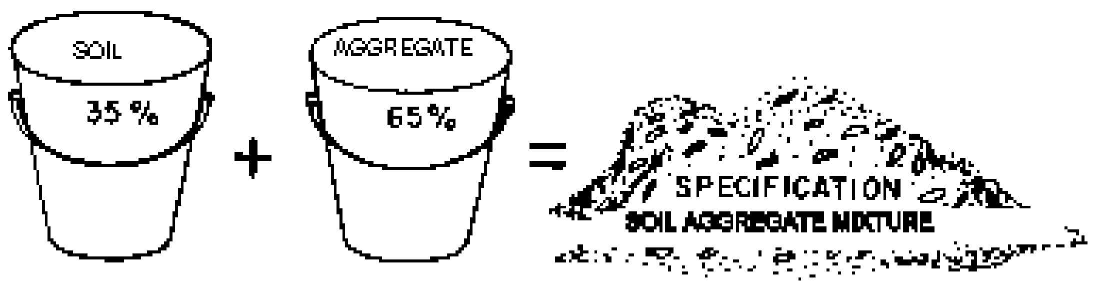




Left View - material having unmeasured components. The unmeasured mixture contains too many large particles and not enough small particles to fill up the large spaces, or voids, between these particles. Compacting this material would be like compacting a can of marbles. The required density would not be reached.

Right View - material having measured components. There are enough small particles to fill the voids between the large particles. A greater density is achieved and therefore, a more stable material.

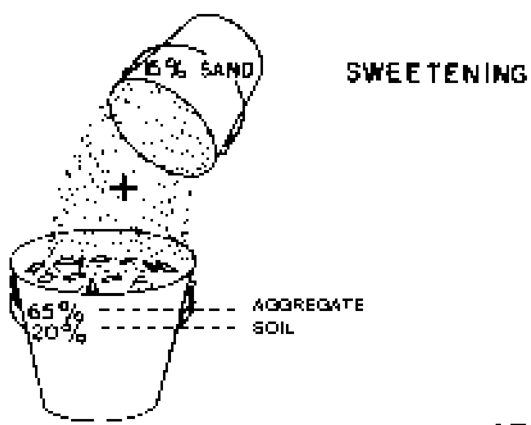
A raw aggregate mixture may either be an artificial mixture or a pit-run mixture. To make an artificial mixture we take a specified percentage of one component and mix it with a specified percentage of another.



We can get by with less work if we can find a pit-run mixture of raw aggregate. Unlike an artificial mixture, a pit-run mixture is a natural deposit. If the pit-run mixture meets specifications, we can use it for base course material. If the mixture does not meet specifications it is deficient, meaning that it lacks enough of one or more components.

Adding components to a deficient mixture is called sweetening. We sweeten by adding necessary amounts of the insufficient components to the mixture.

For example, 65% AGGREGATE + 35% SOIL = SOIL-AGGREGATE



1-28. Plasticity Index =
Liquid Limit - Plastic Limit

1-29. Water
Stick together

1-30. 9

1-31. Cement, lime, or bitumen has been added to a increase the strength of base course material

ANSWER THE QUESTION(S)

1-20 What do you think must be done to a deficient pit-run mixture?

____

1-21 Write "A" if the property describes an artificial mixture or "PR" if it describes a pit-run mixture. Write "B" if both.

__________ 1. natural mixture
__________ 2. man-made mixture
__________ 3. sweetening is usually required
__________ 4. usually a specification mix
__________ 5. aggregate material
__________ 6. must meet specifications before going into base course

---

In addition to mixing requirements, raw aggregate materials must also meet gradation requirements, that is, the components must have particles of specified sizes and a certain proportion of each size particle. Gradation is determined by sieving (the passing of materials through a series of sieves having openings of various sizes). Aggregate particles fall through the sieve openings until they reach the sieves that are too small for them to pass through. Gradation is based on the percentage passing the required sieve.

FILL IN THE BLANK(S):

1-22 Gradation means ____.

1-23 Gradation is determined by ______________________________________.

Sieves are classified according to the size of the openings. For example, the 1½-inch sieve has openings 1½-inches square. The smaller the fractional designation of the sieve, the smaller the opening. When sieve openings become so small that the hole is no longer "fractional" they are referred to in number size, e.g. No. 4, No. 200., etc. When the sieve falls in this category, the larger the number of the sieve, the smaller the holes will be and there will be more holes. For instance, a No. 8 sieve will have 8 openings per linear inch. A No. 100 sieve will have 100 holes per linear inch. A square inch of a number 8 sieve would have 8 X 8 holes or 64 holes per square inch.

ANSWER THE QUESTION(S):

1-24 What type of material do you think could pass the No. 200 sieve?

____

1-25 Sieves are classified according to what?

____

Some other requirements of raw aggregate base courses concern the liquid limit and plasticity index of the materials. Special testing procedures, which we are not concerned with in this course, allow us to determine the liquid limit and plasticity index of a particular material.

The liquid limit indicates the maximum amount of water, in percent, which can be added to a material before it passes from a semi-solid to a liquid or flowing state. The Standard Specifications state that for a topsoil/sand-clay base course, the material which passes the No. 40 sieve must have a liquid limit of 25 or less.

FILL IN THE BLANK(S):

1-26 Liquid limit indicates the maximum amount of __________ which can be added to a material before it passes from a __________to a __________ state.

1-27 The maximum allowable liquid limit for a topsoil/sand-clay base course is __________ .

The plasticity index is determined by first determining the plastic limit of a material. The plastic limit is the minimum amount of water, in percent, which must be in a material in order for the particles of this material to stick together, or be plastic.

The Plasticity Index = Liquid Limit - Plastic Limit

The Standard Specifications state that the materials in topsoil/sand-clay which pass the No. 40 sieve must have a plasticity index of 9 or less.

FILL IN THE BLANK(S):

1-28 The formula for the Plasticity Index is _______________

1-29 The plastic limit is the minimum amount of ____________ which must be in a material in order for the particles to _______________.

1-30 The maximum allowable plasticity index of a sand-clay base course is

Stabilized Soil and Aggregate Base Courses

Soil or aggregate is stabilized by adding Portland cement, lime, or bitumen to it to increase the strength of the base course.

ANSWER THE QUESTION:

1-31 What is the difference between a raw and a stabilized material?

There are four types of stabilized base course materials used in Georgia.

- soil-cement
- cement-stabilized soil aggregate
- cement-stabilized graded aggregate
- lime stabilized soil or soil aggregate

Aggregates stabilized with cement or lime may either be pit-run or artificial.

1-37. Treatment
Soil or soil-aggregate

1-38. asphaltic concrete base
sand asphaltic base

The most common type of stabilized base course is soil-cement. The soil for soil cement is usually a special type referred to as "soil cement material." Soil cement material is classified as Class IIA or better as specified in section 814.02 of Standard Specifications.

Soil cement material for soil-cement shall have a liquid limit of 25 or less and a plasticity index of 10 or less. The Office of Materials and Research will determine the percentage of cement to be used in stabilizing the soil cement.

FILL IN THE BLANK(S):

1-32 The most common type of stabilized base course is ________________.

1-33 Class IIA or better is a special classification of soil referred to as ____________________.

1-34 The amount of cement used in soil-cement is determined by the ______________________.

Another type of stabilized base course is cement-stabilized soil aggregate. The soil aggregate to be stabilized should have the same recommended mixing proportions and gradation requirements as the soil aggregate for raw aggregate base courses. However, the maximum allowable liquid limit for cement stabilized soil aggregate is 25, and the maximum allowable plasticity index is 9.

The percentage of cement required for stabilization of soil aggregate is usually 5% to 6% by weight.

FILL IN THE BLANK(S):

1-35 Cement-stabilized soil aggregate should have the same __________ and _____________ of soil aggregate as that used for raw aggregate base courses.

1-36 The percentage of cement is usually _________ by weight.

The third type of stabilized base course is cement-stabilized graded aggregate. If graded aggregate is to be stabilized, the minimum amount of fine aggregate used is 30 percent by weight. The percentage of cement required for stabilization is usually 4% to 5%.

1-24. Dust from aggregate particles

1-25. The size of the openings

1-26. Water
Semi-solid
Liquid

1-27. 25

1-42. a. Pavement
b. Roadbed
d. Shoulders

1-43. a. Pavement

1-44. b. Fine blading
d. Applying prime coat

1-45. c. Select material

1-46. d. Pit-run

Lime-stabilized soil or soil aggregate is the last type of stabilized base course used in Georgia; however, it is not as common as some of the other stabilized bases. Lime is used more today for treatment of soils and soil aggregates than for stabilization of base course materials. For example, soils having a high Plasticity Index (P.I.) will absorb more water and swell easily. Before the soil can be used, the P.I. must be reduced. Lime treatment will help achieve this.

The soil or soil aggregate must have the same recommended mixing proportions and gradation requirements as for raw aggregate bases; however, when stabilized with lime, the maximum allowable L.L. (liquid limit) is waived, and the P.I. should be within a range of 6-20.

The percentage of lime required to stabilize soil or soil aggregate varies usually from 4% to 8% by weight.

FILL IN THE BLANK(S):

1-37 Lime is used more today for ____________ of ___________ than for stabilization; however, lime can be used in Georgia to stabilize.

Water is a necessary part of all base courses, as it allows the material particles to become dense. The Office of Materials and Research will determine the "optimum moisture content" for each type of base course material through special testing procedures.

Asphaltic Concrete Base Courses

The last type of Base Course that will be discussed is asphaltic concrete base courses. Requirements for base courses of asphaltic concrete are given in Section 400 of the Standard Specifications. Asphaltic concrete base and sand asphaltic base may be used for base courses.

Listed below are materials of which asphaltic concrete base is made.
Coarse Aggregates such as gravel, air-cooled blast furnace slag, crushed stone, or synthetic aggregates.
Fine aggregates such as crushed stone, crushed gravel, crushed slag, synthetic aggregate, natural sand, and blends of fine aggregates.

FILL IN THE BLANK(S):

1-38 __________ and __________ may be used for base courses.

Mineral filler is a very fine material used to fill air spaces, or voids, in the asphaltic mixture. The mineral filler that may be used for asphaltic concrete mix can be any of the following:

rock dust
slag dust
hydrated lime
fly ash
Portland cement
(or other approved material)

FILL IN THE BLANK(S):

1-39 A __________ is a fine dust used to fill voids. It is used when needed for an __________ mixture .

Just as the components of a raw aggregate base course must make up a certain percentage of the whole mixture, the components of an asphaltic concrete base course must also meet certain requirements by weight.
The following chart is based on Section 828 of the Standard Specifications:

Type	Asphalt Cement %	Aggregate%	% crushed retained on #4 sieve	% mineral filler minimum
Base	4.00-5.5	94.5-96.0	as needed	as needed
Sand Asphalt Base	6.0-7.0	93.0-94.0	-----------------	----------------

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CIRCLE TRUE OR FALSE

1-40 True False Aggregates make up a smaller percentage than asphalt cement for asphaltic concrete base mixtures.

1-41 True False Mineral filler is used in sand asphalt base mixture.

1-32. Soil-cement

1-33. Soil-cement material

1-34. Office of Materials and Research

1-35. Mixing proportions
Gradation requirements

1-36. 5 - 6%

CHAPTER 1 REVIEW

CHOOSE THE CORRECT ANSWER(S):

1-42 Three main parts of a roadway are the:
a. pavement
b. roadbed
c. subbase
d. shoulders

1-43 The base course is actually part of the:
a. pavement
b. roadbed
c. subbase
d. shoulders

1-44 Two parts of the "finishing" process are:
a. compaction
b. fine-blading
c. mixing
d. applying prime coat

1-45 The material below that is not one of the three major types of base courses is:
a. graded aggregate
b. stabilized soil or aggregate
c. select material
d. asphaltic concrete

1-46 A graded aggregate or soil aggregate mixture that is a natural deposit is called:
a. artificial
b. deficient
c. natural
d. pit-run

1-53. b. Treatment of soils and soil-aggregates

1-54. a. Asphaltic concrete base

1-55. b. Mineral filler

1-56. The material passes from a semi-solid to a liquid or flowing state

1-57. Stick together or be plastic

1-47 Adding components to a deficient material is called:
a. sieving
b. sweetening
c. grading
d. compensating

1-48 Passing materials through a series of sieves (with openings of various sizes) determines the:
a. moisture content of the material
b. theoretical maximum density
c. gradation of the mixture
d. plasticity index

1-49 The No. 4 sieve has:
a. openings 4 inches square
b. 4 openings per square inch
c. 4 openings per linear inch
d. 16 openings per square inch

1-50 The plasticity index =
a. liquid limit + plastic limit
b. plastic limit - liquid limit
c. liquid limit - plastic limit
d. plastic limit X liquid limit

1-51 The most common type of stabilized base course is:
a. soil-cement
b. cement-stabilized graded aggregate
c. cement-stabilized soil aggregate
d. lime-stabilized soil or soil aggregate

1-52 Soil used in soil-cement is a specific type referred to as:
a. special material
b. soil cement material
c. stabilizing soil
d. type A-5

1-39. Mineral filler
Asphaltic concrete base

1-40. False

1-41. False

1-53 Lime is used more today for:
a. stabilization of base course materials
b. treatment of soils and soil-aggregates

1-54 Which type of asphaltic concrete mixture is used for base courses?
a. asphaltic concrete base
b. sand asphalt base

1-55 A very fine material used to fill voids in some asphaltic mixtures is called:
a. material filler
b. mineral filler
c. aggregate dust

FILL IN THE BLANK(S):

1-56 The liquid limit indicates the maximum amount of water that can be added to a material before ________________________________

1-57 The plastic limit is the minimum amount of water, in percent, which must be in a material in order for the particles to ____

2-1. T

2-2. F

2-3. T

2-4. T

2-5. It decreases the depth of the base course.

CHAPTER 2

PRECONSTRUCTION PROCEDURES

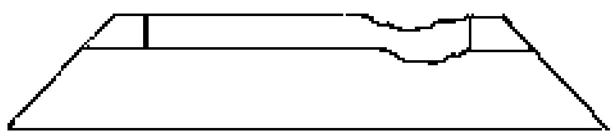
This Chapter includes those procedures that must take place before the actual construction of the base course can begin. If these procedures are not properly carried out, the probability of problems occurring later on is greater. As the inspector, you have an important role in the quality control of these procedures.

INSPECTING THE SUBGRADE AND REPAIRING DEFICIENCIES

Since a roadway may not always have a subbase, we will speak of constructing the base course on top of the subgrade. The subgrade is the top surface of a roadbed upon which the pavement and shoulders are constructed. One of your most important jobs as an inspector is to inspect the subgrade for defects that might indicate serious deficiencies in density and for surface irregularities caused by poor workmanship.

Deficiencies in density, or failures, are structural weaknesses in the roadbed and were caused by either excessive moisture or improper compaction procedures. Failures would probably show up during compaction of the roadbed. (The roadbed would yield under the heavy load of equipment). However, you should visually inspect the subgrade carefully for potential failures that did not show up during compaction.

Failures in the roadbed can cause defects in the base course and surface course.



Notice that the failure is actually in the roadbed, but it is also reflected in the subgrade and in the pavement surface.

1-47. b. Sweetening

1-48. c. Gradation of the mixture

1-49. c. 4 openings per linear in.
a. 16 openings per sq. in.

1-50. Liquid Limit - Plastic Limit

1-51. a. Soil-cement

1-52. b. Soil-cement material

2-9. **Decrease**

2-10. **Increases**

CIRCLE TRUE OR FALSE:

2-1. True False Roadbed failures may cause failures in the base course.

2-2. True False The subgrade need not be inspected before the placement of base course material.

2-3. True False A roadbed, subbase, or base course is unstable if it has failures.

2-4. True False When a roadbed yields, it is a sign of structural weakness.

You will usually have to measure or survey to find surface irregularities in the subgrade. Such a deficiency can prevent a base course from conforming to specifications.

For example, this base course has been spread and compacted over a deficiency such as a high spot:

ANSWER THE QUESTION:

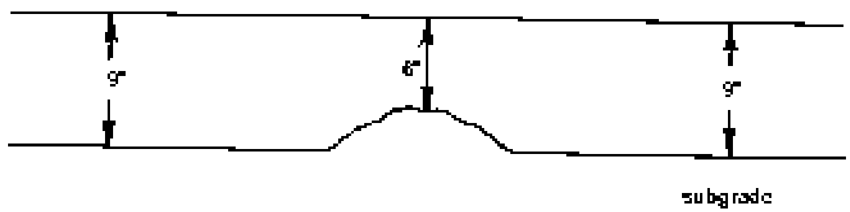
2-5 What effect does the above high spot have on the base course? ________________________________

Deficiencies in the subgrade such as high spots, low spots, corduroy effects, improper elevation, improper grade, and improper cross slope can throw a base course out of tolerance, or can even lead directly to a failure. Plan tolerance is the range a base course may measure and still be within plan dimension. For example, the plan tolerance of the stabilized base course below is ½-inch above and ½-inch below the dimension of 8 inches.

FILL IN THE BLANK(S):

2-6 This means that the base course shown above can measure from ______________________ inches to ___________________ inches deep and still be within plan dimension.

The base course shown below has a plan depth of 8 inches and a plan tolerance of ½-inch over and ½-inch under plan depth.



USING THE DRAWING, ANSWER THE QUESTIONS:

2-7 Is this base course within tolerance?

2-8 What has caused it to be out of tolerance?

2-13. **b.** high and uniform

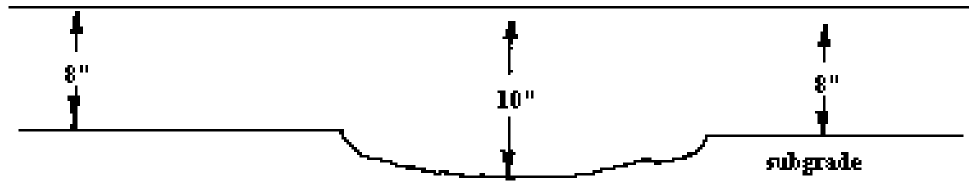
2-14. T

2-15. May not

CIRCLE THE CORRECT ANSWER:

2-9 A high spot in the subgrade will (increase / decrease) the depth of the base course and could cause it to be out of tolerance.

A low spot in the subgrade could throw the base course out of tolerance. For example:

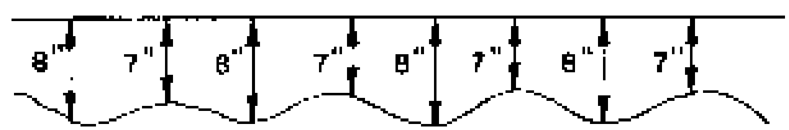


To stay within tolerance the base course must have even depth.

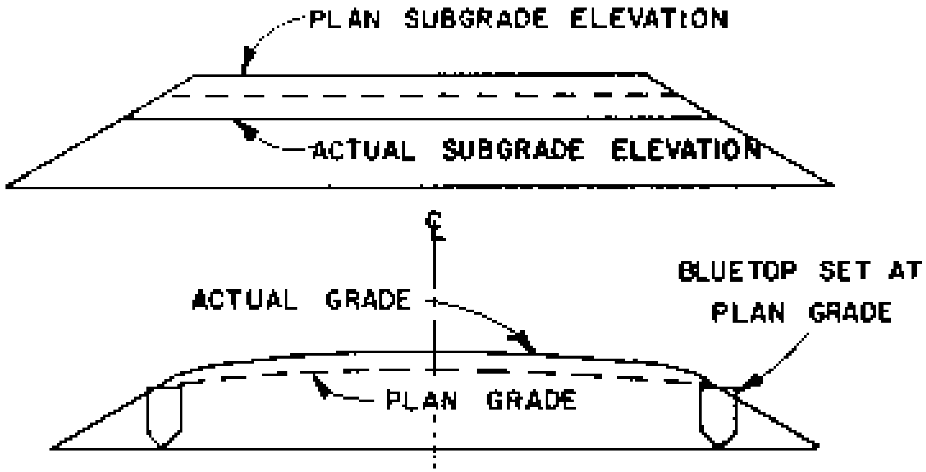
CIRCLE THE CORRECT ANSWER:

2-10 A low spot in the subgrade (increases / decreases) the depth of the base course.

The corduroy effect is another type of deficiency. This is how a corduroy effect in the roadbed could affect the base course:



Improper elevation and improper grade are other deficiencies illustrated below:



CIRCLE THE CORRECT ANSWER:

2-11 In the top view the actual subgrade elevation is too (high / low) and will cause the base course to be too (thick / thin) when finished.

2-12 In the bottom view the actual grade is (above / below) plan grade. This deficiency will be found by (looking at the roadway / measuring or surveying).

The Project Manager and the Materials Office will decide how roadbed defects will be repaired. If you are serving in the capacity of inspector only, you should find out what methods and materials will be used for these repairs, and you should see that the contractor uses these methods and materials in accordance with the specifications. Be sure to document the location of the defect, the date, and the corrective action taken. All defects in the roadbed should be repaired before the base course is placed!

Defects in the roadbed can be repaired by either reworking and recompacting small areas such as soft spots or by removing and reworking larger areas (one or more stations). The repaired area must meet the same density requirements as the rest of the roadbed.

2-6. 7½ to 8½ inches

2-7. No

2-8. A high spot in the subgrade

2-21. 11 cubic feet

There are several ways that you, the inspector, can help prevent roadbed defects. If possible, you should close the roadbed to traffic (unless the contract requires that through traffic be maintained).
You should watch for heavy or overloaded roadway equipment that could cause ruts and depressions in the roadbed. You can't hold up the movement of material, but you can make sure the drivers don't continually ride through the same set of tracks. They should move around the roadbed rather than always use the same lane of travel.

If it rains, you can keep haul trucks and other heavy equipment off the subgrade until it dries.
You can also request that the contractor reduce the loads he carries. This way, the roadbed won't have to support so much weight.Finally, you should always make sure that water trucks do not flood the roadbed.

If the roadbed has all the following features, it will usually provide a firm foundation for the base course:

- You want the entire roadbed to have a uniform appearance
- You want it to have a high density to support the traffic load
- You want a uniform density so it will be stable
- You want a smooth riding surface, with no ridges or ruts
- You want the subgrade to conform to plan grade

Preparation of the subgrade should be kept ahead of base course placement so that construction won't be held up. The contractor should have at least 1,500 feet of finished subgrade ready to receive the base.

CIRCLE THE CORRECT ANSWER(S)

2-13 Roadbed density should be:

a. low and uniform
b. high and uniform
c. uniform but not necessarily high
d. uniform but not necessarily low

CIRCLE TRUE OR FALSE:

2-14 True False Subgrade and roadbed inspection must precede placement of the base course.

CIRCLE THE CORRECT ANSWER:

2-15 The depth of the base course (may / may not) be varied considerably to correct deviations in the subgrade.

2-16 A defective area that has been corrected should:
a. meet the same density requirements as the rest of the roadbed
b. conform to plan grade
c. be allowed to set 3 days before being covered with base course material

2-17 If not corrected, defects such as high spots, low spots, or corduroy effects could affect:
a. the width of the shoulders
b. the thickness of the base course
c. none of the above

2-18 The subgrade should conform to:
a. plan grade
b. original ground
c. shoulder depth

2-19 Deficient areas in the roadbed:
a. should be reworked only.
b. should be removed and reworked (if a large area).
c. are not serious enough to rework if they are small areas.
d. should be reworked and recompacted if they are small areas.

2-20 When inspecting the subgrade, you should make sure that:
a. all Station stakes are in place
b. it is finished far enough in advance of the placement of the base course to allow for proper inspection.
c. it is finished far enough in advance of the placement of the base course to allow for necessary corrections to be made.

CALCULATING MATERIAL QUANTITIES

After the subgrade has been inspected, it will be time to begin hauling in the base course material. The amount of each material that will be required depends on the dimensions of the section to be constructed. These dimensions are given in the plan typical section. Once you have this information you can calculate the spread, or the quantity of loose roadway material needed.

You will need to remember the following rules of rounding:

In intermediate steps, carry all figures two decimal places past the required rounding-off point (the required rounding-off point for problems concerning base course material is to the nearest tenth). Therefore, all intermediate steps should be carried to three decimal places.

2-11. Low
Thick

2-12. Above
Measuring or surveying

Rounding-off should be done only in the final answer. If the last two digits are greater than 50, then round up.

Example: 6.286 = 6.3
If the last two digits are less than 50, round down.

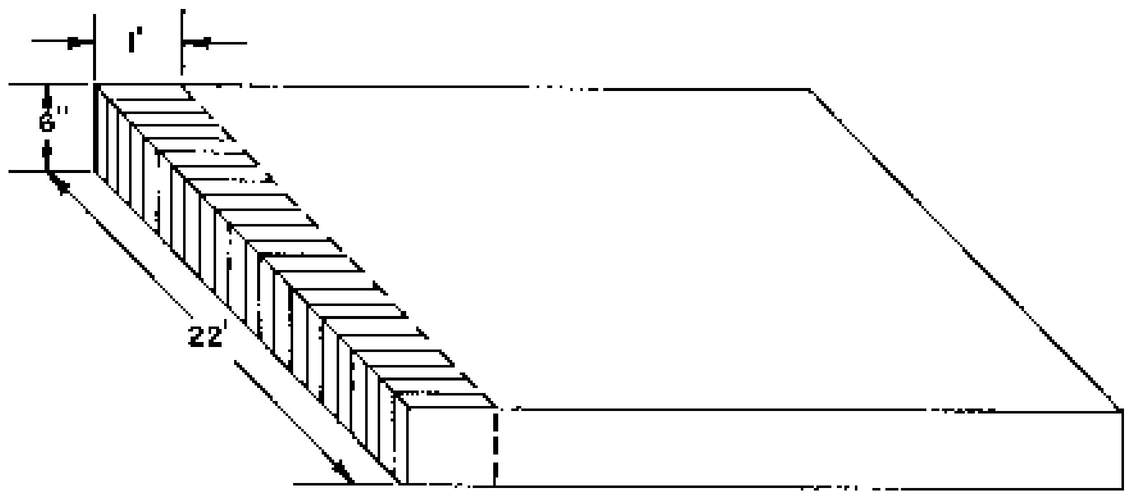
Example: 6.226 is rounded to 6.2
If the last two digits are exactly 50, round to the nearest even number.

Example: 6.250 = 6.2
6.350 = 6.4

Calculating the Required Volume of Raw Material for Base Courses

The first step in finding the total loose material needed is to find the volume of one linear foot of a compacted section. You will find this volume by multiplying the plan dimensions (depth and width) by one linear foot. For example:

2-23. Particles are pressed closer together



ANSWER THE QUESTION(S):

2-21 What is the volume of the shaded area in the previous picture?

(Note: Change 6 inches to 0.5-foot)

After you have found the total compacted volume for one linear foot of base course, you can easily find the total volume for any section. All you do is multiply the total compacted volume for one foot by the length of the section. The volume of one linear foot will be a constant for an entire job, unless the cross-section dimensions change.

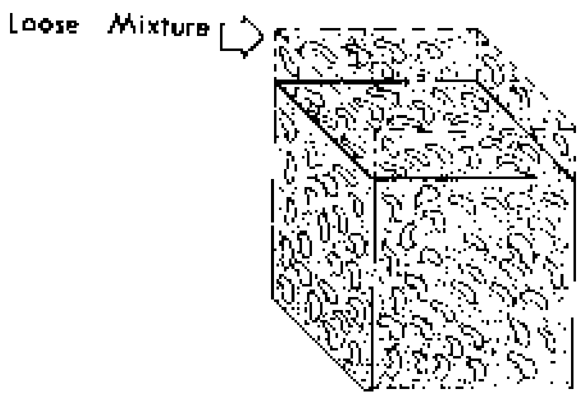
ANSWER THE QUESTION(S):

2-22 If the total compacted volume for one linear foot of base course is 1 cubic foot, what is the total compacted volume for a 100 linear foot section of that base course?

____

Once you know the compacted volume per linear foot, you need to know the volume of loose material needed to fill that foot. The volume of a material shrinks after it is mixed and shrinks again after it is compacted. Therefore, the mixing and compacting procedures are going to affect the amount of material needed, and by understanding the mixing loss and shrinkage factor, you will be able to calculate just how much loose material will be required.

In a loose mixture there are many tiny voids, or spaces, between the particles. Often these voids are not apparent to the naked eye. Voids like these are caused by the shape of the particle. In a loose state, particles do not fit closely together.



2-16.
a. meet the density requirements as the rest of the roadbed
b. conform to plan grade

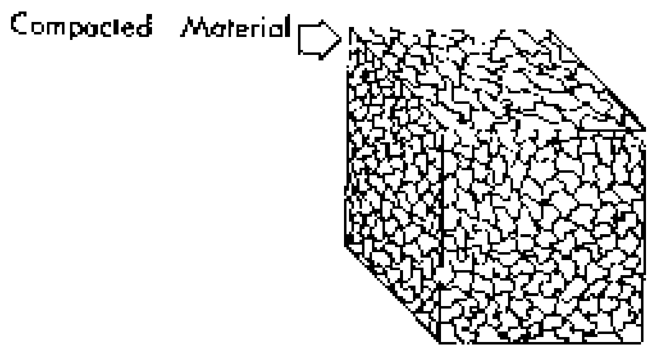
2-17.
b. the thickness of the base course

2-18. a. Plan grade

2-19.
b. should be removed and reworked (if large area)
d. should be reworked and recompacted if they are small areas.

2-20.
a. all station stakes are in place
b. it is finished far enough in advance of the placement of the base course to allow for proper inspection.
c. it is finished far enough in advance of the placement of the base course to allow for necessary corrections to be made.

During compaction, these particles are rearranged and pressed closely together. The voids are filled, so the same amount of material occupies less volume.



2-27. Soil particles

2-28. Voids

2-29. Mixing loss

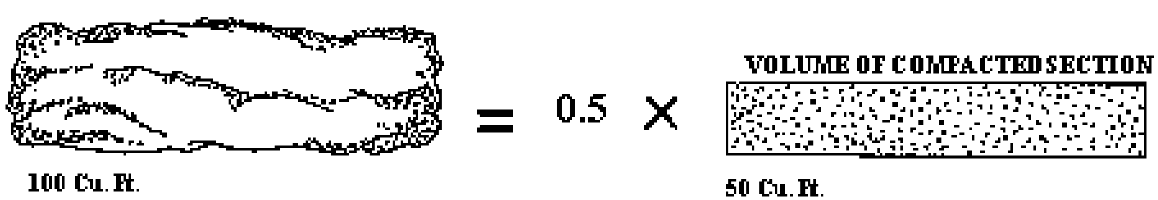
The shrinkage factor tells you just how much less space a certain volume of uncompacted material will occupy after it has been compacted. The formula for finding the compacted section volume is $\frac{\text{loose volume}}{(1-\text{shrinkage factor})}$

FILL IN THE BLANK(S):

2-23 Material occupies less volume after compaction because ____

If the shrinkage factor for a particular material is 0.5, this means you will need 0.5 more loose material than the volume of the compacted section.

REQUIRED LOOSE VOLUME



CIRCLE THE CORRECT ANSWER:

2-24 To find the required loose volume (multiply / divide) the volume of the compacted section by one minus the shrinkage factor.

Find the required loose volume for a soil aggregate section of a roadway that is to be 20 feet wide and 6 inches deep. The shrinkage factor is 0.5.

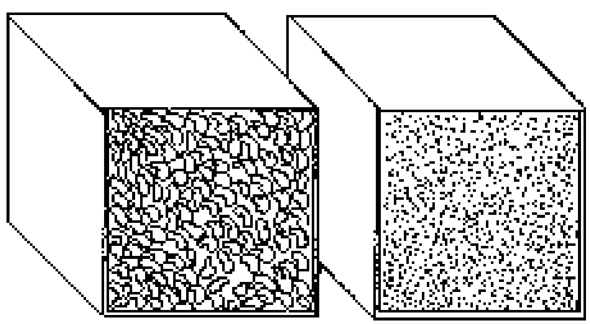
2-25 Find the cubic feet:

_______________________________ cubic feet
(Note: Depth X Width X 1 linear foot)

2-26 Find the loose material needed for that volume:

_______________________________ cubic feet
(Note: 10 cubic feet ¸ 1 minus the shrinkage factor).

Now, let's discuss the mixing loss. Suppose you choose to combine the one cubic foot of aggregate on the left and the one cubic foot of soil on the right.



Since the aggregate particles are larger than the soil particles, they do not fit as closely together as do the soil particles. There are spaces, or voids, between the aggregate particles.

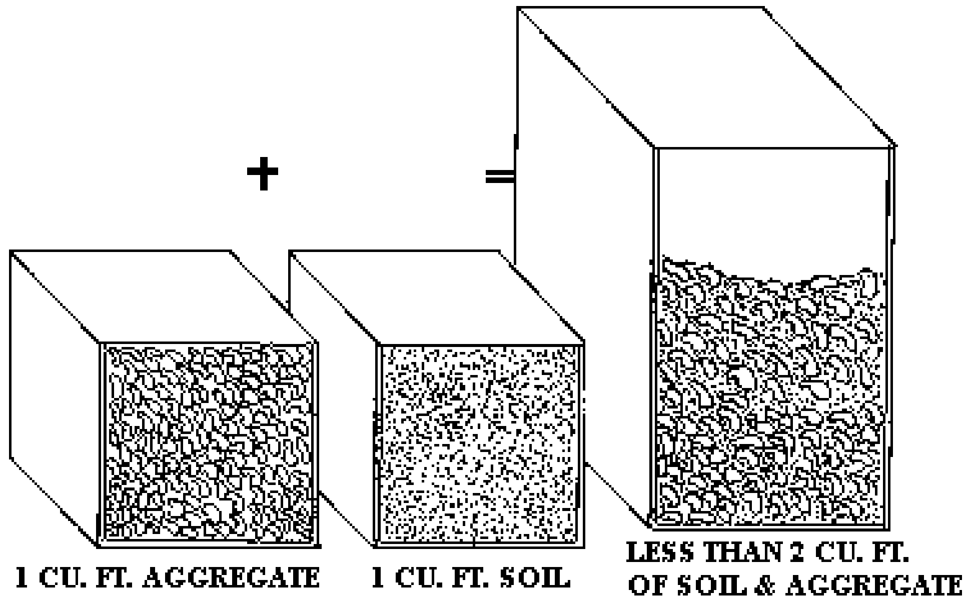
2-22. 100 cubic feet

2-32. **2-32.** 2588.2 cubic feet

2-33. 33.6 cubic yards

2-34. 62.3 cubic yards

When you mix the soil and the aggregate, the soil particles fill in the voids between the aggregate particles. Therefore, when you mix one cubic foot of soil with one cubic foot of aggregate, you will not have two cubic feet of soil-aggregate.



This is the mixing loss - the reduction of total volume (represented by a percent value) that occurs when materials of different particle sizes are mixed. Each combination of material will have a different percentage of mixing loss and the Office of Materials and Research will determine this percentage for each combination.

Mixing loss pertains only to artificial mixtures. Natural mixtures have components that are already combined when we find them.

FILL IN THE BLANK(S):

2-27 Soil and aggregate are mixed_________ _________ fill in the voids.

2-28 The air spaces between particles of materials are called ________________.

2-29 The reduction in volume of the total material that occurs when separate components are mixed is called the ___________________.

2-30 The total volume of a mixture of soil and aggregate will be (greater than / the same as / less than) the total volume of separate components.

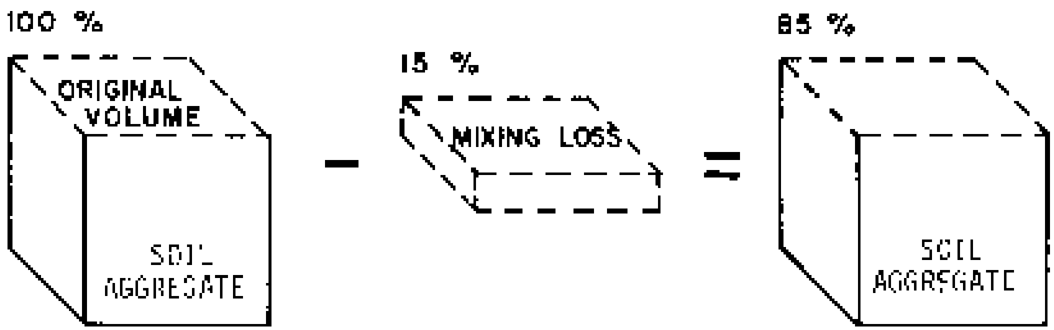
2-31 The mixing loss is expressed as a (percent / ratio / fraction).

Now that you understand the definition of mixing loss, you must now apply it to your calculations.

Let's say the total compacted volume for one linear foot of base course is 11 cubic feet and the shrinkage factor is 0.5. The loose volume needed thus far is 22.000 cubic feet (11 cubic feet ÷ 0.5 = 22.000). Now, to correct for mixing loss if you are working with an artificial mixture:

Subtract the percentage of mixing loss from 100%.

For example, the mixing loss provided by the Laboratory is 15%. This means that when loose components are mixed together, the volume of the components is reduced by 15%.



This tells you that the total mixed volume of your material is equal to 85% of the total unmixed volume.

Divide the loose mixed volume for one linear foot by the resulting figure from the preceding step. (Change 85% to a decimal figure for division).

22.000 / .85 = 25.882 cubic feet of loose unmixed material.

You have now compensated for the shrinkage factor and the mixing loss, and you know that it will take 25.882 cubic feet of loose, unmixed material to end up with one linear foot of base course that is 11 cubic feet in volume.

2-24. Divide

2-25. 10 cubic feet

2-26. 20 cubic feet

2-41. 2303.5 cubic yards

2-42. 1535.7 cubic yards

The loose, uncompacted volume for one linear foot is constant, unless the dimensions or material change. Now you need to know how much loose material will be required to fill a larger section of base course - let's say 100 linear feet. (The loose material will probably be dumped by Stations.) So, multiply the total loose volume for one linear foot (25.882 cubic feet) by 100 feet (the length of the Station).

ANSWER THE QUESTION(S):

2-32 How many cubic feet will be required to fill the 100 feet of base course?

___________________________ cubic feet.

Since trucks will be loaded according to cubic yards, you must change the volume in loose material from cubic feet to cubic yards. 27 cubic feet equals 1 cubic yard.

Therefore, divide the total number of cubic feet by 27

$$\frac{2,588.000}{27} = 95.859 \text{ cubic yards}$$

If artificial mixes are to be mixed on the roadbed, there is one more step - you must calculate the loose volume of each component. Suppose you're mixing soil aggregate material in place. You have calculated the loose spread and found that 95.889 cubic yards are needed per Station. The proportions given to you on the project plans are 35% soil and 65% aggregate.

ANSWER THE QUESTIONS:

2-33 How many cubic yards of soil are needed? _________________________________
(Note: 95.889 X .35)

2-34 How many cubic yards of aggregate are needed? ____________________________
(Note: 95.889 X .65)

You have been through the entire process for calculating the volume of raw material for unstabilized base courses.
Let's briefly go through the steps again:
Find the total compacted volume for one linear foot of base course by multiplying plan width X plan depth X 1 linear foot.

To correct for shrinkage due to compaction: Divide the compacted volume by one minus the shrinkage factor. (This equals the total required loose volume before compaction.)

To correct for mixing loss if the mixture is artificial, subtract the percentage mixing loss from 100% and then divide the total loose volume by (100 - mixing loss). This equals the total required loose volume before mixing and before compaction.

To find the total required loose volume for a larger section of base course multiply the required loose volume for one linear foot by the length of the section.

To find the total required loose volume in cubic yards, divide the cubic feet of the total required loose volume by 27.

To find the required loose volume of each component of an artificial mix: Multiply the total required loose volume in yards by the percentage of the particular component.

Using the following information, answer the question(s):

Plan depth = 9 inches
Plan width = 28 feet
Mixing loss = 15%
Shrinkage factor = 0.60
Desired distance = 1,000 feet
Component proportions = 55% aggregate and 45% soil

2-30. Less than

2-31. Percent

ANSWER THE QUESTIONS:

2-35 What is the total compacted volume of one linear foot of this base course?

____

2-36 What is the required loose volume of one linear foot corrected for compaction?

____

2-37 What is the required loose volume of one linear foot corrected for compaction?

____

2-38 How many cubic yards total is needed.

(Remember - divide your answer by 27 to get the total required loose volume in cubic yards)

2-40 How many cubic yards are needed of each, aggregate and soil?
Aggregate ______________________
Soil ___________________________

ANSWER THE QUESTIONS:

You are constructing a base course 9 inches thick and 20 feet wide. The construction begins at Station 25+00 and ends at 59+00. The base mixture is 60% aggregate and 40% soil. The mixing loss is 18%, and the shrinkage factor is 0.4.

2-41 The component proportion by volume of aggregate is ____________cubic yards

2-42 The component proportion by volume of soil is _________________cubic yards

CALCULATING CEMENT AND LIME SPREAD

In the past sections you were calculating spread volume for loose material. In calculating cement spread, you will be calculating spread distance. Lime spread is calculated like cement spread, so to simplify the explanation, we'll use cement spread as the example.

Note: Cement manufacturers provide cement spread charts. If one of these charts is accessible to you, by all means use it. It will save time and effort on your part.

When cement arrives at the roadway, it usually will be in a large transport that will spread the cement for the base course.

2-44.
Step 1 4.5 cubic yard
Step 2 517.5 pounds per sq. yard
Step 3 41.4 pounds of cement per sq. yard
Step 4 2.44 sq. yards per linear ft.
Step 5 101.0 pounds of cement per linear ft.

2-45. 495.05 linear feet

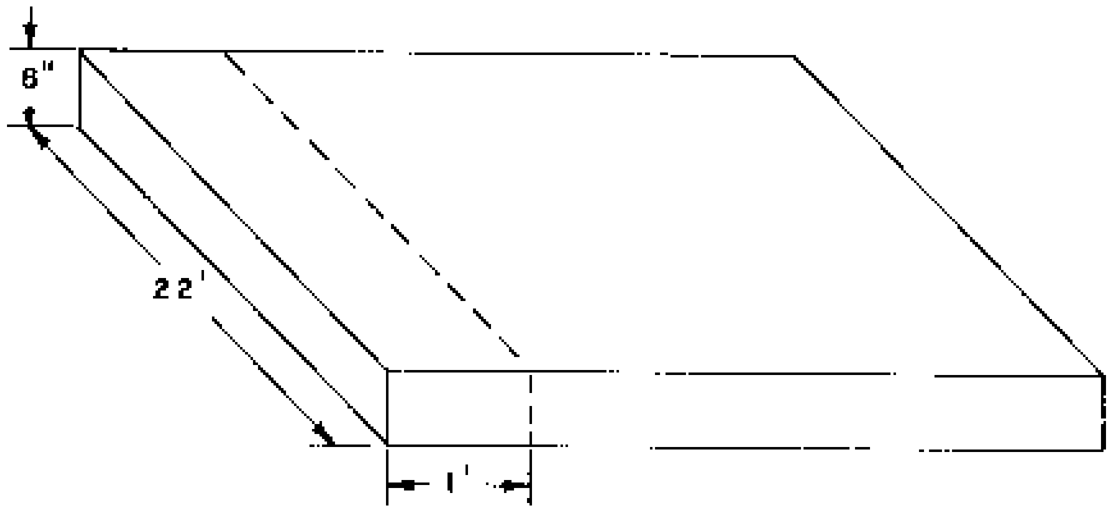
2-46. 110.6 pounds

2-47. 361.7 linear feet

You must determine how many linear feet can be spread with the weight of cement in the transport.

This is one of the approved methods of calculating spread distance.

In Step 1, first find the number of cubic feet per square yard.
(3' X 3' x depth of base course = cubic ft per square yard)



USING THE DRAWING, ANSWER THE QUESTION:

2-43 How many cubic yards are in one square yard of the previous section?

Step 2 in calculating cement spread is to determine the number of pounds of dry soil in a square yard for the plan thickness. (cubic ft. in a square yard X dry weight per cubic foot = lbs. per square yards of soil for the plan thickness)

Step 3 is to determine the number of pounds of cement required per square yard. (lbs. per square yards of soil X percent of cement weight (given by the OM&R) = pounds of cement per square yard)

Step 4 determines the number of square yards of material needed per linear foot of the roadway.(width of the roadway 9 ft. in a square yard)

2-35. 21 cubic feet

2-36. 52.5 cubic feet

2-37. 61.76 cubic feet

2-38. 61760.0 cubic feet

2-39. 2287.407 cubic yards

2-40. 1258.1 cubic yards
1029.3 cubic yards

2-51. **310.5 pounds**

2-52. **4876.2 pounds**

2-53. **23205.8 pounds**

Step 5 is to find the weight of cement per linear foot. (square yard per linear foot X pounds of cement per square yard = pounds of cement per linear foot)

Let's say the lab report indicated that soil cement is suitable for stabilization with 8% cement weight. The dry weight of the soil is 115 pounds per cubic foot and the base is 6 inches thick and 22 feet wide.

2-44 Using the previous steps, calculate the number of pounds of cement per linear foot.
Answers:

Step 1 __________

Step 2 __________

Step 3 __________

Step 4 __________

Step 5 __________

Step 6 is to find out how many linear feet will be covered by a tanker, divide the number of pounds in the load by the number of pounds that will cover one foot.
(Pounds of cement per tanker ÷ pounds of cement per linear foot = the number of linear feet covered by the tanker's cement)

CALCULATE THE ANSWER:

2-45 How far will this load of cement spread?

____

ANSWER THE QUESTION(S):

Plan depth = 6 inches
Plan width = 23 feet
Proportion of cement = 8%
Weight of Cement in transport = 40,000 pounds
Dry weight of soil = 120 pounds per cubic foot

2-46 How many pounds of cement are needed for one linear foot of roadway?

2-47 How many linear feet can the transport spread? ___________

<u>CALCULATE THE ANSWER(S):</u>

You are to construct a base course of stabilized soil aggregate. The component proportions are:

Soil = 37%
Aggregate = 63%
Cement = 6%
Dry Weight of Soil Aggregate Mixture = 130 pounds per cubic foot

The cement transport is loaded with 45,000 pounds. The base course is to be 6 inches deep and 20 feet wide. You are constructing between Stations 45+00 and 60+00. The mixing loss is 15% and the shrinkage factor is 0.3.

2-48 Calculate the loose spread volume for soil: ____________________

2-49 Calculate the loose spread volume for aggregate: _______________

2-50 Calculate the spread distance for cement: _______________

CALCULATING THEORETICAL WEIGHT OF CEMENT PER SQUARE YARD

If you are inspecting a stabilized base course, you will also need to be able to figure the amount of cement required for special situations such as turnouts, transitions, and crossovers.
To calculate the spread weight you must:

find the area of the turnout in square yards. (Your plan typical section will give you the needed dimensions.)
find the pounds of cement for one square yard.
find the total pounds of cement needed for the area.

Since you should be able to find the area of the turnout, let's go directly to the next step - finding the pounds of cement needed for a 10-foot by 6-foot area. The following steps are used:

Area of turn out: Multiply length by width of the area and then divide by 9 square feet per square yard.
Example: $\frac{(10.0 \text{ feet} \times 16 \text{ feet})}{9}$ = 6.67 square yards
Pounds of cement per square yard: Next multiply the dry soil density by the base thickness by the percent cement to get pounds of cement per square yard.
Example: (115 pounds per cubic foot)(0.5-foot)(.08)(9) = 41.4 pounds

2-43. 4.5 square yards

2-56. Raw

Total pounds of cement required: Then, multiply the pounds of cement required for one square yard by the total number of square yards to get the total pounds of cement required.
Example: 41.4 pounds X 6.67 square yards = 276.1 pounds

CALCULATE THE ANSWER(S):

2-51 What will be the total pounds of cement required if the plan depth is 9 inches and the percent cement is 6%? _______________

2-52 What will be the theoretical spread weight of cement if the plan depth is 6 inches, the percentage of cement is 6%, the area of the turnout is 150.5 square yards, and the dry soil density is 120 pounds per cubic foot?

2-53 What will be the theoretical spread weight if the plan depth is 9 inches, the percentage cement is 9%, and the area of the turnout is 329.3 square yards, and the dry soil density is 116 pounds per cubic foot? _______________

CALCULATING WEIGHT OF ASPHALTIC CONCRETE

If a base course is to be asphaltic concrete, you will need to be able to calculate the amount, by weight, of the asphalt mixture needed for any particular section being constructed. A general practice used in the field is to allow 110 pounds of asphalt per square yard per inch of base course.

There are four basic steps involved in this formula which we will now talk about:
Step 1 - Find the area of the particular section in square feet.
For example, the area of a section 100 feet in length and 20 feet wide would be 2,000 square feet.
Step 2 - Convert the area in square feet to square yards. Since there are 9 square feet in one square yard, divide the area by 9.
Example: 2,000 / 9 = 222.222 square yards
Step 3 - Multiply the number of square yards by 110 pounds to get the number of pounds needed for the area. (This will be an area only one inch deep).
Example: 222.222 square yards X 110 pounds = 24,444.420 pounds for the area
Step 4 Since a base course will be more than one inch thick, multiply the number of inches of depth by the number of pounds needed for one inch.
Example: If the base course is to be 3 inches deep, then 24,444.420 pounds X 3 inches = 73,333.260 pounds total
Step 5 - Convert your answer to tons by dividing by 2000.
Example: 73,333.260 ¸ 2000 = 36.666 or 36.7 tons of asphaltic concrete

CALCULATE THE ANSWER:

2-54 A section of base course is 100 feet long, 26 feet wide, and 9 inches deep. What amount, by weight, of asphalt will be required?

2-55 A section of base course is 100 feet long, 24 feet wide, and 6 inches deep. What amount, by weight, of asphalt will be required?

PREMIXING OF BASE COURSE MATERIALS

We said at the beginning of Chapter 2 that the Chapter would cover procedures that must take place before base course construction could begin. This section of Chapter 2, 'Premixing,' deals with a procedure which does take place before construction if the contractor chooses one of the particular methods of premixing. He may however, choose the in-place mixing method, which is done on the subgrade of the roadbed and is part of the actual construction.

Premixing of base course materials is done away from the actual job site. The materials are ready for actual placement and spreading when they are delivered. There are three methods of premixing which we will briefly discuss in this section: the mixing table, the pugmill plant, and the asphaltic concrete plant. Before we get into these methods, let's discuss why mixing is important.

Mixing is important for the following reasons:

Mixing helps to obtain a uniform particle mixture.
Mixing helps to make the mixture stable.
Mixing helps to prevent failures.
Mixing helps the roadway materials obtain the required load-bearing capacity.

The first method of premixing materials is the mixing table, which is used only to mix components of raw materials. The mixing table is a flat area that is usually located near the roadway that the contractor has cleared of trees and debris and has smoothed off. The size of the cleared area depends on the amount of material to be mixed.

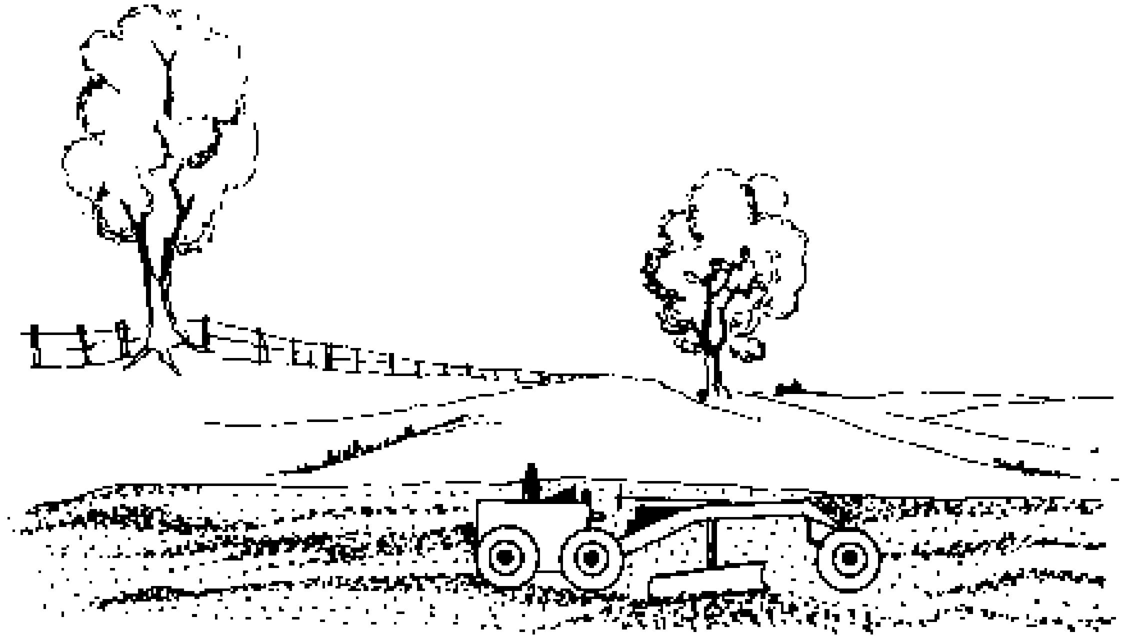
2-48. 345.5 cubic yards

2-49. 588.2 cubic yards

2-50. 576.9 linear feet

2-65. By mixing components on a working surface of the same material

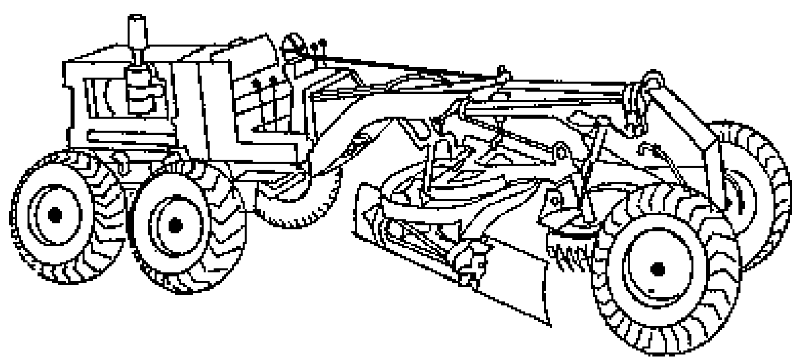
2-66. The aggregate



FILL IN THE BLANK(S):

2-56 A mixing table is used to mix components of _______________________ materials.

Any one of several machines may be used to mix components on a mixing table. This sketch shows the motor grader that is the piece of equipment most commonly used.



CIRCLE TRUE OR FALSE

2-57 True False Materials do not have to be mixed to obtain the required load-bearing capacity.

2-58 True False A 6-acre mixing table is needed to mix any quantity of material.

2-59 True False A mixing table is usually located near the roadway.

2-60 True False We use a mixing table to mix the stabilized aggregates.

2-61 True False The contractor chooses the machine to be used.

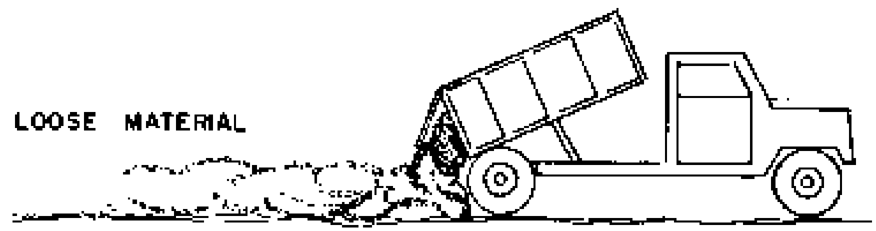
2-62 True False The contractor is responsible for constructing the mixing table.

2-63 True False The amount of material to be mixed determines the size of the mixing table.

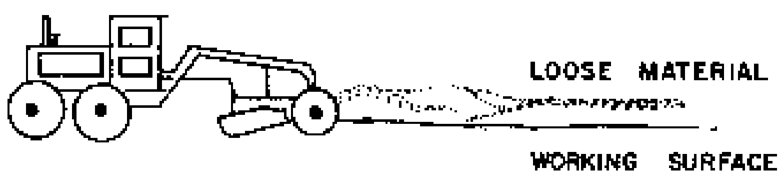
2-64 True False It is not necessary to clear debris from a mixing table.

After the area is cleared, contractors will haul in some of the same material that they'll be mixing. They will spread this material over the mixing table in a layer.

This first layer will serve as a cover or working surface over the native soil during mixing.



THEN THEY'LL MIX THE COMPONENTS:



2-54. 143 tons

2-55. 88 tons

2-68. Raw
Raw
Stabilized

The motor grader operator has to exercise care not to penetrate the working surface in order to prevent contamination of base material by the native soil.

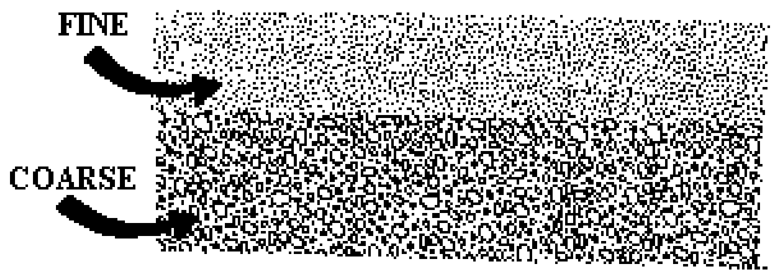
ANSWER THE QUESTION:

2-65 How do contractors make sure that no native soil is mixed in?

____

After the area has been cleared and the working surface compacted, the correct amount of each component of the material is hauled to the mixing table. Each component is sampled, tested, and approved by the lab before being hauled.

These components are spread evenly in depths of 6 to 12 inches. The fine components are spread on top of the coarse components.



ANSWER THE QUESTION:

2-66 If we're mixing soil aggregate, which component do we spread first?

After the components are blended and mixed uniformly, the material is hauled to the roadway, which is the topic of the next section of Chapter 2.

2-67 Number the steps to put them in order of occurrence. You are using a mixing table to blend the material you're using.

_____ A. You make a working surface out of the same material you'll be mixing.

_____ B. You proportion the accepted components.

_____ C. You choose a flat area near the construction site.

_____ D. You haul and spread the fine components.

_____ E. You haul and spread the coarse components.

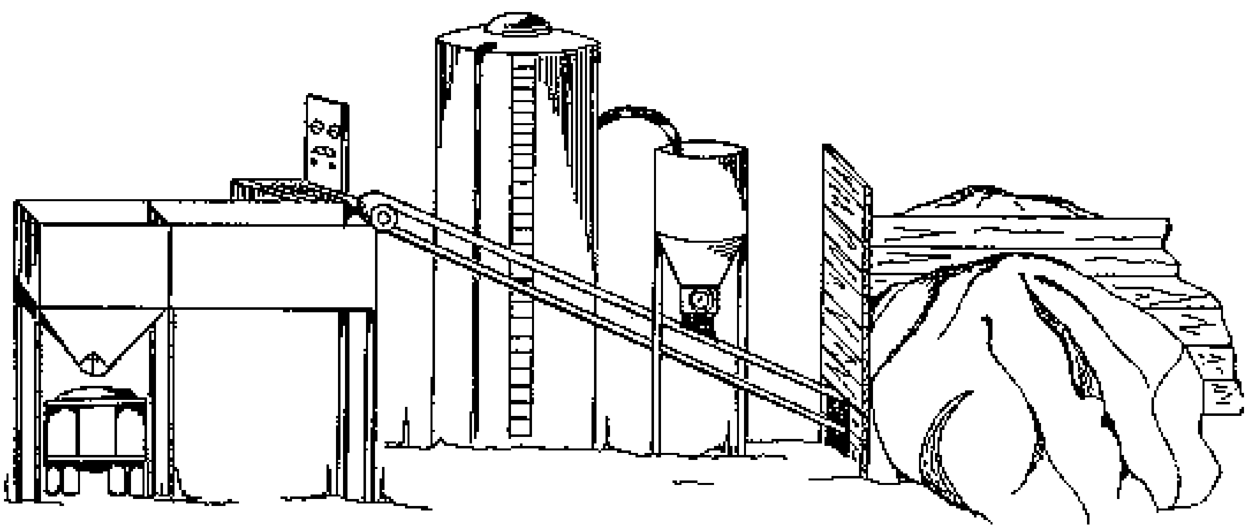
_____ F. You clear the area of trees and debris.

_____ G. You mix the components uniformly.

_____ H. You haul the mixture to the roadway.

Materials used to construct the base course must be inspected both before and after mixing in order to make sure they meet specifications. Non-specification material could cause failures in the base course.

Another method of premixing is through the use of a pugmill plant. This kind of plant is not as widely used today in Georgia as it has been in the past; however, you should be familiar with some of the basic characteristics of the pugmill plant.



2-57. False

2-58. False

2-59. True

2-60. False

2-61. True

2-62. True

2-63. True

2-64. False

The previous sketch is a typical pugmill plant that mixes components of base course materials automatically. The materials can be either raw or stabilized materials.

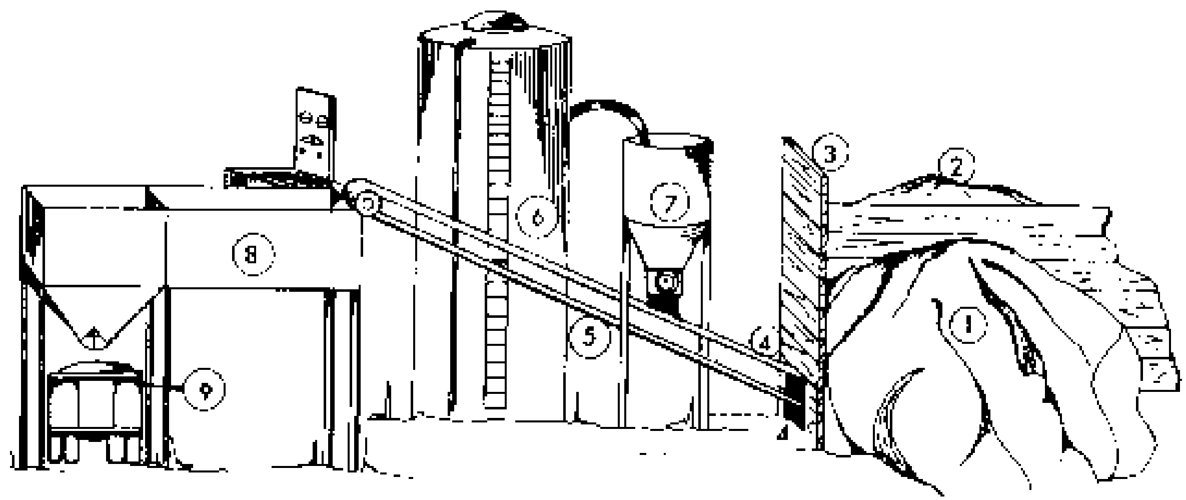
FILL IN THE BLANK(S):

2-68 Mixing tables are used to mix _____________ materials, and pugmill plants can be used to mix _____________ and ______________materials.

The parts of the pugmill plant have been numbered and explained below. This particular plant is being used to mix stabilized soil aggregate.

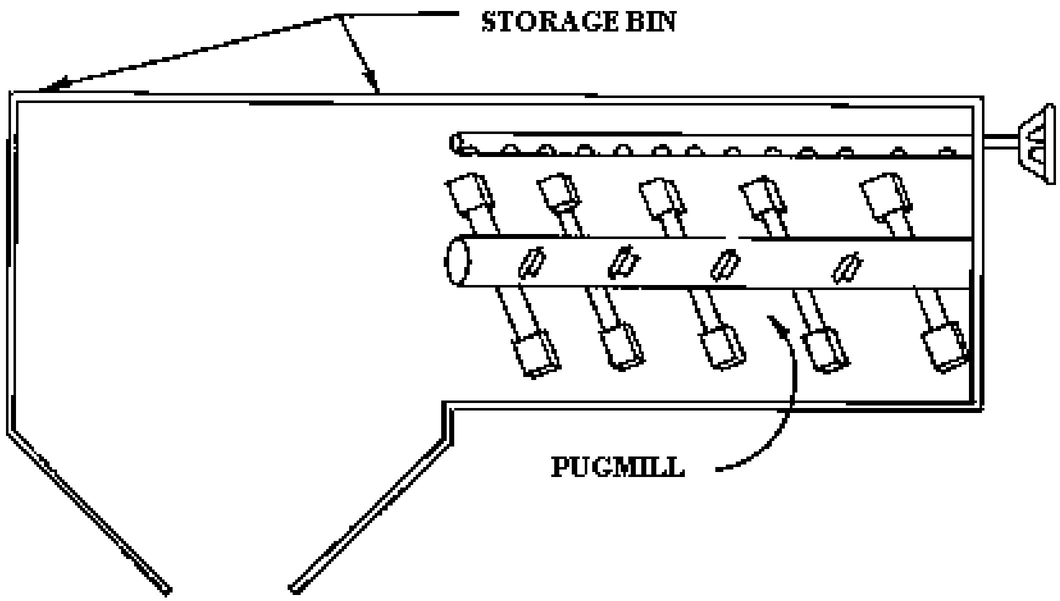
2-69. A. 5
B. 3
C. 8
D. 1 and 2
E. 6
F. 9
G. 4
H. 7

2-70. Shafts and paddles
spray bar



1) and 2) The aggregate and soil are stockpiled.
3) Bulkheads separate the two stockpiles.
4) The front bulkhead contains gates by which material is moved to the conveyor.
5) The main conveyor carries the aggregate and soil to the pugmill.
6) The cement silo stores the cement.
7) The cement hopper deposits cement on to the conveyor.
8) The pugmill mixes and pulverizes the components.
9) The haul truck is loaded with the stabilized soil aggregate mixture for delivery.

Let's take a closer look at the pugmill. If you could see through one it would look like this:

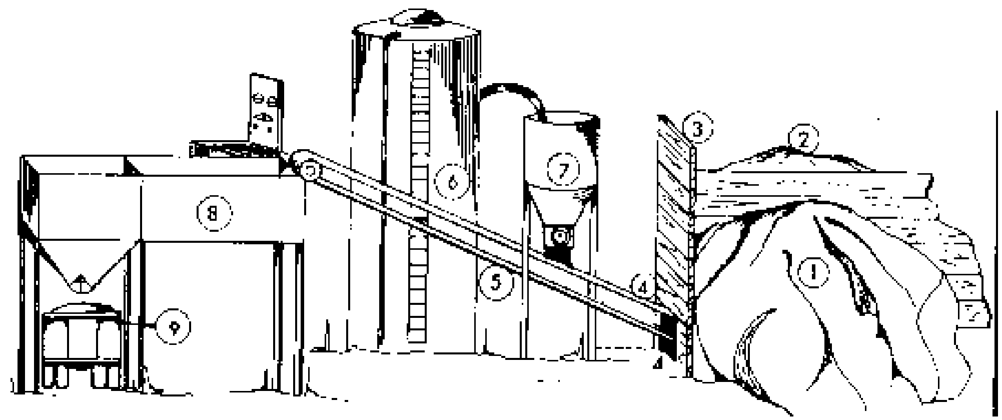


There are two important items in the pugmill. The first are the shafts of paddles that do the actual pulverizing and mixing, and the second is the spray bar that is used to add moisture to the pugmilled mixture. The valve on the right regulates the amount of water sprayed through each bar.

After mixing, the mixture moves into the pugmill storage bin. The discharge gates on the storage bin are closed until the bin is filled. Then the gates open to release the mixture into a haul truck.

2-73. **2-73.** Area Engineer

2-69 Match the parts of the pugmill plant with the appropriate description.



_____ A. carries aggregates to the pugmill

_____ B. separates stockpiles

_____ C. mixes and pulverizes the components

_____ D. stockpiles of aggregates

_____ E. stores cement

_____ F. delivers mixture to roadway

_____ G. gates by which material is moved to conveyor

_____ H. deposits cement onto the conveyor

ANSWER THE QUESTION:

2-70 Two important parts of the actual pugmill are the________________________and the

____

SAMPLING BASE COURSE MATERIALS

If base course materials have been premixed, the mixtures should have already been sampled and tested by the Office of Materials and Research before delivery. However, if they have not or are individually shipped they may need to be still sampled and tested to determine whether or not they meet specification requirements.

The Office of Materials and Research's Testing Management Branch is responsible for the sampling and testing of the materials incorporated on the job. Each time they sample a component, a DOT Form 170 Sample Card, illustrated below, is filled out and submitted with the sample. When the lab tests the sample, they fill out a report form giving the results of all tests run on that sample and submit it to the Area Engineer for review.

DOT 170 SAMPLE CARD FOR ALL MATERIALS

Sample Type: Control Independent Assurance

Project No.________________________________ County____________________
Material______________________________________ Size or Type___________
Date Sampled_______________________________ Sample No. _______________
Sampled From__________________________ Sample Represents _____________
Producer or Property Owner____
Location____
Contractor ____
Examined For ____
Used In_________________________ Submitted By________________________
Remarks:____
____

FILL IN THE BLANK(S):

2-71 Materials delivered to the job site are individually ________________ and ____________________ in order to determine if they meet _______________________.

2-72 Each sample submitted by the _______________________________ has a ____ sample card with it.

2-74.

STATION	STATION	LINEAR FT.
12+80	15+00	220

LBS. CEMENT	SPREAD RATE	TRUCK NO.
28819	08	5

SEAL NO.	DATE	INITIALS
97975, 97976, 97977, 97978, 97979, 97980	5/13/77	W.L.J.

2-75. False

2-76. True

2-77. False

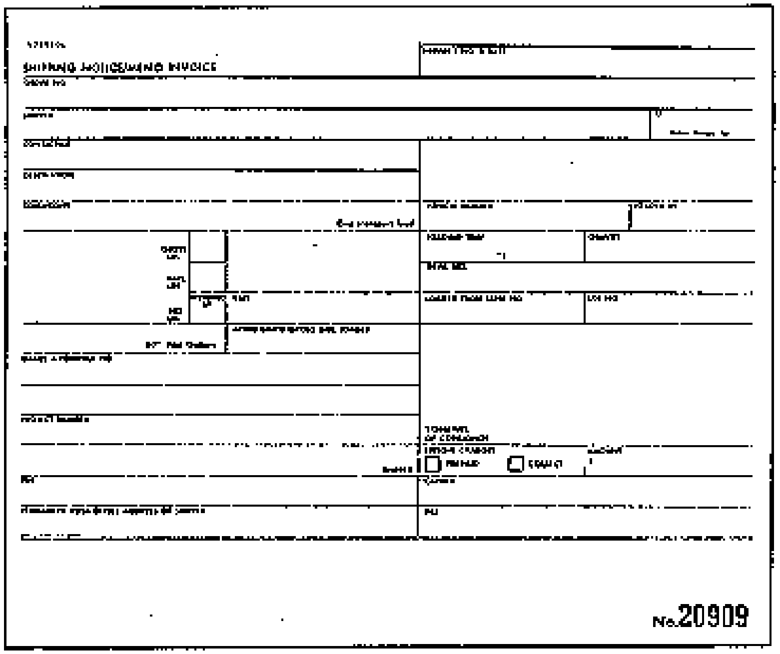
2-73 The results of the tests are reported to the ______________________.

CEMENT OR LIME

Cement and lime are brought to the roadway in a transport. The rear view of this transport shows the distributor pipe. The use of "blow tubes" as shown in the photograph below is not permitted by the specifications. The lime or cement must be spread with a mechanical spreader.

The cement or lime must be carried in a sealed transport. The seals are put on when the transport is loaded, and they are broken only after the transport arrives at the roadway. You are required to keep these seals as part of your project records, you should also be present when the seals are broken. You must reject any shipment having broken or missing seals!

You should collect a Shipper's Invoice from the transport driver. This is a Shipper's Invoice:


No. 20909

You should document all information in a field book:

STATION	STATION	LINEAR FT.	LBS. CEMENT	SPREAD RATE	TRUCK NO.	SEAL NO.	DATE	INITIALS

2-71.
Sampled
Tested
Specifications

2-72.
Office of Materials and Research
(test Management Branch)
DOT 170

2-83. c. Divide the compacted volume by one minus the shrinkage factor.

2-84. a. Percent

2-85. b. 94 pounds

2-86. a. Raw materials

2-87. a. Raw materials
b. Stabilized soils and aggregates

2-88. c. One

2-89. c. Shipper's Invoice

Document the inclusive Stations first. Then record the linear feet. Next, record the pounds of cement, actual spread rate and the truck number. Then record the seal numbers (indicated on the Certificates of Delivery) and the lab number. The last two columns are for the date and your initials.

2-74 Fill in the following information on the previous sample document:

A transport loaded with cement arrives at the roadway on May 13, 1977. The seals are numbered 97975, 97976, 97977, 97978, 97979 and 97980. The cement spread covers Stations 12+80 to 15+00 in zone 3. 28,819 pounds of cement were delivered and spread. 8% cement is used for stabilization. Transport No. 5 brought in the cement.

Cement and lime are usually pretested and approved; however, the OM & R will be required to take one verification sample per project - the sample representing only one tanker. The sample should be taken from a pile on the roadway And not the tube coming from the back of the truck.

CIRCLE TRUE OR FALSE

2-75 True False Cement or lime is never sampled at the roadway.

2-76 True False One sample of cement represents no more than one tanker.

2-77 True False Lime sample are taken from the flow at the back of the transport.

The following is a list of "don't's" concerning cement for base courses:

Different brands of cement must not be mixed together.
Different types of the same brand must not be mixed together.
Different brands, or different types of the same brand, must not be used alternately.
Cement salvaged from discarded bags must not be used.

ASPHALTIC CONCRETE

Asphaltic concrete is delivered to the job site in haul trucks. The mixture is hot - it should be no cooler than 20°F below the minimum allowable temperature of the mixture when discharged from the mixer at the plant. Asphaltic concrete base material is sampled and tested in accordance with the Sampling, Testing, and Inspection Manual.

FILL IN THE BLANK(S):

2-78 The temperature of the mixture must not be lower than ______________________________.

CHAPTER 2 REVIEW

CIRCLE THE CORRECT ANSWER(S):

2-79 What effect does a high spot in the subgrade have on the base course?
a. The depth of the base course is increased.
b. The depth of the base course is decreased.
c. The depth of the base course is not effected.

2-80 Large deficient areas in the roadbed:
a. should be reworked
b. should be removed and reworked

2-81 The shrinkage factor is:
a. the percent compaction to be reached by a lift of material.
b. the process which causes small and large particles of material to fit closely together.
c. the value needed to calculate the volume of loose material required to fill a compacted area of certain dimensions.

2-82 What is the total compacted volume for one linear foot of base course with a depth of 8 inches and a width of 24 feet?
a. 15 cubic feet
b. 15.504 cubic feet
c. 15.984 cubic feet
d. 15.489 cubic feet

2-83 To find the loose material needed for a particular volume:
a. multiply the shrinkage factor volume
b. divide the compaction factor by the by the volume.
c. divide the compacted volume by one minus the shrinkage factor.

2-84 Mixing loss is expressed as a:
a. percent
b. ratio
c. fraction
d. decimal

2-85 One cubic foot of cement weighs:
a. 90 pounds
b. 94 pounds
c. 98 pounds
d. 100 pounds

2-86 A mixing table is used to mix components of:
a. raw materials
b. stabilized soils and aggregates
c. asphaltic concrete mixtures

2-87 A pugmill plant can be used to mix components of:
a. raw materials
b. stabilized soils and aggregates
c. asphaltic concrete mixtures

2-88 How many Sample Cards are filled out when submitting a sample?
a. two
b. four
c. three
d. one

2-89 What form should you collect when cement is delivered?
a. Project Sampling Plan
b. Certificate of Delivery
c. Shipper's Invoice
d. DOT Form 170 Sample Card

CALCULATE THE ANSWER(S):

2-90 How many cubic yards of loose uncompacted soil and aggregate are needed if:
plan depth = 9 inches
plan width = 26 feet
shrinkage factor = 0.4
mixing loss = 18%
spread distance = 1,500 feet
component proportions - soil = 42% and aggregate = 58%

Answer:
soil ___________________ aggregate ___________________

2-91 Calculate the spread distance if:
plan depth = 8 inches
plan width = 24 feet
proportion of cement = 8%
weight of cement in transport = 50,000 pounds
dry density of soil = 111 pounds per cubic foot

Answer ___________________

2-92 Determine the theoretical spread weight of cement if:
plan depth = 8 inches
proportion of cement = 8%
area of the turnout = 180.5 square feet
dry density of soil = 111 pounds per cubic foot

Answer _______________

2-93 Determine the amount, by weight, of asphaltic concrete needed for a section of base course if:
plan depth = 5 inches
plan width = 25 feet
length of the section = 100 feet

Answer _______________

2-78. 25°F below the minimum allowable temperature of the mixture when discharged from the plant

2-79. b. The depth of the base course is decreased.

2-80. b. Should be removed and reworked.

2-81. c. The value needed to calculate the volume of loose material required to fill a compacted area of certain dimensions.

2-82. c. 15.984 cubic feet