
# Portland Cement Concrete Paving Inspection

**Georgia Department of Transportation**

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# FORWARD

Portland Cement Concrete Paving 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 portland cement concrete paving construction. 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 portland cement concrete paving 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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**1-2.** line

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# CHAPTER 1 CONVENTIONAL PAVING

## BASE COURSE (PRELIMINARY PREPARATION)

A concrete paving inspector must check a paving operation from the ground up; therefore, one of the first areas to be inspected is the base course. The base course, stabilized, must be brought to approximate line and grade before the forms are set. Any high spots should be shaved down. Any low areas shall be corrected before the forms are set in order to obtain a level surface and the proper compaction. The base course must be swept, broomed or otherwise cleaned of all loose or surplus materials before the forms are set.

## FILL IN THE BLANK(S):

**1-1.** The _____ must be brought to approximate line and grade before the forms are set.

Reference points are used to see that the base course is placed at the line and grade shown on the plans. These reference points are furnished by horizontal alignment and vertical elevation stakes that are placed before construction begins. The stakes used to measure line or horizontal alignment are called hubs, while the ones used to measure grade or vertical elevation are called blue tops. Guard stakes must protect both hubs and blue tops.

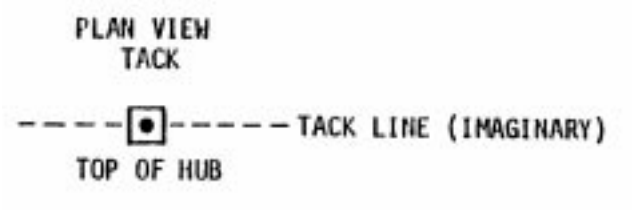
## FILL IN THE BLANK(S)

**1-2.** Hubs are used to check _____.

**1-3.** Blue tops are used to check _____.

These three stakes are usually placed every 50 feet on a straight-away and every 25 feet on a changing grade or in

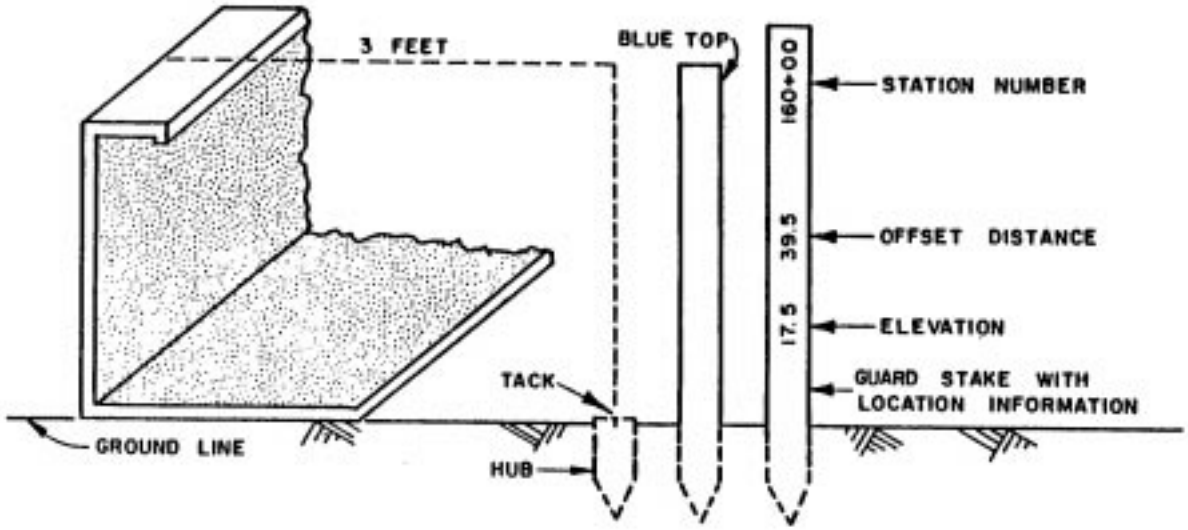
a curve. However, in some instances they are placed at every joint location. Usually, hubs are placed approximately 3 feet outside of where the forms are to be placed, but in some cases they are placed outside the shoulder area. Since they will be used periodically during the project to check line, they must be protected from damage. Therefore, each hub is set almost flush with the ground and has a small metal tack driven into the top. The tack marks an exact reference point on an imaginary horizontal line.




Blue tops are placed on both sides of the roadway (close to the hubs on one side of the roadway) and are used to check the grade or vertical elevation of the project as shown on the plans. Each elevation figure usually refers to the top of the finished concrete pavement at that particular point. Blue tops can be placed in various ways to represent the correct elevations. They can be driven into the ground until their tops are level with the correct grade or with a prior grade. They can be driven almost flush with the ground and the grade projected by using a template and an engineer's rule. Whether this method of grade establishment is used or another option, it is important to

remember this layout is the contractor's responsibility and is to be performed well in advance of the actual paving operation.

Guard stakes are often used to provide protection for the hubs and usually have the cuts, fills, etc., as well as the station numbers printed on them.




**1-4**. ¼"

**1-5**. its depth

**1-6**. inside; top

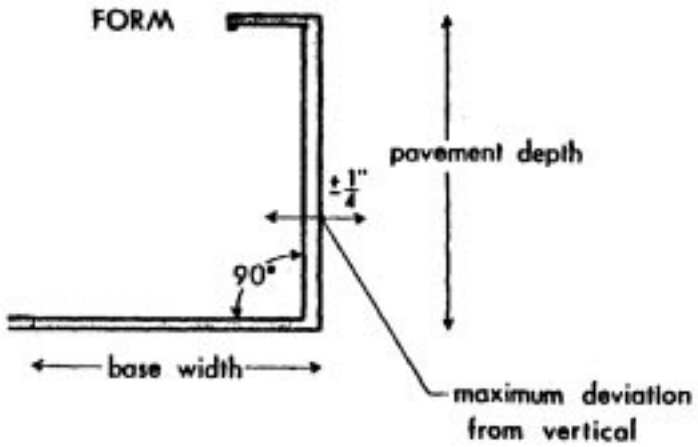
# FORMS

Forms are a necessary part of a conventional concrete paving operation. When set in position, the forms support the freshly mixed concrete until it hardens. They also determine the alignment, grade and thickness of the concrete pavement. During the paving operations, most of the paving equipment travels on the forms.

Because of the vital part that forms play in the concreting operation, the inspector on the job must examine the forms closely to see that they conform to the Standard Specifications and that they are approved for use. He must also see that they are set in place in accordance with the Specifications at the location shown on the plans.

The top face of a form must not vary from a true plane more than 1/8 inch in ten (10) feet if it is to be approved. Any variation in excess of this measurement must be corrected. Twisted, bent, or defective forms cannot be used. This can easily be checked by pulling a stringline along the top of the form and measuring the deviation, if any. Remember that forms being bent upward create as much trouble as those that are bent downward.

Unless otherwise specified by the engineer, the depth of a form must at least equal the thickness of the pavement to be placed. In addition, the base width of a form must at least equal its depth. The upstanding leg of a form should not vary more than ¼ inch from the vertical. In certain cases, the engineer may approve the use of built-up forms; however, the buildup shall not exceed two (2) inches.



## CIRCLE THE CORRECT WORD(S):

**1-4.** The upstanding form leg cannot vary more than (1/4”/1/8”) from the vertical.

## FILL IN THE BLANK(S):

**1-5.** A form’s base width must be at least equal to _____.

In addition to having the correct dimensions, forms must be clean and free of a buildup of old concrete. Dirty side faces of forms may cause voids in the sides of the pavement when the forms are removed. Forms that have old concrete on their tops will cause the pavement to be uneven and out of vertical alignment because the paving equipment rides directly on the forms. Also, forms that have old concrete on their side faces may cause chunks of the new slab break off. This is due to the bonding of the new slab to the old concrete on the forms. In order to eliminate this problem, a bond breaker such as oil must be place on the inside face and top of the forms before the concrete is placed in them.

**1-8**. three

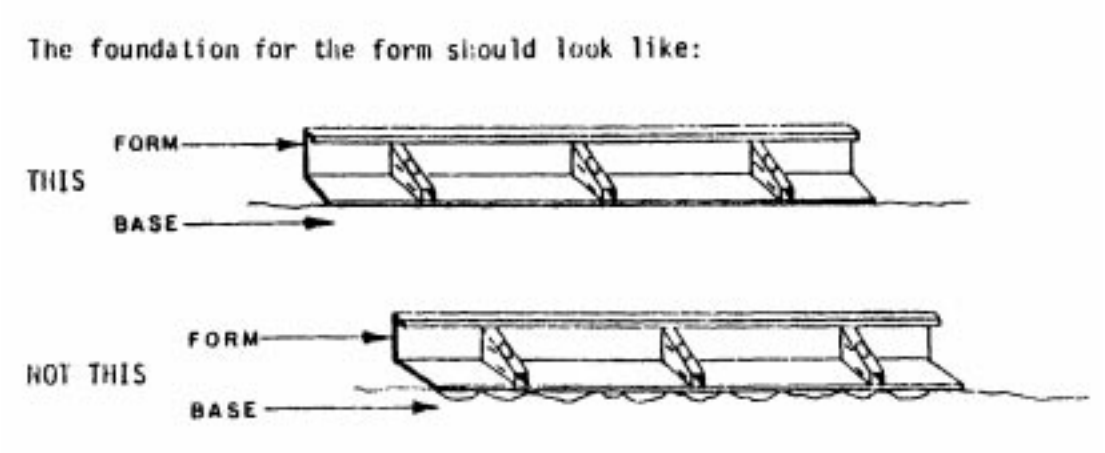
**1-9**. 1/4

## FILL IN THE BLANK(S):

**1-6.** Forms are oiled on the _____ face and _____.

Once the forms have been inspected and approved for use, they must be properly set in place. Using the hubs and blue tops for guidance, the contractor’s men set the forms to line and grade. As the forms are being placed, the inspector must see that each one is firmly in contact with the base for its whole length. Imperfections or variations in grade shall be corrected as necessary. That is, any high spots must be cut down and any low spots filled with suitable material and compacted.

Any openings or gaps between the bottom of the form and the base course should be filled with additional base course material to prevent concrete from flowing under the forms and also to help keep the forms from flexing under the weight of the finishing equipment. When it is necessary to fill under the forms, the ground should be moistened with sufficient water to permit compaction to the same density as the undisturbed portions of the base.

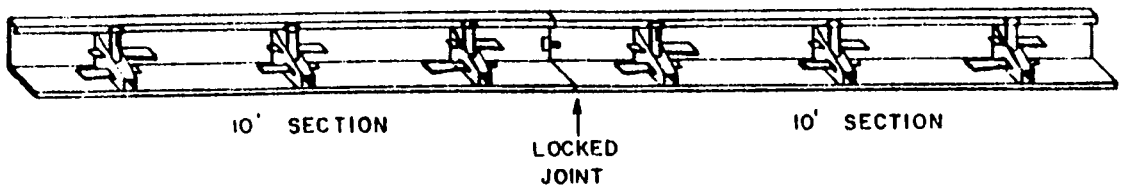



When a stabilized base is used, forms may be wedged into position and supported where needed with shims. However, if this procedure is used too frequently, the base finishing operation should be checked.

# FILL IN THE BLANK(S):

**1-7.** Gaps beneath the forms should be filled with _____.

Properly positioned forms must then be staked into place with at least three steel pins per 10-foot section. When staked correctly, the joints of the forms should be locked together tightly in order to keep the forms from moving or flexing under the weight of the pavement equipment. Once positioned each form section cannot deviate from true line more than ¼ inch at any point.




**1-13.** inside

# FILL IN THE BLANK(S)

**1-8.** There must be at least _____ pins per 10-foot section.

**1-9.** Each form cannot deviate from true line more than _____ inch at any point.

The steel pins used in the forms should be of sufficient length to hold the forms in place and minimized against any “rocking” movement during the finishing operation. A pin should be placed on each side of every locked joint. All pins are secured in place on the forms by wedges.

## FILL IN THE BLANK(S):

**1-10.** There must be _____ on each side of locked joint.

A pin that has been placed properly is straight. The pin is fastened securely by wedges. These wedges must not be bent. If forms are set on a stabilized base, the inspector must see that holes for the pins are drilled through the full depth of the stabilized base. Pins must not be driven through the base. Holes that are drilled for pins shall not be smaller than the size of the pin itself.

## FILL IN THE BLANK(S):

**1-11.** Pins and wedges must not be _____.

**1-12.** Pins _____ be driven through stabilized base.

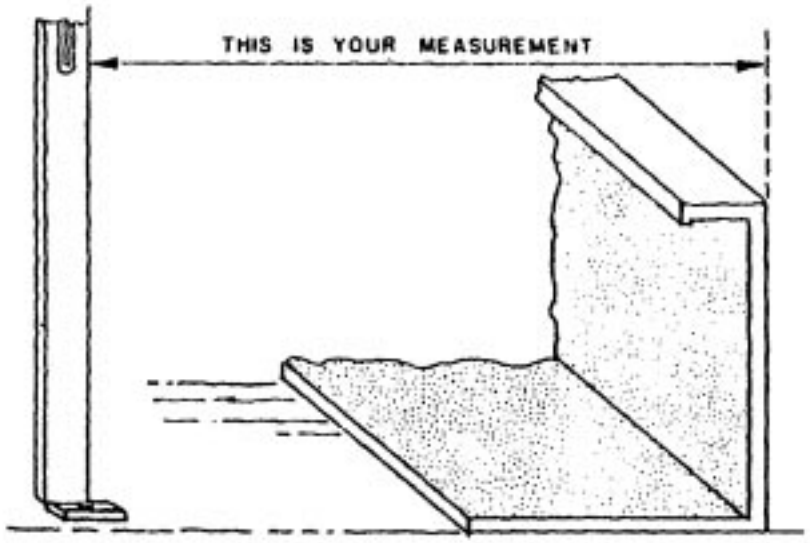
Prior to placing forms, the full width of the subgrade and subbase shall be prepared in accordance with applicable plans and specifications. When the forms are placed they should be set solidly so that contact is maintained between the base and the forms throughout the entire length of the form. Forms should be cleaned and oiled prior to concrete placement.

Once the contractor’s men have secured the forms in place, they must be checked for horizontal alignment and grade. The contractor must correct any improper placement of the forms at this time.

**1-7.** suitable material (i.e. base course material)

Here is one way to check the forms for proper horizontal alignment.

Using the hub, measure the distance from a point directly above the tack in the hub to the inside face of the form. Since the top of the hub is lower than the top of the form, it is necessary to use an engineer's level as shown below. If the hubs are on an exact three-foot offset, your measurement should always be three-feet. This check should be conducted at each hub location and wherever a form appears to be out of alignment.
A formline (stringline) may be placed designating the exact line the forms are to follow.

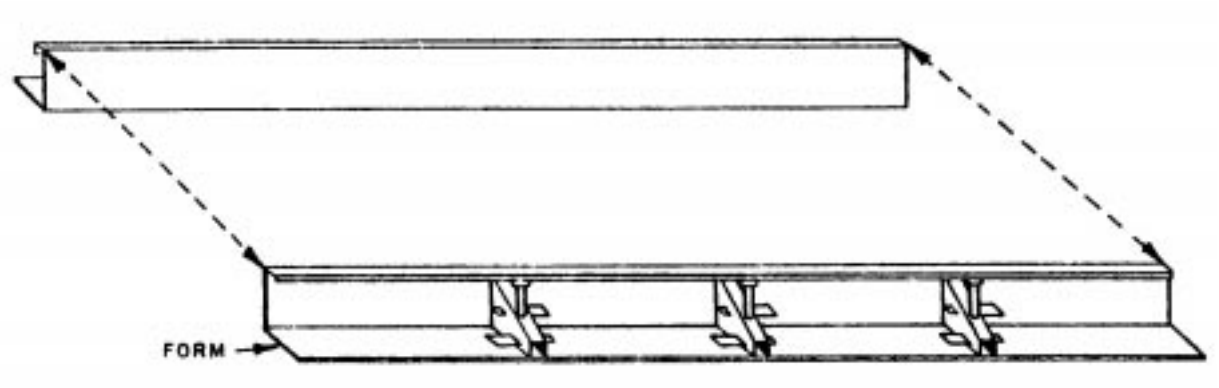



## CIRCLE THE CORRECT WORD(S):

**1-13.** The measurement is from the hub to the (inside/outside) face of the form.

After the horizontal alignment on one side of the roadway is checked, the other side must be checked also.

Use a steel tape or other suitable measuring device to check the distance between forms. Measure from the top of the inside face, of the form just checked, to the inside top of the one directly across the roadway. By doing this, you will get the true width along the slope lines. This check should also be made at each hub and where there appears to be a form out of horizontal alignment.




**1-10.** pins

**1-11.** bent

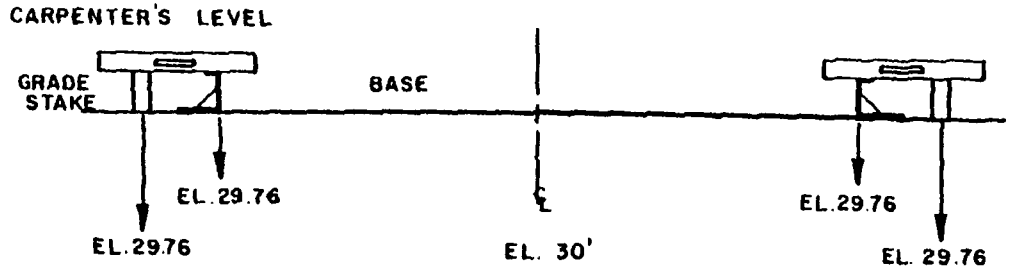
**1-12.** must not

## CIRCLE THE CORRECT WORD(S):

**1-14.** The measurement must be made at the (top / bottom) of the forms and to the (inside / outside) faces.

The inspector must also check the grade or vertical elevation to make sure the forms are set to the correct grade. Usually, the correct grade is the top of the finished concrete pavement.

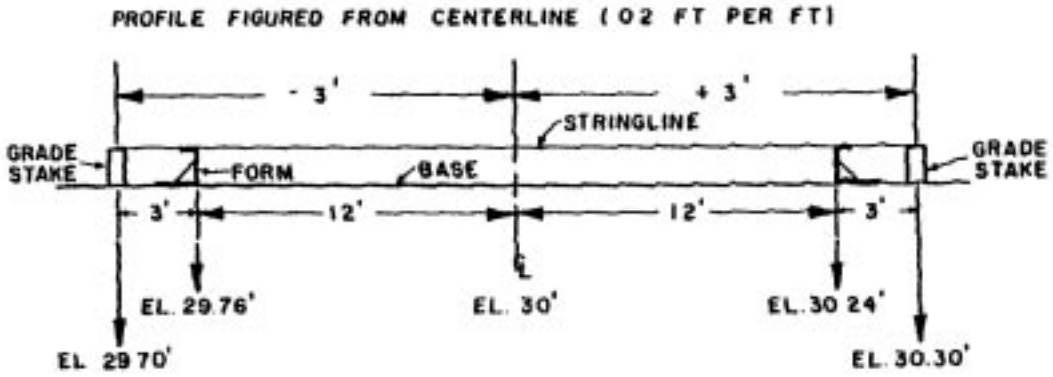
As stated earlier, the inspector uses the blue tops to check grade. If the blue tops have been driven down level with the finished grade at the edge of the pavement, the inspector could check each form by laying an engineer's level on the top of a blue top and the form it references. The example below shows this method.



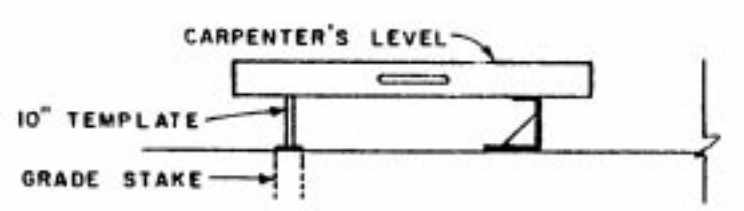

**1-15.** grade

**1-16.** at locked joints

If the blue tops have been driven down level with a prorated grade, the inspector could check each form by running a stringline between the two blue tops directly opposite each other across the roadway.




If the blue tops have been driven down flush with the ground, a different procedure for checking grade must be used. In this case, an inspector can use a template attached to an engineer's level to project the stake elevation to the correct finished grade. He then checks the level to see that form is set properly. The same procedure is followed at both sides of the roadway. The example in the figure below shows the method.

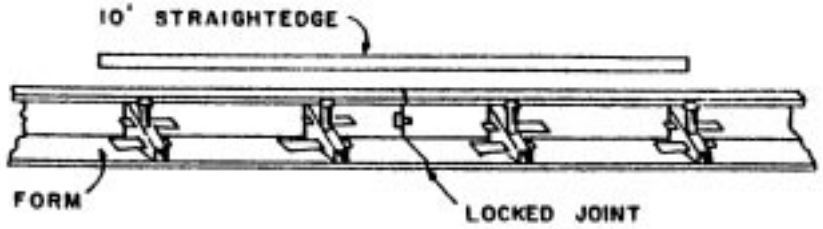



**1-14.** top; inside

# FILL IN THE BLANK(S):

**1-15.** The vertical elevation is the same thing as _____.

Grade must also be checked at the locked joints between form sections. Placing a 10-foot straightedge or a string-line on the top face of the forms does this. The inspector must make sure that there is no "hump" or variation in elevation at locked joints.




**1-19.** stringline

# ANSWER THE QUESTION:

**1-16.** Where are humps likely to occur? _____

Inspectors must also make certain that forms are uniform in grade between the blue top measurements. This is done by placing of a 10-foot straightedge on the tops of the forms or by running a stringline above the forms.

In addition to checking the horizontal and vertical alignment of the forms and checking the grade by measuring, the inspector should "eyeball" the forms from time to time as a further check on horizontal alignment and grade. Any high or low spots that are detected must be corrected. Correct vertical form alignment is essential for smooth riding pavements. Eyeballing should be used only as a supplement to measuring not a substitute.

## CIRCLE THE CORRECT WORD(S):

**1-17.** The (vertical / horizontal) alignment affects the riding surface of the pavement.

On projects where a stabilized base is used, the alignment of forms and setting of forms to grade can be done in a slightly different manner. The offset blue tops and hubs are still used for reference points; however, the forms are not set directly off of them. Instead, a stringline is set to grade and line at the location where the forms are to be placed. The forms are then placed right beside the stringline, thus they are placed at the correct line and grade. As described previously, before the forms are staked in place, they must rest on a level surface or be shimmed to the correct elevation.

The inspector usually checks the alignment of the forms by making sure the top of the forms are to line and grade with the stringline. He must also occasionally check the line and grade from the stakes to make sure that the stringline has not settled or stretched, thereby causing the forms to be out of alignment.

## CIRCLE THE CORRECT WORD(S):

**1-18.** When forms are set to line and grade off of a stringline, hubs and blue tops (are / are not) necessary.

# BASE COURSE (FINAL PREPARATION)

Final base preparation shall be done prior to form placement. Typically, this is done with a motor grader or fine grader.

If the base is stabilized, such as cement or lime stabilized, it should be checked for proper elevation using the same methods used for subgrade preparation, i.e. stringline, etc. All high areas are then trimmed down to the proper elevation. Trimming can be done by hand tools if the area is small or by a motor grader if the area is large. Any low areas that are left, are to be filled with concrete during the paving operation, at no additional expense to the Department.

**1-32.** hubs; blue tops

**1-33.** are

A stringline is used to check elevation of an approved stabilized base course just before the concrete is placed.

**1-34.** stabilized

## FILL IN THE BLANK(S)

**1-19.** A _____ is used to make the final check on stabilized base course elevation.

**1-35.** wet

**1-36.** move

The forms must be correctly placed and the base course must be finished sufficiently in advance of the point where the concrete is being placed. About 500 feet in advance is a general rule of thumb; however, the distance should be increased when more than one paver is in operation. The purpose of this is to prevent those persons placing the forms or grading from slighting their work because of being hurried by the near approach of the paving crew.

If the base course is dry at the time that the concrete is placed, it will absorb moisture from the concrete, which may cause volume changes in the base. Excessive moisture loss at this time may also cause shrinkage in the concrete. These problems are prevented by wetting the base until its moisture content is such that it will not absorb the moisture from the concrete. However, the base is not to be muddy or have puddles of water on it. The base should be sprinkled well ahead of the paving operation, and then sprinkled just ahead of the paver, as needed.

## CIRCLE THE CORRECT WORD(S):

**1-20.** If the base course was not sprinkled before the concrete was poured, the concrete would (expand / dry out too fast).

**1-21.** The base course is brought to approximate line and grade (before / after) the forms are set.

**1-22.** Forms are used in (conventional / slip form) paving.

**1-23.** Forms are normally (5/10) feet in length.

**1-24.** Forms are held in place by (clamps / pins).

## FILL IN THE BLANK(S):

**1-25.** There must be a _____ on each side of each locked joint.

**1-26.** There must be at least _____ pins per 10-foot section of forms.

**1-27.** Each form section must not deviate from true line more than _____ inch at any point.

**1-28.** Pins _____ be driven through a stabilized base.

**1-29.** Pins and wedges _____ be bent.

**1-30.** Grade is the same as _____.

**1-31.** Horizontal alignment is referred to as _____.

**1-17.** vertical

**1-18.** are

**1-32.** Forms are set to line by use of stakes called _____ and to grade by stakes called _____.

**1-33.** Forms _____ oiled before use.

**1-34.** A stringline is used to make the final check on elevation on a _____ base course.

**1-35.** The base course should be _____ before the concrete is placed.

***IF YOU MISSED ANY ANSWERS, REVIEW 1-1 THROUGH 1-35.**

# JOINTS-FORMING

Joints are an important part of concrete pavement. They reduce shrinkage stresses caused by seasonal changes in the volume of concrete. This means they allow the pavement to move, that is, to expand in summer and contract in winter. In addition, they serve as the method of ending each day's construction operation. Joints are planned breaks in the pavement and, as such, they prevent unplanned and uncontrolled cracking of the pavement surface. Although a major part of joint construction is accomplished during and after placement of the concrete, joints are often laid out prior to the paving operation. For this reason, joints will be discussed in this section of the course, before we look at the actual paving. We will cover the various types of joints and how to seal them.

## FILL IN THE BLANK(S):

**1-36.** Joints allow the pavement to _____ with seasonal changes.

There are two basic categories of joints: longitudinal, which run the length of the pavement parallel to the centerline and transverse, which run across the pavement at right angles to the centerline. Within the longitudinal category, there are two main types of joints: weakened plane and keyed or construction. Within the transverse category, there are three types: contraction, expansion, and construction. Each type joint is shown on Georgia Standard 5046H. Regardless of the category or type, all joints must be constructed according to the plans, Specifications, and Special Provisions; therefore, it is important that you as an inspector be familiar with the sources of information. It is from these sources that you learn the type, location, and dimensions of each joint.

# LONGITUDINAL JOINTS

Longitudinal joints are constructed to control longitudinal cracking. Whether or not longitudinal joints are used depends on the width of the pavement. Longitudinal weakened plane joints are required on roadway pavement and on ramps 16-feet or greater. Longitudinal construction joints are required when called for in the plans.

## ANSWER THE QUESTION:

**1-37.** What are the two types of longitudinal joints? _____ __
_____

## FILL IN THE BLANK(S):

**1-38.** Ramp widths of _____ feet or more require longitudinal joints.

**1-20.** dry out too fast

**1-21.** before

**1-22.** conventional

**1-23.** 10

**1-24.** pins

**1-25.** pin

**1-26.** three

**1-27.** 1/4

**1-28.** must not

**1-29.** must not

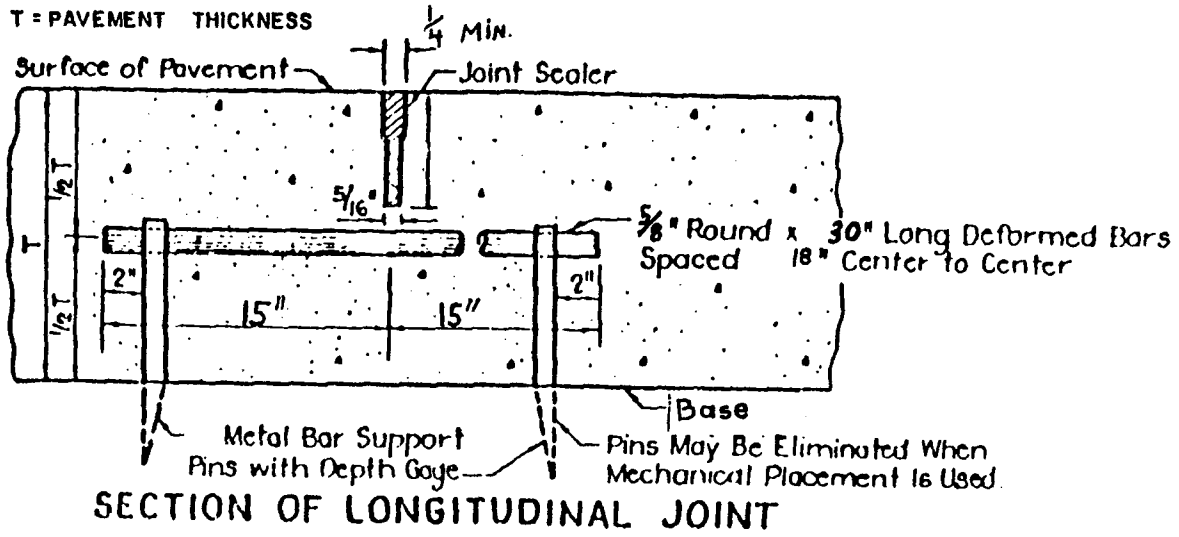
**1-30.** vertical elevation

1-31. **line**

Weakened plane longitudinal joints are generally formed using one of two methods. In the first method an approved device constructs a formed joint while the concrete is in a plastic state. When formed joints are constructed in this manner, methods and equipment must be utilized which will insure that joint reinforcement is properly located and not disrupted during construction. In the second method, joints are cut with a suitable mechanical saw. Joint sawing shall commence no later than 3 days after the concrete is placed, and before any traffic or equipment is allowed on the pavement. Both methods utilize unpainted and uncoated deformed steel bars of a specified size and length placed perpendicular to the joint. These bars may be placed by an approved mechanical device or rigidly secured in place by approved supports.

An example of a longitudinal joint with tie bars is shown below. The tie bar is deformed, that is, it has protrusions, so that the concrete will adhere to the bar. Tie bars shall not be enclosed in tubes or sleeves or painted or coated with asphalt or other materials that would act as bond breakers. These tie bars hold the slab together in the area where the longitudinal cracking is planned, thereby helping control the opening of the crack. The tie bar is 30 inches long.

**1-43.** shrinkage



SECTION OF LONGITUDINAL JOINT

# CIRCLE THE CORRECT WORD(S):

**1-39.** The main purpose of the tie bar for a longitudinal joint is to (tie slab together / transfer load).

**1-40.** The steel bar used in this joint is (smooth / deformed).

**1-41.** The tie bar used in a longitudinal joint is (5/8 / 7/16) inches in diameter.

**1-42.** The tie bar is (30 / 20) inches long.

The deformed tie bars shall be placed perpendicular to the longitudinal joints. Placement can be accomplished by tree different means. The illustration below shows bar placement by use of a mechanical wheel. In this procedure, a wheel device is attached to the rear of the paving machine, as it moves forward the wheel drops the tie bars at 18 inch intervals, then travels over the bar forcing it into the concrete.

**1-37.** weakened plane/construction

**1-38.** 16

The bars may also be placed by hand using a form bar. This is usually a "home-made" device such as a piece of reinforcing with a hook welded to it at the correct depth. The bars are laid out on the concrete at 18 inch intervals. One of the workers will take the form bar, place it over the tiew bar and use his weight to force it into the concrete. It is much the same as using the foot to force a shovel into soil.

The most common method is the use of tie bar baskets or cages. This is usually a frame, constructed of reinforcing steel, which is affixed to the base course. These must be placed in advance of the concrete operation. The frame holds the tie bars at the correct depth and location as concrete is poured over it. At first glance this appears to be the simplest method; however, if the frames are not properly affixed to the base, dislocations will frequently occur.

# TRANSVERSE JOINTS

There are three types of transverse joints. These are contraction joints, expansion joints, and construction joints. Transverse joints may be either at right angles to the centerline or may be skewed as specified on the plans.

Contraction or dummy joints are planes of weakness that are placed in the concrete pavement to relieve the stress that takes place when the concrete shrinks due to a change in weather. These joints allow controlled movement of the pavement slabs and prevent unplanned cracks. Contraction joints in all but continuously reinforced concrete pavement shall be placed at 20-feet intervals to control cracking, or placed as shown on the plans. All contraction joints shall have load transfer devices such as dowel bars.

# CIRCLE THE CORRECT WORD(S):

**1-43.** Contraction joints help control stresses caused by (shrinkage / expansion) of concrete.

Transverse contraction joints shall be sawed before uncontrolled cracking occurs. Sawing shall commence as soon as the concrete has sufficiently hardened to permit sawing without surface raveling and usually starting after about 4 hours and not later than 24 hours after placement. The sawing operation shall continue both day and night regardless of weather conditions.

## CIRCLE THE CORRECT WORD(S):

**1-44.** Sawing shall commence as soon as the concrete has sufficiently hardened so that (raveling / rutting) does not occur.

**1-45.** Sawing shall continue both day and night regardless of (temperature / weather).

Load transfer devices are dowel assemblies. These are built as an integral part of transverse joints. They are installed across a joint in such a way as to permit the joint to open and close, yet hold the slab ends on each side of the joint as nearly as possible to the same elevation. The deflection (movement out of it's original position) of one slab under load is resisted (through the dowel) by the other slab. The other slab, in turn, is caused to deflect and thus carry a portion of the load imposed upon it by the first slab.

## FILL IN THE BLANK(S):

**1-46.** Load transfer devises we use in transverse joints are _____.

**1-39.** tie slab together

**1-40.** deformed

**1-41.** 5/8

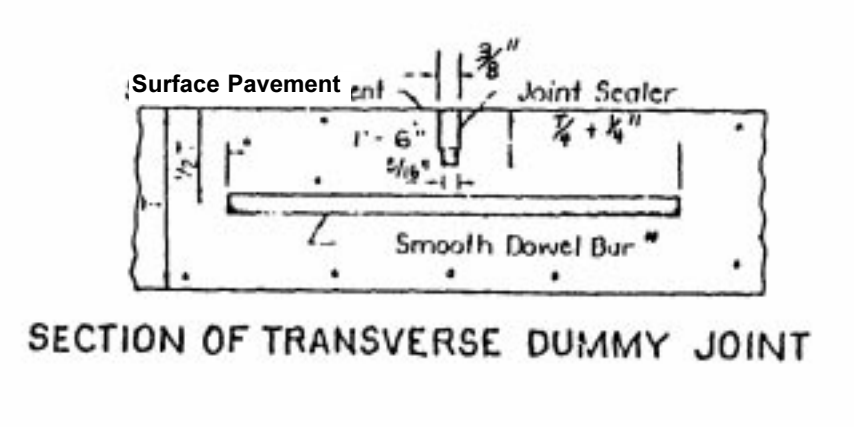
**1-42.** 30

**1-52.** five (5)

**1-53.** the same

Dowel bars are generally placed in dowel baskets. These baskets are positioned and anchored into place at the joint location prior to the paving operation. However, when approved, a mechanical device may place dowels after the concrete has been placed. If a mechanical placing device is used, care must be taken to see that the dowels are properly positioned at the correct depth and that they are correctly aligned parallel to the centerline. Regardless of the method of placing dowels, samples must be submitted to the Materials Laboratory before use. Samples are to be taken according to the Sampling Manual or latest directive.

A typical transverse dummy joint using dowels as the load transfer device is shown below. Notice that a dowel basket is not shown in the plans. However, dowels are usually supported by baskets unless they are placed by machine after the concrete has been poured.



SECTION OF TRANSVERSE DUMMY JOINT

Transverse dummy joints are to be placed according to the project plans on all thickness of pavement. When using dowel bars, be sure that all burrs or ragged places caused during manufacturing of the dowels are ground smooth. Dowels must be smooth so that concrete will not bond to them.

The smooth dowel bar shall be 1 1/8 inch in diameter when the pavement thickness is to be 6, 7, 8, or 9 inches. When the pavement thickness is 11 or 12 inches, 1 1/4 inches dowel bar in diameter shall be used.

# FILL IN THE BLANK(S):

**1-47.** When dowel baskets are used, they are placed _____ the concrete is poured.

**1-48.** Contraction joints are placed according to _____ .

**1-49.** Dowels are to be _____.

Dowel bars to be used in baskets must be plastic coated or epoxy coated. In addition the epoxy-coated dowels must be thoroughly coated with a thin film of waterproof grease. The grease keeps the concrete from bonding to the dowels. Motor oil is not an acceptable coating.

# CIRCLE THE CORRECT WORD(S):

**1-50.** Plastic coated dowel bars (are /are not) permissible.

**1-51.** Motor oil (is / is not) acceptable in lieu of grease.

Dowel bars are placed at transverse joints as required by plans. The picture below illustrates the dowel basket assembly in place. Notice that the basket covers the full width of the pavement. The dowel baskets must be fabricated completely in units equal in length to either one-half or the full width of the pavement.

**1-44.** raveling

**1-45.** weather

**1-46.** dowels

**1-54.** steel tape, framing square at stringline

The spacing of dowels at a contraction joint is 12 inches. (The spacing of dowels is the same for transverse expansion and construction joints.)

The dowel bars must be placed at a depth of one-half the thickness of the pavement. For example, if you have a 9-inch pavement to place, the center of the dowels should be 4 ½ inches from the base.

The distance between the base and the center of the dowel bars should be checked. This check should be conducted randomly and on both ends of the dowel bars.

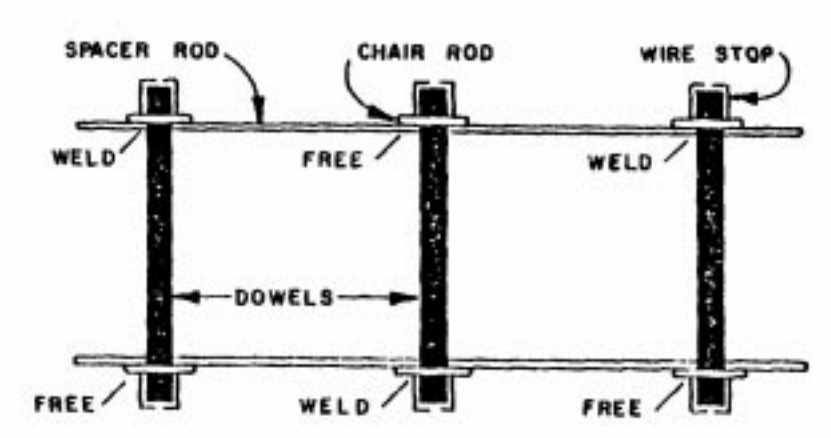
# FILL IN THE BLANK(S):

**1-52.** Dowel bars on 10-inch pavement must be placed _____ inches above the base.

**1-53.** The spacing of dowels at all transverse joints is (the same/ different) _____.

The spacing between the forms and the center of the first dowel must be six (6)inches. The length, spacing, and diameter of the dowel bars must be spot checked with a ruler or tape. If slip form paving is used, the measurement would be taken from the stringline used to control the paver since there are no forms.

The drawing below shows a typical dowel basket.




Alternating ends of the dowels are not welded but left “free” so that there can be some movement in the joint. The welded ends must be checked to see they are secure. Check the dowels by trying to move the welded end with your hand.

The dowel basket must be set at exact joint location shown on the plans. Knowing the joint spacing, each location is determined by measuring along the side of the roadway with a steel measuring tape. As the exact location on one side of the roadway is found, it is marked on the form. The exact corresponding location on the other side of the roadway is then determined by placing a framing square against the inside face of the form and stretching a stringline along the square to the other side of the roadway.

**1-47.** before

**1-48.** the project plans

**1-49.** smooth

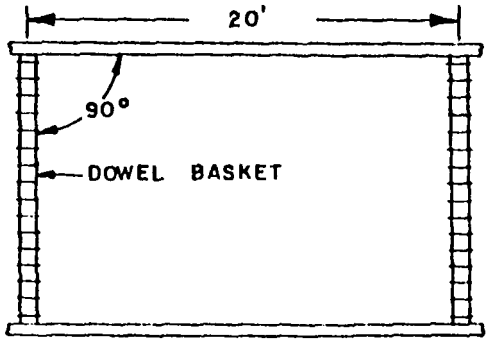
**1-50.** are

**1-51.** is not

# FILL IN THE BLANK(S):

**1-54.** You use a _____, _____, and _____ to make sure joint locations are at exactly the same place on both sides of the roadway.

After the exact joint location is determined, the dowel basket can be set in place. The distance between the center of one dowel basket and the center of the next basket must conform to the spacing between the transverse joints as shown on the plans. The center of each dowel basket is to be at the center of each transverse dummy joint. Once set in place, the basket must be perpendicular to the centerline and planned pavement edge.




The dowel baskets must be rigid enough to maintain alignment during the concreting operations. In addition, they must be firmly supported and securely staked to the base course to prevent movement.

No stones or other objects should be allowed as supports for the dowel baskets. If this is allowed, the dowels will be tipped out of alignment when the concrete is placed on them. Tipped or crooked dowels will cause restraint, preventing the joint from opening and closing during volume changes in the concrete. This will result in chipping or cracking of the concrete slab near the joint.

## CIRCLE THE CORRECT WORD(S):

**1-55.** Dowel baskets (should / should not) be supported with stones.

To function properly, the dowels must be aligned parallel to the surface and to the centerline of the pavement. This vertical and horizontal alignment must be checked. In form paving, the forms can be used as a reference to check the alignment and grade of the dowels. Using either a stringline, level, or a carpenter's level can do this checking.

## CIRCLE THE CORRECT WORD(S):

**1-56.** Dowels (should / should not) be parallel to each other.

**1-57.** Dowel bars must be set (parallel / perpendicular) to the centerline and surface of the pavement.

## FILL IN THE BLANK(S)

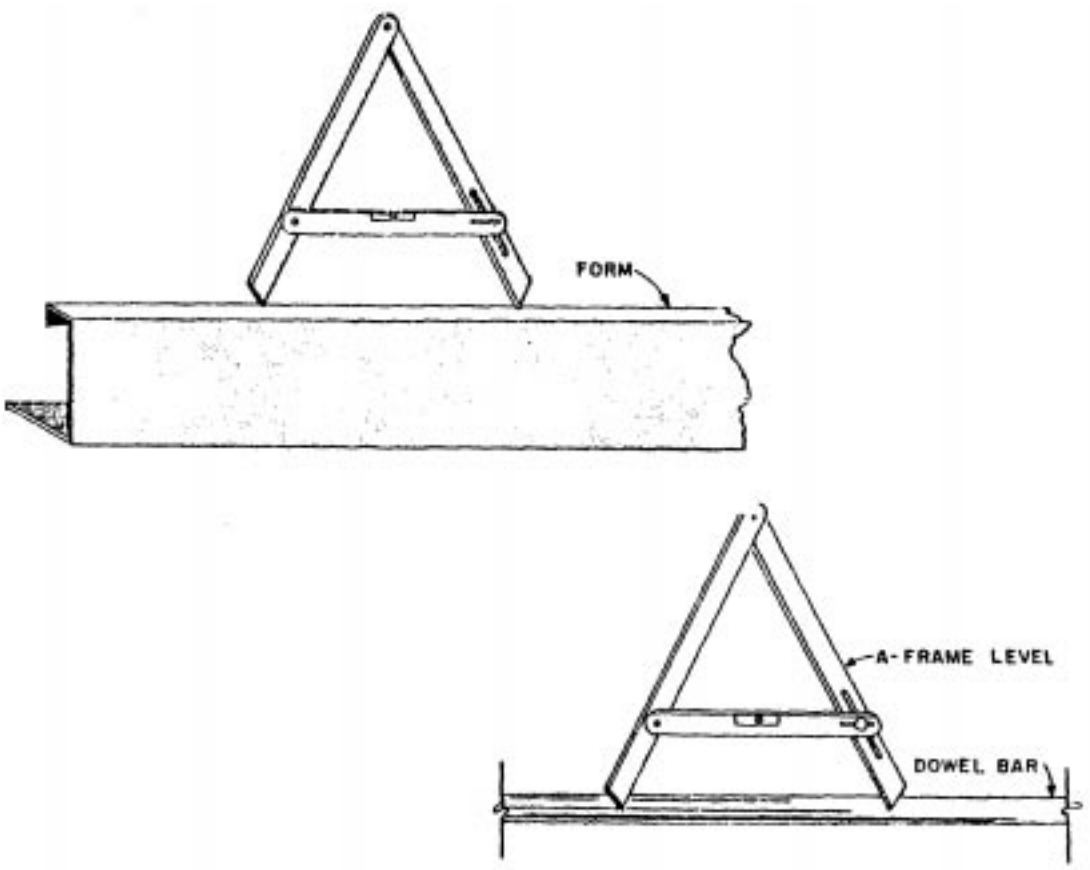
**1-58.** Alignment and grade can be checked by using a _____, _____, or _____ _____.

**1-61.** 3/8; 1/2

**1-62.** beveled

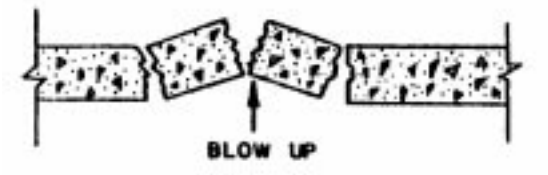
**1-63.** 1"

**1-64.** One




Care must be taken to see that the center of each dowel assembly is marked in order that the new cuts may be made at the center of the assemblies. The locations of the dowel assemblies may be marked by stakes placed in the lane on each side of the pavement. A chalk line may then be used to mark the center of the dowel assemblies prior to sawing. After the joint is cut, the filler must be inserted carefully to insure correct depth.

Transverse expansion joints allow pavement to move slightly when the concrete slabs become longer. This increase in volume is due to high temperature, increased moisture content, infiltration, or incompressible materials becoming lodged into the joints. If the pavement could not move, the expansion would cause cracking and chipping of the concrete slab, or possibly the raising up (blow up) of the pavement at a joint or crack.




These expansion joints are located at points of great stress or movement, such as at an intersection, or where pavement abuts fixed objects such as bridges and railroad crossings.

Like transverse contraction joints, expansion joints must be provided with load transfer devices of either the dowel basket or as required by the plans. Expansion joints must also be sealed after the pavement has cured; however, they <u>are not</u> sawed.

## CIRCLE THE CORRECT WORD(S):

**1-59.** Transverse expansion joints (do / do not) require load transfer devices.

**1-60** Transverse expansion joints (are / are not) sawed.

**1-55.** should not

**1-56.** should

**1-57.** parallel

**1-58.** stringline; level; carpenter level.

Dowels are used as load transfer devices for expansion joints much like they are for contraction joints. Like the dowels for contraction joints, they are smooth and lubricated or plastic coated. Unlike the dowels for contraction joints, they must be equipped with a sleeve. Each tube must fit the dowel bar tightly and the closed end must be watertight. When properly fitted, the tube provides an air space that permits the joint to open or close. Silicone compound is recessed 3/8" to 1/2"inch from the surface.

On transverse joints with 6 inch to 9 inch thick pavement, use 1 1/8 " bars; on 10 inch, 11 inch, 12 inch pavement, use 1 ¼ inch bars.

## FILL IN THE BLANK(S):

**1-61.** The silicone compound is recessed _____ to _____ inches from the surface.

**1-62.** The expansion joint is _____ at the top.

**1-69.** ¾ inch

**1-70.** three (3)

The dowel bars for expansion joints, must be secured in place by approved supporting assemblies, usually dowel baskets of the same type used for contraction joints. Like contraction joints the supporting assemblies must be capable of holding the dowels in place through construction.

Dowel bars shall be placed to a vertical and horizontal tolerance of plus or minus one inch of the plan position. Dowel bar misalignment shall not exceed 3/8 inch per foot in the horizontal plane nor shall misalignment exceed 3/8 inch per foot in the vertical or oblique plane.

The primary difference in an expansion joint and a contraction joint is the addition of the preformed joint filler and the expansions tube on the dowel bar.

## CIRCLE THE CORRECT WORD(S):

**1-63.** Dowel bars in expansion joints must be placed to a horizontal tolerance of (2 inch / 1 inch) of plan position.

**1-64.** (One / Each) end of each dowel bar in an expansion joint has an expansion tube.

The spacing of the dowels across the roadway is the same for expansion, contraction, and construction joints. As this may vary from project to project, it is imperative the inspector check the plans for proper spacing. The dowels are to be centered at on-half the pavement thickness.

The vertical and horizontal alignment must also be checked by stringline or an A-frame level as previously described.

# FILL IN THE BLANK(S):

**1-65.** The spacing for dowels in contraction and expansion joints _____ the same.

**1-66.** The dowels are spaced at _____ inch centers.

**1-67.** The dowels are placed at _____ the thickness of the slab.

**1-68.** The outside dowels are placed a minimum of _____ inches from the pavement edge.

**1-59.** do

**1-60.** are not

Expansion joints are not sawed. This means that the joint must be formed while the concrete is still plastic. One way of forming the joint is to tack a ¾-inch wide piece of filler material to the top of the redwood strip. Then, after the concrete has been finished, the strip is pulled out and the edges are hand finished. The edges of an expansion joint are beveled to a ¼-inch radius by hand so that there will not be any right angles.

**1-71.** before

A ¾-inch expansion joint will be required at the transition from the roadway pavement to the approach slab of a bridge. In addition to the required expansion joint, the next three contraction joints shall have dowels even if dowels are not required on all contraction joints by the plans.

## CIRCLE THE CORRECT WORD(S):

**1-69.** A (1/2”/3/4”) expansion joint is required at the approach slab of a bridge.

**1-70.** The next (2 / 3) contractions joints from the approach slab will be doweled.

Transverse construction joints must be constructed when there is an interruption of more than one hour in the concreting operation. Construction joints for interruptions caused by emergencies such as rain or equipment failure are referred to as emergency construction joints. A transverse construction joint is also used at the end of each day's operation to head up the concrete; this joint is referred to as a planned construction joint.

Regardless of whether a construction joint is planned or emergency, it shall not be constructed within 10-feet of an expansion joint, contraction joint, or plane of weakness. If there is not enough concrete already mixed at the time the interruption occurs to form a slab 10-feet long, the excess concrete shall be removed back to the last preceding joint and disposed of as directed.

Dowel bars of the dimensions and type specified for transverse contraction joints are to be used as the load transfer device in transverse construction joints.

**1-65.** is

If the construction joint is not to be the starting point for other construction within a week, it is common practice to remove the dowels from the concrete after it has hardened. This procedure insures that the dowels will not be damaged. The dowels are reinserted before the new slab is cast.

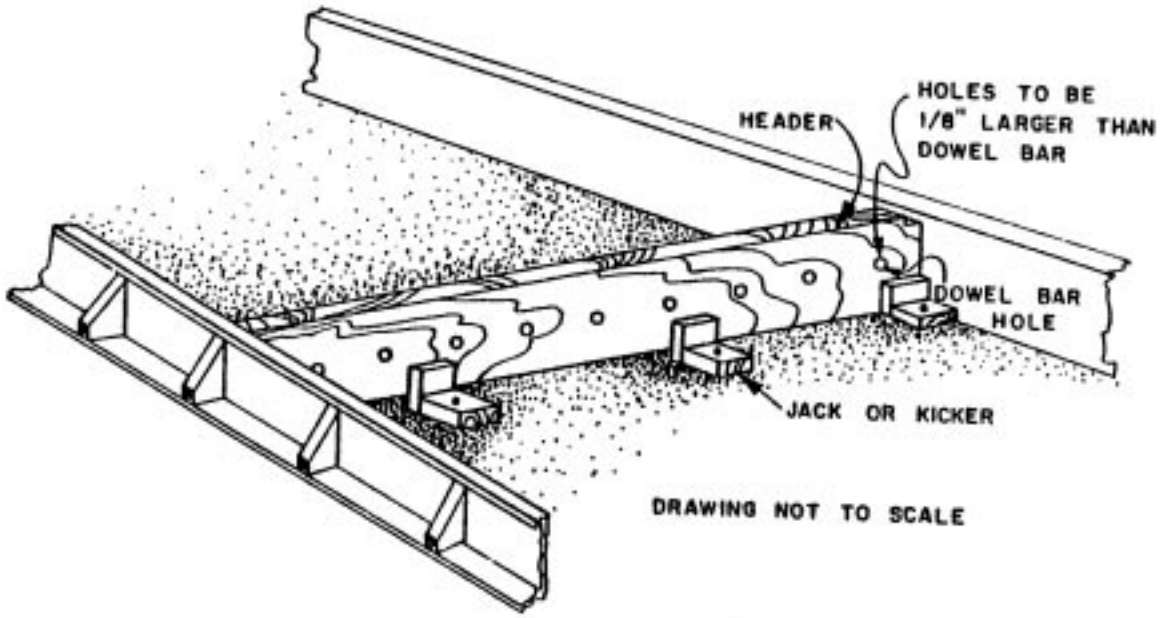
**1-66.** 12

All right, let's take a look at how to form a transverse construction joint. If the joint is a planned one such as for the end of a day's operation, it is usually located at a transverse contraction joint. Do not make a contraction joint end on an expansion joint as this exposes this type of joint to severe damage.

**1-67.** half

Prior to the paving operation reaching the joints location, a header board will be secured in place on the base. A header board is merely a wooden form that extends from form to form and has holes spaced for the dowel bars according to plan dimensions. It is held in place by braces that are called jacks or kickers.

**1-68.** six (6)




**1-74.** smooth

# CIRCLE THE CORRECT WORD(S):

**1-71.** The header for a planned construction joint is set up (before / after) the concrete has been placed.

Headers shall conform to the full cross section of the pavement. The wood or form that is used is one or two inches thick and of a depth equal to about ¼-inch less than the full depth of the pavement. Holes are bored in the header at the spacing shown on the plans for dowel contraction joints, and the header is secured in place by wooden braces for the for the full width of the pavement. Headers should be readily available in case of mechanical breakdowns or stoppage due to weather.

You must make sure the header is set perpendicular to the forms. Set one end of the header where the joint is to be made. Then with a framing square and stringline, set the other end of the header. The front face of the header should be located at the edge of the joint.

Next, make sure the header is set at the proper height. To do this, place a ¾-inch block on the form on each side of the roadway and pull a stringline across the blocks. Then set the top of the header ¾-of an inch below the stringline. Then tack the header to the jacks or kickers that have been placed on and anchored to the base course. The jacks or kickers are anchored to the base by 60-penny nails on stabilized bases and form pins on unstabilized bases. Leave outside corners of header about 1½ inches to permit the passage of equipment wheel flanges over the header.

# FILL IN THE BLANK(S):

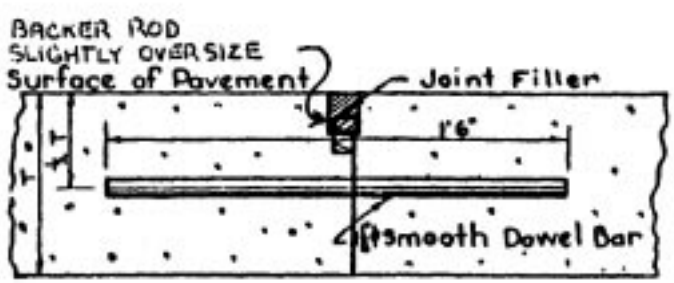
**1-72.** The header must be set _____ to the forms.

**1-73.** Use a framing square and _____ to set the headers.

Immediately after the concrete has been placed and vibrated and the machine has moved away dowel bars are inserted into the fresh concrete through the holes in the header. When inserted properly, one-half of each dowel must be inside the concrete when measured from the front face of the header (the side of the header in contact with the concrete). The dowels used in construction joints must be thoroughly lubricated as required by the Specifications or else they must be plastic coated.

After the concrete has set for 30 minutes, the dowel bars should be turned out to prevent bonding. When ready to resume paving, the bars are pulled out, the header is removed, and the bars are greased and reinserted. The fresh concrete is then cast against the hardened concrete. Like contraction joints, this joint will be sawed and sealed after the concrete has cured.

A complete construction joint, showing the dowel assembly, is shown below.




**1-76.** is

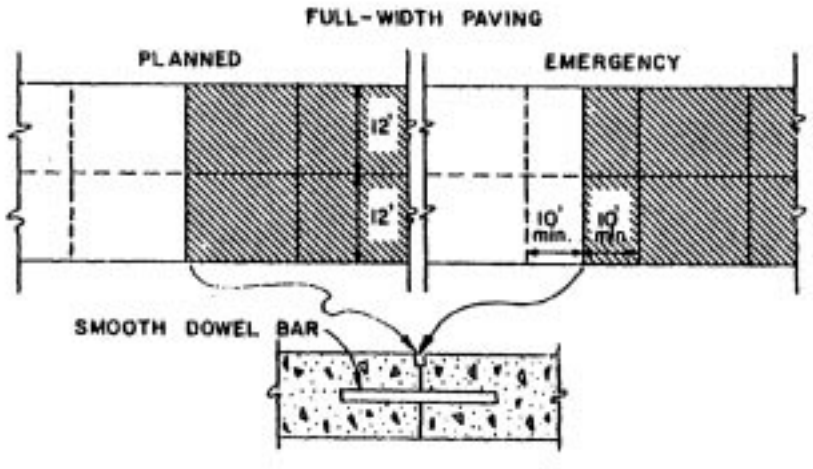
# CIRCLE THE CORRECT WORD(S):

**1-74.** The dowel bars used in planned construction joints are (smooth / deformed).

Construction joints, like other joints, must be set at the correct line and grade. It is up to the paving inspector to check horizontal and vertical alignment.

The same precautions taken on construction and expansion joints must be taken on contraction joints. The dowels must be parallel to the centerline and the pavement surface.
Emergency joints must be constructed 10-feet from any other transverse joint. If there is not enough concrete for a 10-foot slab, the concrete shall be removed back to the last preceding joint.

# ANSWER THE QUESTION:




**1-72.** perpendicular

**1-73.** stringline

**1-75.** If there is enough concrete for an 8-foot section, is it used or discarded?

Where pavement is constructed one lane-at-a-time or where there are more than two abutting lanes, just as with full-width paving,planned joints are installed at normal joint locations and consist of butt-type joints. Dowels are used for load transfer in construction joints.

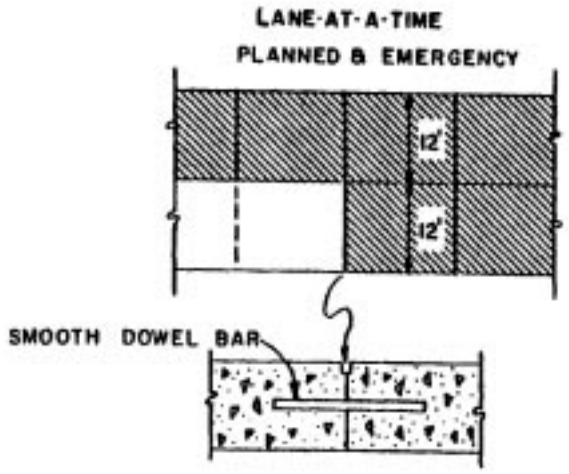
When an emergency joint must be placed in one lane-at-a-time paving, it must coincide with a joint on the previously placed lane, even if it is possible to place a 10-foot section. This will prevent undue stress on the existing pavement.

A construction joint, either planned or emergency, should not be placed at the location of an expansion joint.

**1-89.** are

**1-90.** contraction

**1-91.** ten (10)




## CIRCLE THE CORRECT WORD(S):

**1-76.** It (is / is not) necessary for emergency construction joints to match up with a joint in a previously placed lane.

Let's review.

## CIRCLE THE CORRECT WORD(S):

**1-77.** A header is used in transverse (contraction / construction) joint.

**1-78.** How may dowel bars are required for pavement 14 feet wide? (13/14)

**1-79.** A longitudinal joint (is / is not) required on ramps which are 16-feet wide.

**1-80.** A deformed tie bar that is 5/8 inch in diameter is used on a (longitudinal / transverse) joint.

**1-81.** The dowel bar used in transverse construction and a contraction joint is (smooth / deformed).

**1-82.** Contraction joints help control stresses caused by (shrinkage / expansion) of concrete.

## FILL IN THE BLANK(S):

**1-83.** The spacing between transverse contraction joints is per _____ _____ _____.

## CIRCLE THE CORRECT WORD(S):

**1-84.** The dowel bars (should / should not) be greased.

**1-85.** The dowel bar is placed at (1/2 / 3/4) slab thickness.

**1-86.** Dowel bars are (sometimes / always) placed in baskets.

**1-87** Dowel (baskets / bars) must be placed perpendicular to the forms.

**1-88.** Dowel bars must be placed (parallel / perpendicular) with the pavement surface.

**1-75.** discarded

**1-89.** Plastic coated dowel bars (are / are not) allowed.

**1-90.** A dummy joint is the same as a (contraction / expansion) joint.

**1-91.** Transverse construction joints in full width paving must be at least (5/10) feet from other transverse joints.

# SAWING JOINTS

All transverse joints shall be sawed in accordance with the specifications and plan details. Sawing shall commence without surface raveling and usually starting after about 4 hours and not later than 24 hours after placement. The sawing operation shall continue both day and night regardless of weather conditions.

**1-93.** is not

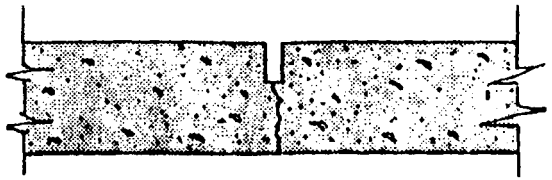
**1-94.** shallow

**1-95.** frequently

**1-96.** standards

Any time after the initial cut has been made and after the concrete has hardened sufficiently to prevent spalling or raveling, the secondary cut shall be made to the width and depth shown on plans. Making a completed cut in a single operation by use of a gang saw will not be permitted. Should any spalling of the edges occur which would detrimentally affect the joint seal, it shall be patched with an approved epoxy patching compound and allowed to harden prior to installation of the joint material. Each patch shall be true to the intended neat lines of the finished cut.

The purpose of the joint is to make the cracking occur at a specified controlled location. You want the cracking to occur directly below the joint groove. Therefore, you must see that the groove is sawed at exactly the right spot. Cracks away from the joint insert should not be followed. Such cracks may sometimes require removal of concrete and extensive patching, (i.e. removing concrete to the full depth of the slab). This patching is done using epoxy resins and concrete with no feathering at the edges.



**I-92.** The crack above is at the (right/wrong) place.

**1-77.** construction

**1-78.** 14

**1-79.** is

**1-80.** longitudinal

**1-81.** smooth

**1-82.** shrinkage

**1-83.** per project plans

**1-84.** should

**1-85.** 1/2

**1-86.** sometimes

**1-87.** baskets

**1-88.** parallel

## CIRCLE THE CORRECT WORD(S):

**1-93.** Spalling at the edges of joint grooves (is/is not permitted).

Measure the depth of the saw cuts frequently. Sometimes operators continue to use blades that have worn too much to cut the specified depth. The blade also tends to ride up when hard aggregate is encountered and towards the end of a cut. Check Standard 5046H for required depths of initial saw cuts.

## CIRCLE THE CORRECT WORD(S):

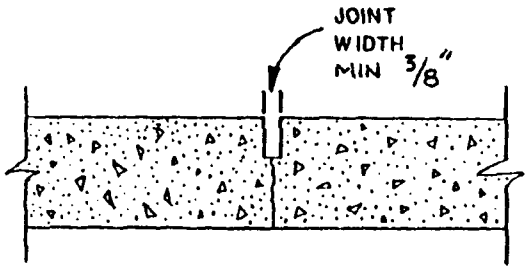
**1-94.** Worn blades, hard aggregate and lifting the saw towards the end of a cut tend to make saw cuts too (deep / shallow).

**1-98.** 40 degrees F.

**1-95.** Saw cuts should be measured (frequently / occasionally).

**1-96.** Information concerning initial saw cuts can be found in the (Standards/Details)

It is also important, especially in transverse contraction joints, that the joint be cut to exactly the proper width as shown on the plans. The contraction joints are designed to provide the correct shape and dimensions for good joint seal. Make sure that the width of the cut for contraction joints does not exceed plan width because a wide joint will affect the performance of preformed compression seal. If a joint exceeds the width tolerance, filling the affected area with an approved epoxy resin system and then resawing to plan width should repair it.




**I-92.** right

## CHOOSE THE CORRECT WORD(S):

**1-97.** A wide joint (does / does not) affect the performance of a preformed compression seal.

After sawing, all spalls, fractures, breaks, or voids in the concrete at the joints are to be patched. A spall is a broken wedge or piece of concrete that begins in the joint, making that portion of the joint too wide and uneven to be sealed. According to Specifications, these areas shall be chipped back to sound concrete and repaired with an approved epoxy resin system in accordance with the manufacturer's recommendations.

Joints must be sealed before the pavement is opened to traffic and as soon after the completion of the sawing period as feasible. Therefore, preformed compression seals and hot poured sealants are usually installed immediately after the sawing operation. However, if an elastomeric polymer (cold poured sealant) is to be used, the temperature must be 40 degrees F. When elastomeric polymers are used, the location, size, and configuration of the joints to be sealed shall be detailed on the plans.

# CIRCLE THE CORRECT WORD(S):

**1-98.** Elastomeric polymer is used when the temperature is (30 degree F. / 40 degree F.)

**1-102.** plans

**1-103.** straight/vertical

**1-104.** epoxy resins

**1-105.** should

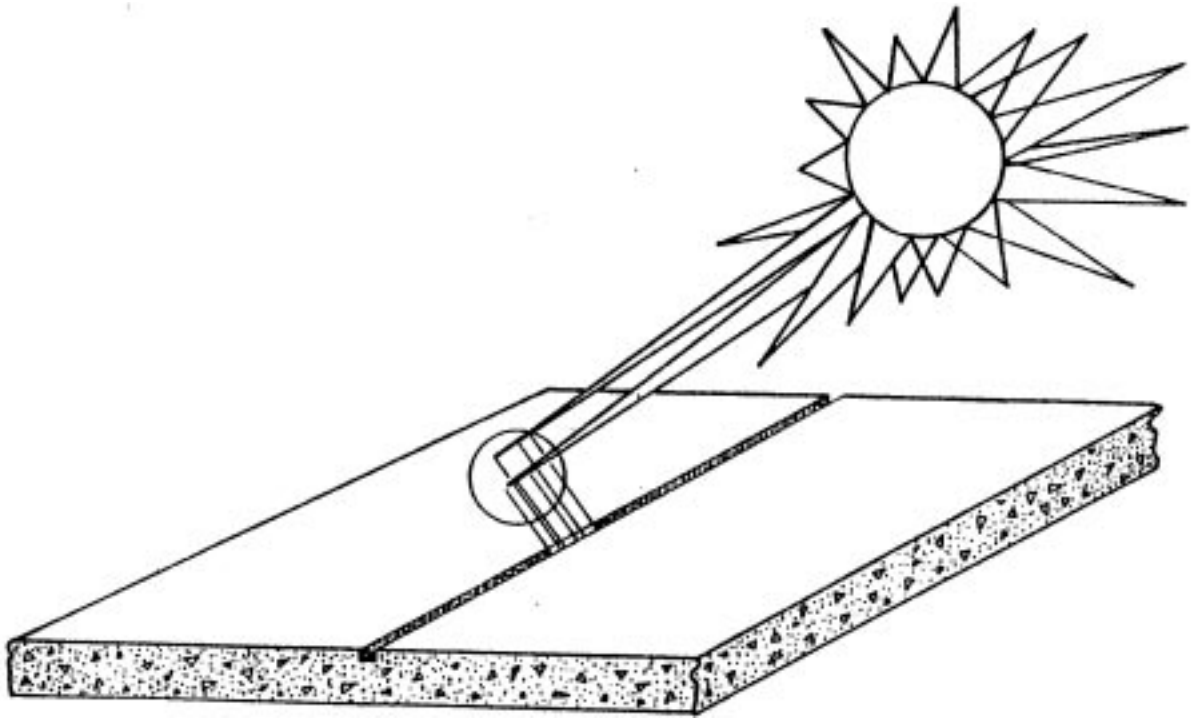
**1-106.** 40 degrees F.

**1-107.** water; compressed air

Prior to installing a sealant or a primer or lubricant-adhesive, the joints shall be thoroughly cleaned using one of the three approved methods outlined in the specifications. Usual methods include flushing with a jet of water. Just before the joint sealer is placed, compressed air having a pressure of at least 90-psi, shall be used to blow out the joint and remove all traces of dust.

Care must be taken to see that all dust, curing compounds, and sawed-out filler is removed from the sides of the joint. This will insure that the sealers will bond to the concrete.

Using a pocket mirror is an easy way of checking to see that the joint is clean. Use the mirror to direct light from the sun down to the bottom of the grove.



**1-97.** does

## CIRCLE THE CORRECT WORD(S):

**1-99.** It (is / is not) important to remove all foreign materials from the joint faces.

## FILL IN THE BLANK(S):

**1-100.** Sawing usually begins about _____ hours after concrete placement.

## CIRCLE THE CORRECT WORD(S):

**1-101.** Circular saws with abrasive blades are used for (sawing / cleaning).

**1-102.** Joints must be sawed to the width and depth shown by the (plans / allotment request).

**1-103.** The joint groove should be (straight / zigzagged) and (v-shaped / vertical).

**1-104.** Patching on the concrete around the joint is done with (asphalt / epoxy resins).

**1-105** Joints (should / should not) be sealed as soon after sawing as feasible.

**1-106** When using cold poured elastomeric sealants, the sealant is not to be installed if the temperature is less than (30 degree F/ 40 degree F.)

## FILL IN THE BLANK(S):

**1-107.** Joints are usually cleaned using _____ and _____ _____.

**1-109.** has

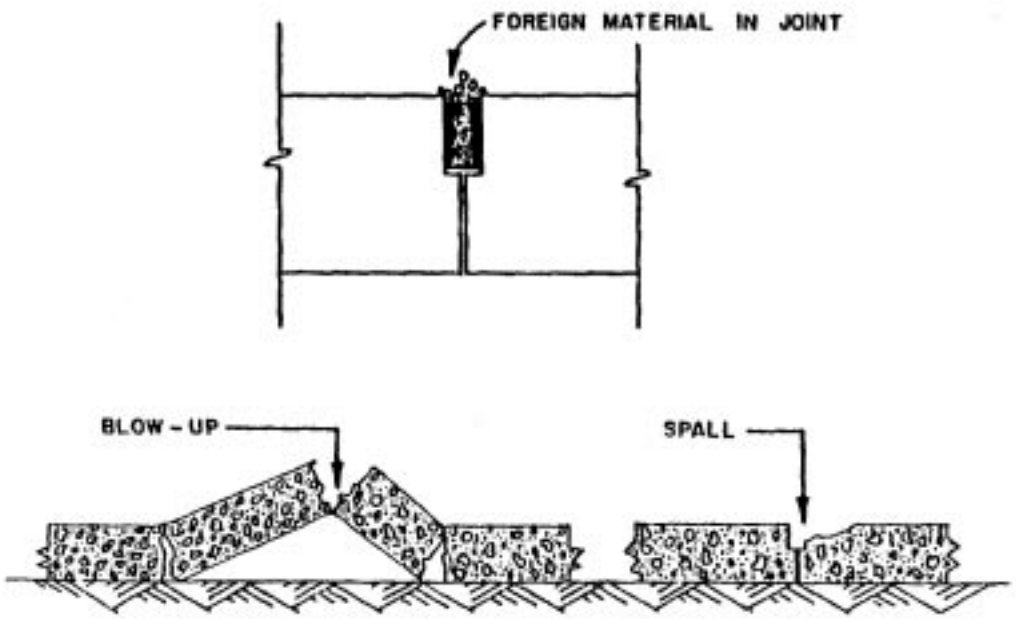
**1-110.** must

**1-111.** all

# JOINT SEALING

Joints are sealed to keep sand and other incompressible materials from getting in the planned grooves or cracks. The joint sealer also keeps surface moisture from reaching the materials underneath the pavement.

Almost all pavement that has contracted during cold weather will later tend to expand when the weather warms up. If foreign material is allowed to accumulate in the joints, while they are open, the pavement could have a lot of spalling or blow-up when the pavement expands.




**1-99.** is

**1-100.** four (4)

**1-101.** sawing

# FILL IN THE BLANK(S):

**1-108** You can prevent the above things from happening by _____ the joint with a material that will expand or contract with the joint.

During the curing period specified by the manufacturer, traffic should be kept off the filled joints. Construction traffic should use the shoulders.

**1-113.** 3/8 to 1/2

**1-114.** 3/8 to 1/2

**1-115.** must

**1-116.** must not

**1-117.** is

**1-118.** resilient

**1-119.** should not

The sealed joints should be closely inspected several days after sealing in order to find and replace any seal that has failed. Each seal should be checked to see that it:t has failed. Each seal should be checked to see that it:

a) Has been placed at the proper depth – check current specifications or manufacturer's recommendation.

b) Has adhered to the faces of the joint - the seal must stick to the joint faces to prevent incompressibles from getting between the seal and the faces.

c) Is cohesive, the seal must not be punctured, torn, or split. It must hold together and not pull apart.

d) Is aligned properly, both top edges of the seal must be equally distant from the edges of the joint.

e) Has properly set up the seal must be resilient (neither too soft nor too hard) so it will expand and contract when the pavement moves.

f) Does not have air bubbles.

If a seal needs replacement, the entire seal must be removed and the joint faces sandblasted clean and the seal repoured. Once the joint is resealed, it must again be checked as described above.

## CIRCLE THE CORRECT WORD(S):

**1-109.** Each hot poured sealant must be checked to see that it (has / has not) adhere to the joint faces.

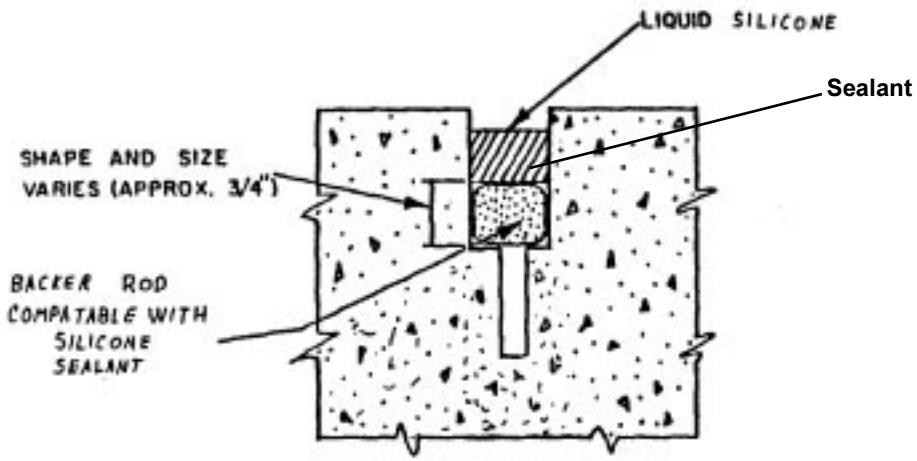
**1-110.** After setting up, the seal (must / must not) be resilient.

**1-111.** If a faulty seal needs replacement (part / all) of the seal must be removed.

As the sealant is being applied, check to see that no air bubbles are present in the sealant and that it has sufficient ability to flow and level out, but not to overflow the joints. The silicone sealant is not self-leveling and must be tooled to provide the required recess. The top of the poured sealant should be placed per the current specifications or manufacturer's recommendation.

During the curing period specified by the manufacturer, traffic should be kept off the filled joints. Construction traffic should use the shoulders.

An example of a joint with silicone sealant is shown below.




**1-108.** sealing

# CIRCLE THE CORRECT WORD(S):

**1-112.** Silicone sealant is not self-leveling and must be (tooled / mixed) to provide the proper recess.

## FILL IN THE BLANK(S):

**1-113.** The top of the sealant is to be _____ inch below the surface of the pavement.

The sealed joint should be closely inspected several days after sealing in order to find and have replaced any seal that has failed. The requirements for each seal are the same as the six described previously.

If a seal needs replacement, the entire seal and any back-up material must be removed and the joint faces cleaned, the back-up material reinserted, the primer reapplied and the seal repoured. If a joint is resealed, the seal must again be checked to see if it meets requirements.

**1-125.** truck mixers; central mix plants; dry paver mixers

## FILL IN THE BLANK(S):

**1-114.** The top of the seal must be _____ below the surface of the joint.

## CIRCLE THE CORRECT WORD(S):

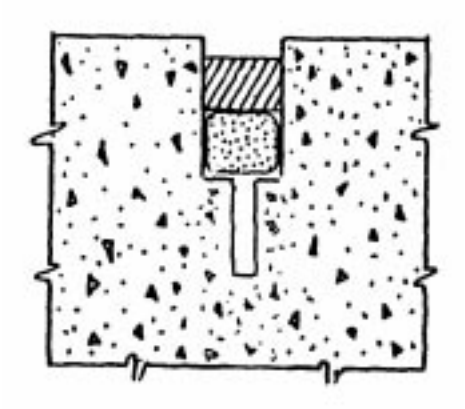
**1-115** The seal (must / must not) adhere to the faces of the joint.

**1-116.** A seal (must / must not) be punctured, torn, or split.

**1-117.** It (is / is not) important that the top edges of the seal be equally distant from the edges of the joint.

**1-118.** If a seal has properly set up, it is (resilient / non-resilient).

**1-119.** The seal (should / should not) have air bubbles.



**1-112.** tooled

## USING THE ABOVE DRAWING, CIRCLE THE CORRECT WORD(S):

**1-120.** The sealant above is (preformed elastomeric compression / silicone).

**1-121.** (Back-up material / air space) is shown directly below the sealant.

**1-122.** The above sealant should be (higher/lower) than the surface of pavement?

**1-123.** The sealant (is / is not) flush with the surface.

**1-124.** Silicone sealant (is / is not) self-leveling.

# MIXING CONCRETE

Paving concrete may be mixed in truck mixers, central mix plants, or dry paver mixers. Presently, most of our concrete is mixed by one of the first two methods; dry paver mixers are rarely used anymore.

## FILL IN THE BLANK(S)

**1-125.** The three methods for mixing concrete are _____, _____, and _____.

**1-128.** cold weather

Because of the use of End Result Specifications, the inspector on the roadway is now primarily concerned with observing the placement of the concrete itself to see that the construction methods used conform to Specifications. In addition, he collects the certified plant tickets.

As an inspector, you must check the elapsed time between the addition of cement to the mix and placement. This may not exceed 60 minutes unless retarder is being used. If retarder is used, up to 90 minutes is allowed.

## CIRCLE THE CORRECT WORD(S):

**1-126.** The time limit between addition of cement to the mix and placement is (90 / 60) minutes without retarder being added.

As an inspector, you must perform at least three verification tests per day for slump and air content, as well as testing for conformance to surface tolerance requirements and checking surface texture. The procedures you will use are explained in the chapter entitled "Testing".

It is important to remember that performing the minimum number of tests required does not complete your job. You must make additional slump tests on any batches that appear deficient, and if additional slump and air tests are deemed necessary to insure uniformity during a day's pour, then these tests should be performed.

## FILL IN THE BLANK(S):

**1-127.** A minimum of _____ verification tests per day should be made for slump and air content.

The Department's inspector has the authority to reject any obviously defective mix before placement, and to require the contractor to remove and replace any concrete of questionable performance. However, this does not mean that the mix should be rejected if, on occasion, a slight deficiency is noted. Instead, the plant should be notified to make corrections. Only if the deficiency is major, or is allowed to consistently recur, should the mix be rejected or the plant shut down until corrective adjustments are made.

**1-120.** silicone

**1-121.** back-up material

**1-122.** lower

**1-123.** is not

**1-124.** is not

There are hot weather and cold weather limitations on the mixing, placing, and finishing of Portland Cement Concrete pavement. However, unless otherwise specified, the hot weather limitations will only apply to structural concrete that is used in the decks of bridges.

The cold weather limitations are as follows: Concrete arriving at the jobsite must have a minimum temperature of 50 degrees and upon placement shall be kept at a temperature about 50 degrees for at least 72 hours. It shall also be kept above freezing for at least 6 days after placement.

When the placement of concrete is authorized during cold weather, the aggregates may be uniformly heated, by either steam or dry heat, before being placed in mixer. If the temperature of either the water or aggregate is in excess of 150 degrees F they shall not be mixed. If temperature is in excess of 100 degrees F, the water and aggregate will be charged into the mixer and allowed to equalize before cement is added. Frozen aggregates are never to be used in the concrete; concrete is never to be placed on a frozen base.

All concrete is to be mixed, placed, and finished when natural light is sufficient unless an adequate and approved artificial lighting system is operated.

**1-130.** spreader

## CIRCLE THE CORRECT WORD(S):

**1-128.** Concrete can be placed at any time provided that requirements for (hot weather / cold weather) placement is strictly adhered to.

# PLACING CONCRETE

When mixing is completed, the concrete must be deposited on the roadway. Before the concrete is deposited, care must be taken to see that the base is dampened. This will prevent water from the concrete being absorbed by the base. If water from the concrete goes into the base, it will alter the water-cement ratio, thus affecting the durability of the concrete. The base should be damp, but not soupy. There should not be puddles of water on the base.

**1-126.** 60

**1-127.** 3 (three)

# CIRCLE THE CORRECT WORD(S):

**1-129.** The base (should / should not) be dampened before concrete placement.

When the concrete is deposited on the base, it should be dropped as closely as possible to the roadbed and to its final location. The concrete is placed directly in front of the spreader, which is part of the paving train. The spreader then uses paddles or an auger to distribute the concrete. When placing concrete in front of the spreader, it is important to remember that it should be placed in a manner to minimize segregation.

**1-133.** Internal

# CIRCLE THE CORRECT WORD(S):

**1-130.** Concrete is distributed by a (spreader / vibrator).

When the concrete is being dumped the direction of discharge should be such that any separated rock falls on concrete where it may be readily worked into the mass. Dumping so that free rocks roll out onto forms or onto the base is undesirable. (see photo above.)

# CIRCLE THE CORRECT WORD(S):

**1-131.** Separated rock should fall (into / away from) the concrete mass.

To help prevent segregation, the concrete must be placed in such a manner as to require as little rehandling as possible. If hand spreading is necessary, it should be done with shovels, not rakes.

Workmen must not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances. The inspector must make sure that the workers do not disturb joint assemblies.

# FILL IN THE BLANK(S):

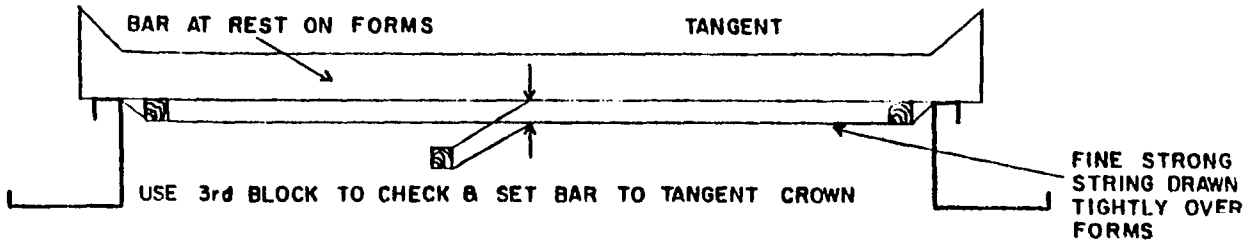
**1-132.** Rehandling concrete or raking concrete causes _____.

**1-129.** should

Following the placing of the concrete, it must be struck off to conform to the cross-section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the established elevation.

In conjunction with the spreader and immediately behind the paddles, or auger, is the strike-off bar. The strike-off bar levels the concrete immediately after it is spread. The inspector should stringline the strike-off before use to make sure it is true to line and grade.

Here's how the strike-off bar can be checked:
A stringline is stretched across the width of the pavement and measured. Of course, a parabolic crown must be set according to the plan's cross sections. This will be discussed later in this chapter.




**1-135.** 8,000

Either immediately before or after the concrete is struck off, it is vibrated. Vibration helps consolidate the concrete. Our Specifications require that concrete must be vibrated internally. Vibrators are often attached to the spreader. However, they may be attached to the finishing machine that follows the spreader or be mounted on separate carriages.

## CIRCLE THE CORRECT WORD(S):

**1-133.** (External / Internal) vibration is required by the Specifications.

There are two types of vibrators currently noted in our Specifications. The inspector must check all vibrators to see that they are in good working order and that they produce the required impulses per minute.

Vibration frequency can be counted with a pencil type counter which is held next to the vibrator. Make sure that the vibrator is producing the required impulses per minute.

1. Surface Pan Vibrators - 3,000 to 6,000 impulses per minute.
2. Multiple Spud Vibrators - 8,000 to 12,000 impulses per minute.

This frequency also applies to spud type internal vibrators. Neither hand operated nor attached to spreader, shall be used adjacent to forms.

# FILL IN THE BLANK(S):

**1-134.** Surface Pan vibrators must produce at least _____ impulses per minute.

Hand vibrators are frequently used on construction joints, split slab pavement, ramps, and intersections, whereas vibrators that are attached to the equipment of the paving train are used on straight-aways. Hand spud vibrators must produce at least 8,000 impulses per minute.

**1-131.** into

**1-132.** segregation

**1-138.** should

**1-139.** truck mixers; central mix plants; dry paver mixers

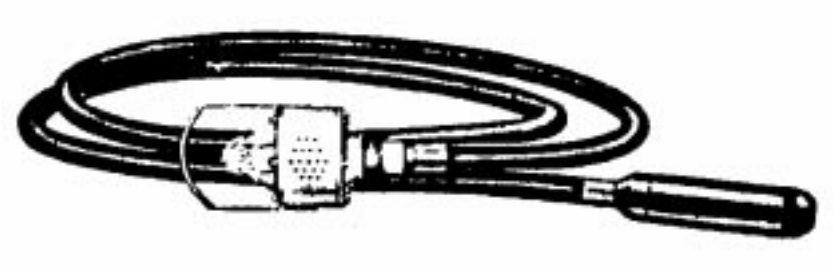
**1-140.** 60

**1-141.** three (3)

**1-142.** deposited close to

**1-143.** struck off

**1-144.** shovels



## FILL IN THE BLANK(S):

**1-135.** A hand spad vibrator must produce at least _____ impulses per minute.

The hand vibrator should be inserted vertically, at points 18 to 30 inches apart, and slowly withdrawn. However, in shallow or inaccessible concrete some consolidation can be obtained by using the vibrator in a sloping or horizontal position. Vibration periods of 5 to 15 seconds are usually sufficient. The amount of vibration in one spot may be gauged by the surface movement and texture of the concrete and by the appearance of cement paste. Proper spacing of the points of vibration should be established to ensure that no portions of the concrete are missed.

# CIRCLE THE CORRECT WORD(S):

**1-136.** Hand vibrators should normally be inserted into the concrete (vertically / at an angle).

Multiple spud vibrators are shown below. These vibrators are used to consolidate mass concrete. Multiple spud vibrators should be mounted in such a way that they can be readily raised and lowered to eliminate dragging through the concrete and banging against each other. Most important of all, vibrators must be lifted over load transfer devices at the joints.

# FILL IN THE BLANK(S)

**1-137.** Multiple spud vibrators must produce a maximum of _____ impulses per minute.

**1-134.** 3000

The frequency and positioning of the vibrators should be adjusted to produce the maximum consolidation with minimum segregation. This will vary with concrete consistency. Proper consolidation is achieved when the surface is smooth and submerged coarse aggregate is barely visible on or immediately under the surface.

The vibration should be continued only until the concrete is consolidated thoroughly and the voids filled. Do not permit over-vibration. This causes segregation and is harmful to concrete durability. You can tell if concrete is over-vibrated by the flushing of excess mortar or water to the surface. Vibration must be discontinued whenever the forward motion of the machine is stopped and whenever the machine is making extra passes.

Machine vibrators must automatically start and stop vibrating as the machine starts and stops. In no case shall the vibrator be operated longer than 15 seconds in any one location.

## CIRCLE THE CORRECT WORD(S):

**1-138.** When the forward motion of the vibrator stops, the vibration (should / should not) stop.

Concrete along the forms should be vibrated to draw mortar to the edge of the slab and ensure a face free from honeycomb. Concrete must be thoroughly consolidated for its full width and against and along the faces of all forms and along the full length and on both sides of all joint assemblies. It is important to make sure that vibrators do not come in contact with the forms, joint assemblies, or the base.

## FILL IN THE BLANK(S)

**1-139.** The three methods of mixing concrete are _____ _____, _____ _____ _____, and _____ _____ _____.

**1-140.** The time limit between addition of cement to the mix and placement, without retarder added, is _____ minutes.

**1-141.** A minimum of _____ slump and air content tests should be run per day for verification purposes.

## CIRCLE THE CORRECT WORD(S):

**1-142.** Concrete should be (deposited close to / dropped from a foot above) the base.

**1-143.** Immediately after spreading, the concrete is (floated / struck off).

**1-144.** Concrete should be rehandled with (shovels / rakes).

**1-149.** wheels; top of forms

**1-145.** (Internal / External) vibrators are required by Specifications.

**1-146.** Vibrators must produce between (3,000 - 12,000 / 7,000-10,000) impulses per minutes.

## FILL IN THE BLANK(S)

**1-147.** Vibrators cannot be operated more than _____ seconds in one place.

# FINISHING CONCRETE

Either attached to the spreader or following it in the paving train is the finishing machine.

Transverse screeds (leveling devices) work back and forth across the full width of the roadway and smooth the concrete. There are normally two transverse screeds. Each screed should carry a roll of concrete ahead of it. The loss of the roll indicates a low spot and that the concrete is not being consolidated properly. In this event, additional concrete should be supplied or equipment adjustments made. Do not allow mortar wasted over the form to be used for this purpose.

The front screed is not parallel to the slab surface; the front edge is raised about 1/8 inch to permit enough concrete past this screed to use with the rear screed.

This rear screed should have a uniform 2-inch roll ahead of it. Otherwise another pass with the finishing machine may be necessary. Two passes of the finishing machine is the usual minimum number of passes necessary.

## CIRCLE THE CORRECT WORD(S):

**1-148.** Each screed (should / should not) have a roll of concrete in front of it.

**1-136.** vertically

**1-137.** 12,000

The wheels on the machine must be kept clean of excess concrete. The top of the forms must also be kept clean. Extra concrete on the wheels and the top of the forms will cause the finishing machine and screed to ride too high. This will result in an uneven surface.

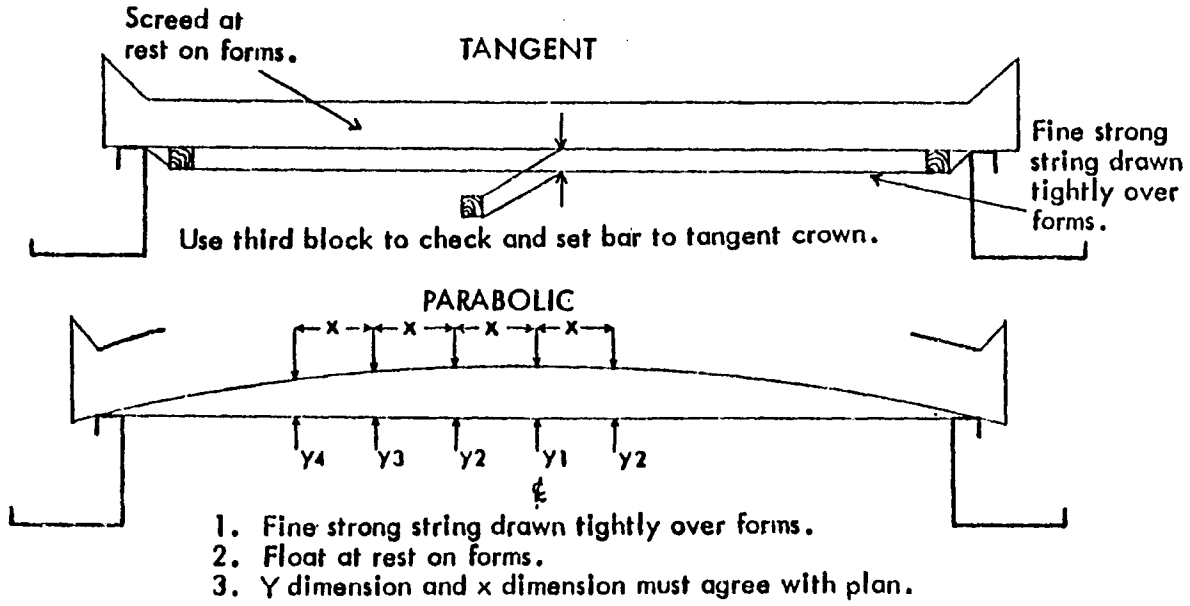
# FILL IN THE BLANK(S)S:

**1-149.** Excess concrete must be kept off the _____ and _____.

The screeds must be checked for proper adjustment. The check is made in the same manner as the strike-off bar check.

**1-154.** is not

**1-155.** combines longitudinal and transverse



## FILL IN THE BLANK(S):

**1-150.** In order to check the screed for a parabolic crown, you would check the cross-section shown in the _____.

## CIRCLE THE CORRECT WORD(S):

**1-151.** For a tangent (straight) crown, the measurements should be (equal / unequal).

The combination of traction speed and screed motion to be selected will depend on the concrete mix and the grade and crown of the pavement. The screed should work the rock down and a cement paste up with no visible tearing. This can be accomplished by either increasing the speed and/or stroke of the oscillating screed or decreasing the forward travel of the finisher.

In most machines the controls for speed and traction are independent. A change in either requires only shifting a lever.

The slab surface behind the finishing machine should be checked for accuracy of cross-section. Further adjustment of the screeds may be necessary if the slab cross-section is not correct. The contractor's man, not the inspector, makes adjustments on equipment.

## CIRCLE THE CORRECT WORD(S):

**1-152.** An adjustment to change the screed stroke should be made by the (contractor's man/inspector).

## FILL IN THE BLANK(S)

**1-153.** Adjustment to the screed may be necessary if the slab _____ is not correct.

**1-145.** Internal

**1-146.** 3,000-12,000

**1-147.** 15

**1-148.** should

Machine finishing as just described is to be used on all concreting operations. Hand finishing methods will not be permitted except under the following conditions:

1. If mechanical equipment breaks down, hand methods may be used to finish concrete already deposited on the grade when the breakdown occurred.
2. If the pavement width does not exceed 16-feet or if the area has irregular dimensions that make mechanical operations impractical, hand methods may be used.

## CIRCLE THE CORRECT WORD(S):

**1-154.** In general, hand finishing (is / is not) permitted.

If hand methods are used, the concrete shall be struck off and screeded as soon as placed. An approved portable screed at least 2-feet longer than the maximum width of the slab is to be used. The screed shall be sufficiently rigid to retain its shape and shall be constructed of metal. **Consolidation shall be attained by the use of a suitable internal vibrator**.

During operation, the screed used in hand finishing shall be moved forward on the forms with a combined longitudinal and transverse shearing motion. The direction of movement is always to be in the direction in which work is progressing.

The screed must be manipulated so that neither end is raised from the side forms during the striking off process. If necessary, screeding shall be repeated until the surface is of uniform texture, true to grade and cross-section, and free from porous areas.

## CIRCLE THE CORRECT WORD(S):

**1-155.** Hand screeding is to be done in a (transverse only), (longitudinal only) , or (combined longitudinal and transverse) direction.

**1-156.** parallel

It is important to remember that regardless of which method of finishing is used, the addition of water to the surface of the concrete to assist in finishing operations will not generally be permitted. The addition of water to the surface affects the water-cement ratio; the more water, the less durable the concrete. If the application of water to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

If not previously set on chairs on the base, longitudinal joint tie bars are set following the machine. When a cutting wheel is used for longitudinal joint grooves, the inspector should check the machine before use to see that the cutting wheel is centered. To do this, an inspector can measure the width of the machine between wheels and divide this distance in half. Then measure the distance between an outside wheel and the cutting wheel; if correct the wheel is at the center of the machine.

If the tie bars are pushed into the fresh concrete, the inspector must check to see they are placed parallel to the base at the correct depth. In addition, the depth of the pavement can also be checked at this time.

**1-150.** plans

**1-151.** is not

**1-152.** contractor's man

**1-153.** cross section

## CIRCLE THE CORRECT WORD(S):

**1-156.** Tie bars should be (parallel / perpendicular) to the base.

In some instances, the tie bars and longitudinal joint filler displace the concrete considerably. When this problem arises, be sure that the area is straightedged on 45-degree angle halfway across the pavement as shown in the following picture. Then the straightedges should be used on a 90-degree angle to the forms. Using the straightedges in this manner will smooth out the marks left by the longitudinal joint placement and reconsolidate that area.

# TRANSVERSE CONTRACTION JOINTS

**1-158.** 10

After the longitudinal joints have been formed, the transverse joints are placed per the plans. This can be done by hand as described previously under “Contraction Joints”, or it can be done by sawing.

**1-159.** 27

Regardless of the method to be used, before the joint is placed a small area of concrete should be dug out on both edges of the roadway at the transverse joint location to make sure that the joint is placed directly above the transfer devices.

# EXPANSION JOINTS

Unlike longitudinal and transverse contraction joints, transverse expansion joints are always secured to the base before the paving operations begin. The details and specifications for placing these expansion joints have been covered earlier under “Transverse Expansion Joints”. The inspector needs to see that the expansion joints are not disturbed during the paving operation. After the paver has passed and before the longitudinal float is used, a stringline should be run to see that the joint is still straight. Any expansion joint that has been disturbed or moved should be straightened before proceeding with the paving operation.

### Floating

Specifications state that after the concrete has been struck off and consolidated, it shall be smoothed and trued by an approved float or finishing machine that minimizes or eliminates hand finishing. Normally, hand finishing will not be permitted except under the following conditions:

1. Narrow widths, or areas of irregular dimensions where operations of the mechanical equipment is impractical, may be finished by hand methods.
2. In the event of breakdown of mechanical equipment hand methods may be used to finish only that concrete already deposited on grade when the breakdown occurred.
3. Abnormal circumstances of short duration with approval of the engineer.

### Straightedging

Upon completion of all floating, any excess water and loose material that still remain on the surface must be removed. The excess is removed with a 10-foot or longer straightedge successive drags shall be lapped one half the length of the blade.

## CIRCLE THE CORRECT WORD(S):

**1-157.** Excess water and loose material should be removed with a (straightedge / bull float).

After removing excess water and loose material, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness (high or low spots) with a 10-foot straightedge.

For this purpose, the contractor shall furnish and use an accurate 10-foot straightedge swung from handles approximately 3 feet longer than one half the width of the slab. (see photo on next page)

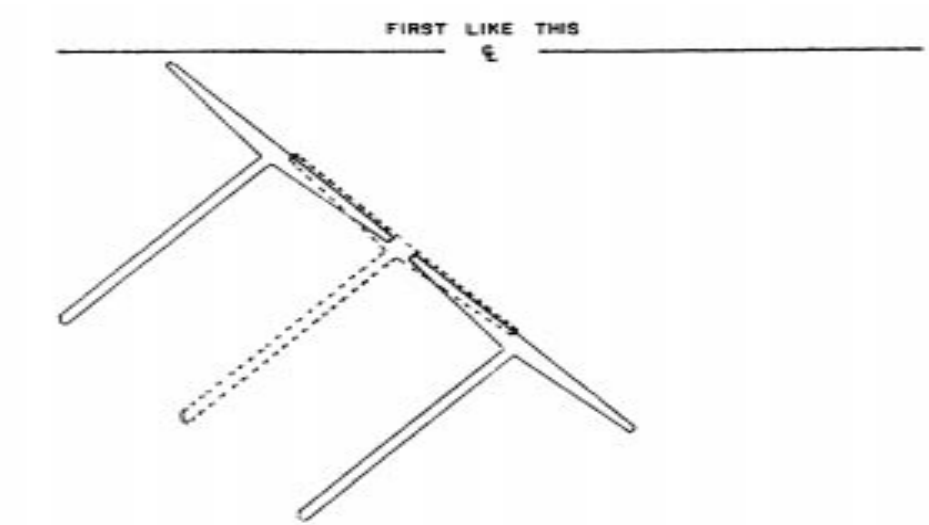
**1-160.** at an angle; parallel

# FILL IN THE BLANK(S):

**1-158.** The blade of the straightedge is _____ feet long.

**1-159.** The handle for a straightedge to be used on a 24-foot slab would have to be at least _____ feet in length.

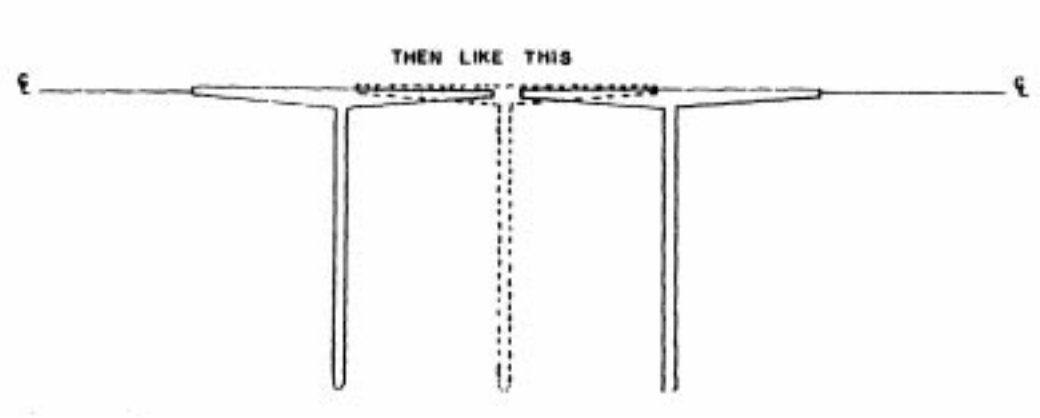
On a tangent crown it is a good idea to work the straightedge first at a 45 degree angle to the centerline and then with the blade parallel to the centerline. Of course, as you get closer to any side forms the angle is decreased.




**1-157.** straightedge

The straightedge should work with the blade parallel to the centerline and the whole area gone over from one side of the slab to the other as necessary. Therefore, usually there is a person on each side of the slab working a straightedge toward the centerline.

Successive drags must be lapped not more than one half the length of the blade. The sketch below illustrates the proper lapping and proper blade position of the straightedge.




**1-162.** before

**1-163.** straightedge

Hold the handle down when pushing the straightedge toward the center of the slab. Lift the handle up when pulling the straightedge back to the edge of the slab.

## CIRCLE THE CORRECT WORD(S):

**1-160.** When working the straightedge, the blade is first worked (at an angle / parallel) to the centerline and then (at an angle / parallel) to the centerline.

On two-lane construction, the straightedge should be pushed from the edge of the pavement to the center, and then lifted or jumped over any mortar that has been piled up.
Caution should be taken not to drop the straightedge in the center of the pavement. This will leave a mark.

When the straightedge is pulled back, any extra material should be wasted over the edge of the pavement or form. Advance along the roadway in successive stages of 5-feet (one half the length of the straightedge).

Any depressions found must be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. Any high areas must be cut down and refinished making sure that depressions are filled with fresh concrete and not mortar dragged from high spots on the slab.

The straightedge should make an audible scraping sound due to the stiffness of the concrete. It is on this process that the riding surface depends. If it is done too early, low surface due to concrete softness will not be detected ahead of the final finishing. However, the straightedging must be done before the concrete hardens.

The straightedging of the slab after the passing of the joint machine should be done with great care. Special attention must be given to assure that the surface across joints meets the requirements for smoothness. In addition, straightedging helps prevent spalling at transverse joint locations.

In some cases a special straightedge may be needed. In this case, a removable metal joint forming device isand it is exposed above the surface of the concrete. Therefore, notches were made in the straightedges and the straightedges were then pulled across the joint area.

# FILL IN THE BLANK(S):

**1-161.** Straightedging transverse joints helps prevent _____.

Straightedge testing and surface corrections must continue until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross-section. It is much easier and more satisfactory to correct irregularities before the slab has hardened.

## CIRCLE THE CORRECT WORD(S):

**1-162.** Surface irregularities must be fixed (before / after) the concrete hardens.

Finishers must not be allowed to throw water on the surface of the pavement to make their work easier. This will cause scaling and very rapid wearing of the surface under traffic. If water must be added, a fog spray must apply a minimum amount.

If the straightedges are doing a great deal of cutting and filling, all of the finishing machines—transverse screeds and float—must be checked again for proper elevation and crown adjustment.

**1-172.** fresh concrete

**1-173.** before

**1-174.** metal tine

## FILL IN THE BLANK(S):

**1-163.** Screeds and floats are checked for grade and adjustment by using a _____.

Let's review.

## CIRCLE THE CORRECT WORD(S):

**1-164.** Water (should / should not) be added to the concrete surface to aid finishing operations.

## FILL IN THE BLANK(S):

**1-165.** Tie bars for longitudinal joints should be _____ to the base.

**1-166.** Transverse or expansion joints are placed _____.

## CIRCLE THE CORRECT WORD(S):

**1-167.** Transverse (contraction / expansion) joints are always secured to the base in advance of the paving operation.

**1-168.** Floating should begin (before / after) the concrete has been struck off.

## FILL IN THE BLANK(S):

**1-169.** The handle of a straightedge for a 24-foot wide slab should be at least _____ feet long.

**1-170.** The blade of a straightedge is _____ feet long.

**1-171.** The straightedge is worked on a _____ angle to the centerline and then _____ to the centerline.

**1-161.** spalling

## CIRCLE THE CORRECT WORD(S):

**1-172.** Depressions in the concrete should be filled with (fresh concrete / mortar already on the surface).

**1-173.** Surface irregularities should be corrected (before / after) the concrete hardens.

**IF YOU MISSED ANY ANSWERS, REVIEW FRAMES 1-164 THROUGH 1-173**

# FINAL FINISH

**1-177.** four (4)

Specifications state that final finishing shall be done by using the drag finish with the final surface texture produced by a metal tine finishing device. In this two-part finishing process, timing is very important.

**1-178.** damp

## FILL IN THE BLANK(S):

**1-174.** Final finish consists of a drag finish followed by a _____ finish.

If finishing is started too soon, the result can be texture that is excessively rough because pieces of coarse aggregate are exposed. If coarse aggregate is exposed because the tining process was started too soon, the surface should be refloated, then dragged and textured again. If finishing is started too late the result can be insufficient texture depth because the concrete has started to stiffen.

Although it is impossible to specify the exact time to start the finishing process because of factors such as wind, temperature, and humidity, finishing should generally start when there is still a slight water sheen on the surface. Since the surface cannot be too wet or too dry when finishing is started, close observation is very important. The inspector must watch closely to see the concrete is textured at the proper time.

## CIRCLE THE CORRECT WORD(S):

**1-175.** Starting finishing too late can result in (rough / insufficient) texture.

**1-176.** There (should / should not) be a slight water sheen on the surface of the concrete when finishing begins.

## BURLAP DRAG

Concrete is initially finished using a damp burlap drag. The burlap is dragged longitudinally along the full width of the pavement. It evens out surface irregularities, produces a gritty texture, and removes excess moisture from the surface. For pavement 16-feet or more in width, the drag must be mounted on a bridge that travels on the forms.

To do its job properly, the burlap drag must be the correct size. Specifications state that the drag must have at least a 4-foot length in contact with the pavement and that it must be at least two layers thick. In addition, the bottom layer is to be approximately 6-inches wider than the upper layer.

However, two layers of burlap are often not sufficient. If the burlap is lightweight, two layers may not be heavy enough to produce a proper finish. Therefore, more layers should be used. Several layers of a lightweight, loose weave burlap may be preferable to two layers of a heavy, close weave burlap as more texture is produced by the loose weave.

**1-164.** should not

**1-165.** parallel

**1-166.** as shown on the plans

**1-167.** expansion

**1-168.** after

**1-169.** 27

**1-170.** 10

**1-171.** 45 degree/perpendicular

# FILL IN THE BLANK(S):

**1-177.** To do its job, the burlap should have at least _____feet in contact with the pavement.

The burlap drag must also be kept damp at all times. If not dampened, the drag would absorb too much water from the surface, thus affecting the water-cement ratio. While one purpose of the drag is to remove excess water, care must be taken to see that the burlap does not overdo its job.

# CIRCLE THE CORRECT WORD(S):

**1-178.** Burlap drags must be kept (dry / damp).

**1-180.** will

Drags that cannot be cleaned must be discarded. However, too clean a material is just as bad as too dirty a material. Neither will produce sufficient texture. Some buildup of mortar should be allowed since the dried mortar helps roughen the texture. It is necessary to clean the burlap daily, however, so that it will not be solidly coated with mortar.

# METAL TINE DEVICE

After the surface has been dragged, a metal tine device is to be used to obtain final surface texture. These tines make transverse grooves in the concrete thereby producing the surface's texture. When texturing main roadway pavement lanes, the tine device shall be operated by approved mechanical means. Manual methods may be used for texturing ramps, connections, split slabs, and certain other areas when approved by the engineer.

# CIRCLE THE CORRECT WORD(S):

**1-179.** The tine device shall be operated in the (transverse / longitudinal) direction.

The surface texture produced by the metal tines is referred to as macrotexture. Sufficient macrotexture is necessary to remove water from beneath vehicle tires as well as to increase traction and aid skid resistance. Since macrotexture is so important, the device and procedure used to groove the concrete must be correct. An example of the texture produced by a tine machine is shown in the photo.

**1-175.** insufficient

**1-176.** should

# CIRCLE THE CORRECT WORD(S):

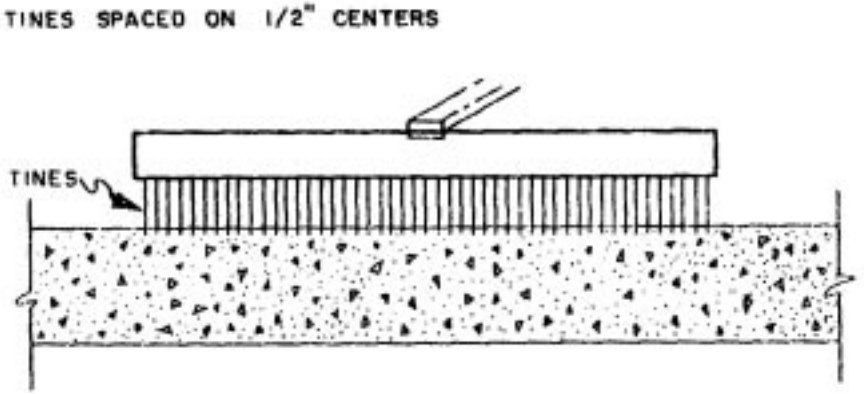
**1-180.** Sufficient macrotexture (will / will not) help prevent hydroplaning which is caused by water pooling on the roadway surface.

According to the specifications, the mainline finish shall be produced by mechanical equipment for transverse grooving of plastic concrete. This equipment shall utilize rectangular shaped spring steel tines. Tines used in a continuous operation shall be of the same size and of uniform length. The width of tines shall not be less than 0.08 inches, nor greater than 0.13 inches. The spacing between tines shall be approximately ½ inch.

While the tines themselves must be spaced on ½-inch centers, the spacing between the grooves does not have to be exact. The tines are flexible; therefore, they may bend during use and spring slightly out of alignment. This is all right because the somewhat random spacing of the grooves helps eliminate excessive noise.

**1-183.** crown

**1-184.** 0.080 inch



# CIRCLE THE CORRECT WORD(S):

**1-181.** The actual space between each groove (is / is not) required to be ½ inch.

An important factor that affects the amount of surface texture achieved is the depth of the grooves. Specifications require the texture depth to be a minimum depth of 0.080 inches. In addition, the depth of the groove should be uniform, that is, the tines should all groove to the same depth.

In order for the tines to groove to an even depth, the tips must be even and the tine device must be parallel to the surface. Therefore, the inspector should check the tine device every morning and then periodically during the day to see that the tines are evenly aligned.

# CIRCLE TRUE OR FALSE:

**1-182.** T F It is all right to have one tine adjusted to groove 3/16" and the one next to it, to groove 1/8".

The groove depth should also be uniform across the full width of the pavement; one area should not have grooves at the correct depth while the other areas have grooves that are too shallow or too deep.

In order to achieve uniform groove depth across the surface, the carrier for the tine device must have the same crown as the pavement surface. Therefore the carrier must be checked regularly for proper alignment.

**1-179.** transverse

# FILL IN THE BLANK(S):

**1-183.** In order to obtain uniform texture depth across the surface, the carrier for the tines must have the same _____ as the pavement surface.

Since the depth of the grooves is so important, the inspector must check them carefully in accordance with GHD 72. This procedure is explained in detail in the chapter on "Testing".

Natural silica sand is used for the procedure, with measurements taken to the nearest 0.1 inch. In order to get the texture depth, you must use the conversion table found in GHD 72. The required minimum texture depth is 0.018 inches. You must make a sufficient number of random measurements throughout each day's operation to insure that the required texture depth is obtained.

**1-186.** white pigmented impervious membrane

# FILL IN THE BLANK(S):

**1-184.** The required texture depth is _____.

In addition to correct depth, the grooves must be transverse or perpendicular to the centerline. A practice to be avoided when producing this pattern is excessive overlapping. The amount of overlap should be minimized to prevent weakening the concrete surface by putting too many grooves in too small an area. However, there should not be a gap between passes of the tines. A small amount of overlap is preferable to no grooves at all.

It is important to note here that a space of approximately 2-inches on each side of a transverse joint should not be tined. This will help prevent spalling and allow better seal for preformed compression sealants.

## CIRCLE THE CORRECT WORD(S):

**1-185.** The amount of overlap on grooves (should / should not) be minimized.

# EDGING AT FORMS AND JOINTS

After the final finish, but before the concrete has initially set, the edges of the pavement along each side of the slab and on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints must be worked with an approved tool. Each edge is to be rounded to the radius required by the plans. A well-defined and continuous radius must be produced and a smooth, dense mortar finish obtained. Care must be taken during edging to see that tilting the edging tool does not disturb the surface of the slab.

When forms are used, a trowel is run along the sides of the forms to break any bond with the concrete before the edging is done. Then the edger is run along the edges of the pavement to round them to the correct radius. When the edger is being used, the leg between the concrete and the forms should be held vertically against the form at all times.

# CURING

According to Specifications, curing may be accomplished by using white pigmented impervious membrane. Curing should be started immediately after finishing; it is not necessary to wait since the compound will not mar the surface. The curing process allows the concrete to maintain its internal moisture. This results in strong and durable concrete. If curing is started too late there is a rapid loss of surface water that can cause a weakened surface texture, surface cracking, and surface dusting.

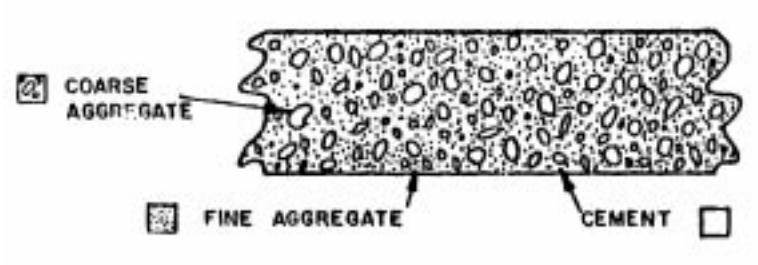
**1-181.** is not

**1-182.** false

# FILL IN THE BLANK(S):

**1-186.** Curing may be accomplished by using _____.

If the concrete is properly cured, the internal moisture will act upon the cement. This action will allow the cement to gel and fill up the holes between the pieces of aggregate. Once the concrete has dried out, the reaction between the internal moisture and the cement stops.




**1-190.** should

**1-191.** should

The Specifications also allowed the use of curing papers such as white polyethylene sheeting. Experience has shown that the weight of the sheeting damages the surface texture. Therefore, white pigmented compound is now preferred for curing PCC pavement. The curing compound used on the pavement must be an approved product that does not contain any material such as linseed oil, which might prevent the surface from hardening and attaining the required strength. The covering material previously used should still be kept close by at all times to cover the last hours pour against rain.

# CIRCLE THE CORRECT WORD(S):

**1-187.** Covering material should be used during a sudden (wind / rainstorm).

The right amount of curing compound must be applied correctly in order to properly cure the concrete and help protect the surface texture. Too little compound or improperly applied compound will result in the same problems as curing too late. Specifications state that the curing compound shall be applied under pressure by mechanical sprayers at a rate of one (1) gallon to not more than 150-square feet. The spraying equipment shall be fully automated and equipped with a tank agitator.

Let's see how you check to see that the coverage requirement is met. The curing compound comes in 55-gallon drums; therefore each 55-gallon drum of compound should not cover more than 8250 square feet.

Let's say the width of the pavement is 24-feet. To find the maximum distance down the roadway the 55 gallon should go, you use the following formula:

$$24 \times L = 8250$$

$$L = 344 \text{ or } 343 \text{ feet}$$

$$\frac{\text{Total Square Feet}}{\text{Width}} = \text{Length}$$

**1-185.** should

# CIRCLE THE CORRECT WORD(S):

**1-188.** If the curing machine travels 345-feet down the 24-foot wide roadway per 55-gallons of compound, the specification requirement (is / is not) being met.

**1-189.** If paving 24-foot wide 10-inch slip form pavement, the maximum length would be (360 / 321) feet.

Specifications state the spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be STIRRED CONTINUOUSLY by effective mechanical or other approved means in order to achieve the correct consistency.

The mechanical sprayers must be adjusted correctly so that the layer of compound covering the surface will not be too thin. Also, the nozzles must be kept clear of debris so that the compound will evenly cover the surface.

## CIRCLE THE CORRECT WORD(S):

**1-190.** The compound (should / should not) be stirred continuously during application.

**1-192.** outward

Hand spraying of odd widths or shapes and on concrete surfaces exposed by the removal of forms will be permitted. Upon removal of any side forms, the sides of the slab exposed shall be protected immediately by spraying at the same rate provided for the surface.

Should the film become damaged from any cause within the required 72-hour curing period, the damaged portions shall be repaired immediately with additional compound.

## CIRCLE THE CORRECT WORD(S):

**1-191.** After removal of forms, the sides of the exposed slab (should / should not) be sprayed with curing compound.

# COLD WEATHER CURING

All concrete which is frozen before the time of initial set shall be removed and replaced at no cost to the Department. Concrete which has set but is exposed to freezing temperatures within 24 hours from the time of placement shall be protected with polyethylene or canvas in a manner that will insure the internal temperature of the concrete is maintained above freezing for a minimum period of 24 hours after the concrete is placed. Other means of protection such as hay, straw, or grass and the duration of protection shall be approved by the engineer.

For all conventional formed paving operations, it is important that the tops of the forms and the wheels of the mechanical equipment be kept clean and free from any accumulation of mortar or concrete. It would be useless to insist on a careful check of form alignment and surface tolerances while permitting the equipment to run on an irregular surface caused by concrete accumulation.

# FORM REMOVAL

Normally, forms may not be removed from freshly placed concrete until it has set for at least twelve hours, except when auxiliary forms are used temporarily in widened areas. Form pins are pulled with hand tools or equipment that rides on or works outside the forms. When the pins are being loosened, care must be taken never to pry against the slab. If forms have been properly cleaned and oiled, it should be easy to remove them. The forms must be removed carefully so as not to damage the pavement. Do not allow the pins or forms to be thrown on the new concrete.

**1-187.** rainstorm

**1-188.** is not

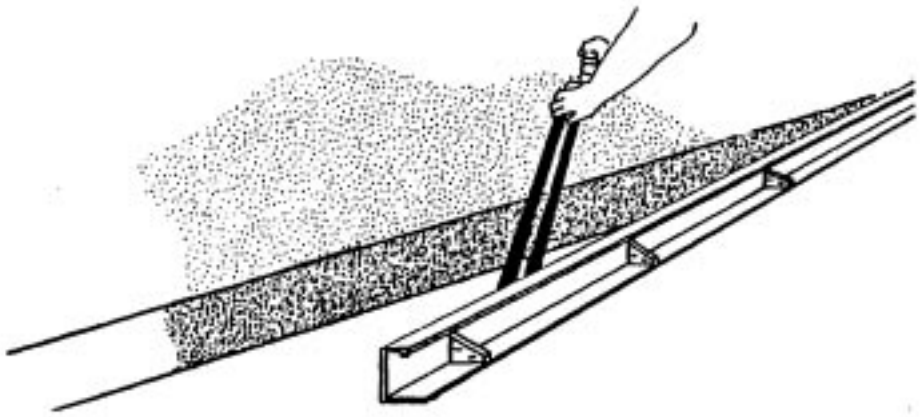
**1-189.** 321

**1-194.** metal tine device

**1-195.** should

**1-196.** four (4)

**1-197.** transverse



## CIRCLE THE CORRECT WORD(S):

**1-192.** The forms should be removed by prying (inward / outward) from the slab.

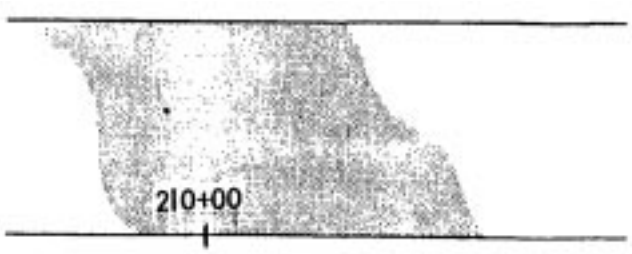
After the forms have been removed, minor honeycombed areas must be filled with mortar composed of one part of cement and two parts of fine aggregate. Major honeycombed areas will be considered as defective work and must be removed and replaced. Any area or section so removed must not be less than 10-feet in length or less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10-foot in length shall also be removed and replaced. All repaired or replaced areas must be cured with a curing compound as described previously.

# FILL IN THE BLANK(S):

**1-193.** Minor honeycombed areas must be filled with mortar composed of _____ part(s) cement and _____ part(s) fine aggregate.

# STATION MARKING

Station numbers must be marked at 500-foot intervals along the roadway after the entire paving process has been completed. This can be done by impressing the numbers in the concrete while it is still green or by painting the numbers on the concrete after it has hardened. A typical station marking is shown below.



# FINAL SURFACE TEST

The mainline riding surface shall produce a Roughness Index Value which does not exceed 65 for each mile of each vehicle lane. Tests shall be conducted in accordance with procedures outlined in GHD-93. These tests shall be conducted before transverse contraction joints are sealed. Lanes less than ½ mile in length which are added to mainline pavement shall meet the roughness index requirements of ramps.

Mainline pavement may be subjected to rolling straightedge tests in addition to testing by GHD-78. These tests shall be conducted in the wheel paths of each lane. Areas found to deviate from the plane of the rolling straightedge by more than 1/8" in 10-feet shall be corrected. The engineer at his discretion may request use of the Rainhart Profilograph to aid the use of rolling straightedge in isolating locations of individual bumps or depressions.

**2-1.** stringline

**2-2.** stationary side forms are not required

Ramps, acceleration lanes, and deceleration lanes shall produce a Roughness Index Value of 14 inches per mile or less as tested by the Rainhart Profilograph in accordance with procedures outlined in GHD-78. In addition, individual bumps or depressions exceeding 2/10 inch from the blanking band on the profilograph trace shall be corrected. Planing or other approved methods shall correct pavement not meeting the preceding requirements. The final surface shall conform to the texture depth requirement.

Let's review

## CIRCLE THE CORRECT WORD(S):

**1-194.** Final surface texture shall be obtained by using a (burlap drag / metal tine device).

**1-195.** There (should / should not) be a slight water sheen on the surface of the concrete when final finishing begins.

**1-196.** A burlap drag should have at least (3/ 4) feet in contact with the pavement.

**1-197.** The tine device must be operated in a (transverse / longitudinal) direction.

**1-198.** The actual space between each groove (is / is not) required to be ½ inch.

**1-199.** The amount of overlap at grooved areas (should / should not) be minimized.

## FILL IN THE BLANK(S):

**1-200.** Curing must be accomplished by using _____.

## CIRCLE THE CORRECT WORD(S):

**1-201.** Curing should start (immediately after finishing / when surface will not be marred).

**1-202.** Curing compound is to be applied at the rate of one gallon per (100 / 150) square feet.

**1-203.** During form removal, the forms and pins (can / cannot) be placed on the green concrete.

**1-193.** one; two

# CHAPTER 2 SLIP FORM PAVING

## PAVING MACHINERY

Slip form paving is a highly mechanized means of placing a large amount of concrete pavement in a relatively short period of time. Through the use of mobile side forms, slip forming saves time by eliminating stationary forms. Use of these movable side forms is possible because the concrete mixture for slip forming usually is a stiffer consistency than required for conventional concrete pavement. Thus slip form paving the side forms are used for shaping and not for support.

The slip form paving train consists of several separate machines: at least one spreader, a slip form paver, a transverse joint machine (if the pavement is not continuously reinforced), a longitudinal tube float with burlap drag, a transverse tines machine, and a curing machine. When set up, the machines are guided by following a stringline set on either side of the roadway. In some cases, an operator guides the machinery along the stringline; in other cases the machines are guided electronically.

**2-3.** separate machine

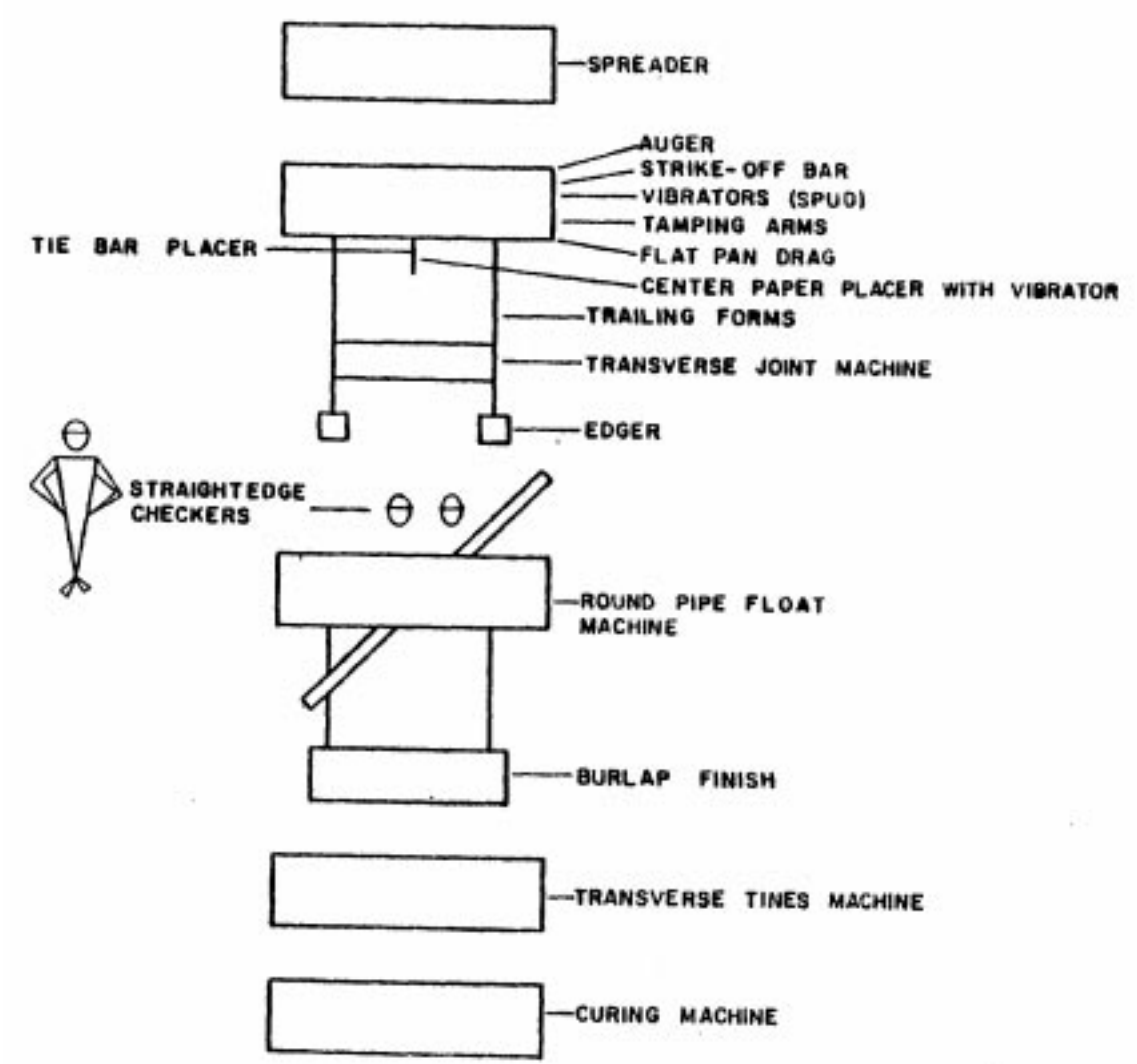
**2-4.** conventional concrete

## FILL IN THE BLANK(S):

**2-1.** Slip form paving machinery is guided by following a _____.

**2-2.** One reason slip form paving is faster than conventional paving is _____.

A general layout of a slip form paving train is shown below.




As the name implies, the slip form spreader spreads the concrete over the base. The paver then uses an auger and

**1-198.** is not

**1-199.** should

**1-200.** white pigmented impervious membrane

**1-201.** immediately after finishing

**1-202.** 150

**1-203.** cannot

strike-off bar to further push the concrete into place. The pavers' internal vibrators compact the concrete, the tamping bars push the large aggregate into the concrete and the flat pan drag shapes the concrete to the desired crown and thickness. If working on conventional concrete without reinforcement, the paver can be equipped with a wheel to place tie bars for the longitudinal joint (continuously reinforced concrete pavement tie bars are not necessary). At the end of the paver, the edger squares off the edge of the fresh concrete.

## FILL IN THE BLANK(S):

**2-3.** Is the spreader usually part of the slip form paver or is it usually a separate machine?

_____.

## CIRCLE THE CORRECT WORD(S):

**2-4.** Tie bars are used in (conventional concrete / continuously reinforced concrete).

**2-9.** True

The next machine in the paving train is the longitudinal tube float with its burlap drag. The float makes three to four passes on a 45-degree diagonal and, as such, serves as a 10-foot straightedge. The burlap drags smoothes the surface and slightly textures it. Next, the transverse tines machine places transverse grooves in the plastic concrete. These tines are on ½" centers and groove the concrete at right angles to the centerline to a depth of 0.18 inch. Lastly, a separate curing machine applies white pigmented liquid curing compound to the surface of the concrete, at the specified rate of at least 1-gallon per 150 square feet of surface.

# MIXING CONCRETE

Concrete for slip form paving is usually mixed at a central mix plant and delivered to the paving site in side-dump trucks. From these trucks the concrete is dumped into or in front of the spreader and distributed across the full width of the roadway by means of an auger or saddle spreader as in form paving. The concrete may also be mixed in an on-site paver mixer as in form paving and deposited across the roadway by a bucket, which travels along the boom of the mixer. Transit mix concrete is also sometimes used on small pours.

## CIRCLE TRUE OR FALSE:

**2-5.** True False Transit mix, central mix, and dry batch concrete may be used in conventional and slip form paving.

The inspector must see that the maximum time limit between the addition of cement to the mix and depositing the concrete in place is not exceeded. The time limit varies depending on the type of haul truck used. When a non-agitator, side dump truck is used to deliver air-entrained concrete, the time limit is one hour.

## FILL IN THE BLANK(S):

**2-6.** When dry batching, or agitator trucks are used, the maximum time limit is _____.

In slip form paving the concrete mix should be similar to that specified when conventional paving methods are used. However, the concrete is usually somewhat stiffer (less water is added) than that used for conventional concrete. The concrete should be uniform in consistency and the slump not be less than 1-inch nor more than 2 ½ inches. In addition, concrete to be used for slip form paving requires the addition of an air-entraining admixture.

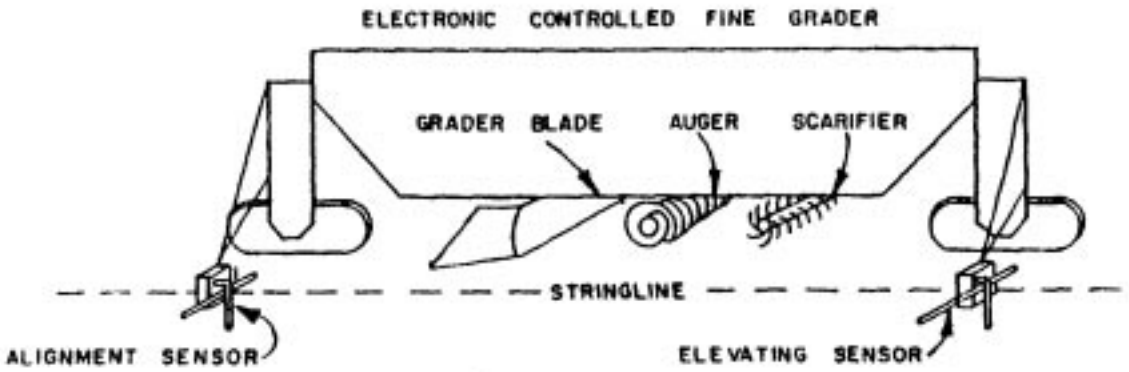
Fill in the blank(s):

**2-7.** The minimum slump allowed in slip form paving is _____ inch(es).

**2-8.** The maximum slump allowed in slip form paving is _____ inch(es).

# FINE GRADING

Slip form pavement is usually placed on a soil-cement base or on an asphaltic concrete base (black base). In slip form paving on soil-cement the fine grading is usually done with an electronic fine grader. The electronic fine grader with its cutting parts is shown below.




**2-11.** one (1)

With the grader moving from left to right, the first part to be used is the scarifier teeth that are rotated by a shaft. Then an auger on the next shaft is used to carry the excess material to one side of the grader. Lastly, the grader blade scrapes a smooth surface to the desired elevation and crown.

# CIRCLE TRUE OR FALSE:

**2-9.** True False Slip form pavement can be placed on cement stabilized base.

Electronic controls are used to achieve the required tolerances on soil-cement. These electronic controls keep the machine operating at the proper grade and in proper alignment. Notice that these electronic controls are against a stringline. A pair of stringlines is used to guide the fine grader.

+ One stringline controls alignment.
+ Both stringlines control elevation.

# FILL IN THE BLANK(S):

**2-10.** Elevation and alignment are controlled by _____.

For slip form paving on asphaltic concrete base (black base), the base shall be placed and spread in accordance with Specifications and plan dimensions. The spreaders used shall be of an approved type capable of spreading and finishing the base to the required line, grade and cross-section without the use of forms or side supports.

As stated earlier, slip form paving eliminates the use of stationary side forms by making use of forms that travel along with the paving train. The forms must be held together rigidly to prevent them from changing, thereby altering the alignment of the concrete. As in conventional pavement, the concrete is placed in one lift.

**2-5.** True

**2-6.** 60

**2-7.** one (1)

**2-8.** two and one-half (2 ½)

**2-12.** internal

**2-13.** depth gauge

---

## CIRCLE THE CORRECT WORD(S):

**2-11.** Concrete for slip form paving is placed in (one / two) lift(s).

# PAVING PROCESS

Depending on the type of equipment used, the concrete is either placed into or in front of the spreader. It is usually spread by means of an auger or paddles. When the concrete is deposited into the spreader, it is placed into the hopper that moves at a right angle to the centerline from one side of the roadway lane to the other side. An example of this type of operation is shown below. In this case, the spreader is operated electronically along a stringline.

The inspector must make sure that the concrete is dropped a minimum distance in order to avoid segregation. He must also spot check the depth of the concrete to see that too little or too much concrete has not been placed on the roadway. If any hand spreading is necessary, use shovels not rakes.

At the rear of the spreader is a flat strike-off bar. The bar levels the concrete behind the spreader as in conventional paving.

Immediately following the spreader is the slip form paver that has several pieces of equipment attached to it. At the front of the paver is an auger, which helps to distribute the concrete across the roadway. Then a strike-off bar again levels the concrete. This strike-off bar should be checked to see that it is level and at the correct height for the pavement. You will note in the picture on the previous page that a small roll of concrete is maintained in front of the paver. This prevents low spots or depressions from occurring. As stated earlier, this machine also travels


along a stringline.
Internal vibrators (tube or arm type) are located just behind the strike-off bar on the slip form paving machine. After the concrete is struck off it is compacted by these internal vibrators. Immediately behind the vibrators is the tamping bar. This bar tamps the large aggregate down into the concrete so that the flat pan drag will not expose pieces of large aggregate.

The inspector must check to see that all vibrators are in good working order. If any vibrator is not working, the inspector should have the contractor stop operations and replace the faulty vibrator immediately.

**2-10.** stringline

**2-14.** two, 1/2

**2-15.** deformed / 5/8

**2-16.** evenly

**2-17.** perpendicular

# CIRCLE THE CORRECT WORD(S):

**2-12.** (Internal / External) vibrators are used on the slip form paver.

The vibrators and the tamping bar that follows them are adjustable to pavement width and thickness. The concrete must be vibrated for the full width and depth of the slab. Tubes or working arms like those shown on the previous page accomplish the vibration.

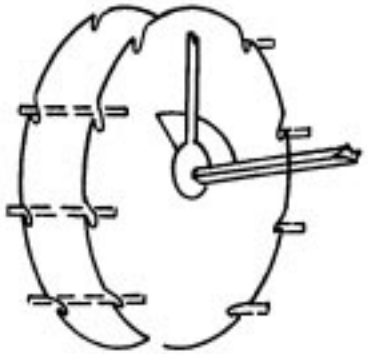
Just behind the vibrators and the tamping bar on the paving machine is a rigid float or flat pan drag that levels the concrete after vibration. A depth gauge is usually attached to the side of the rigid float. This depth indicator must be set to the desired slab thickness.

# FILL IN THE BLANK(S):

**2-13.** The inspector must make sure the _____ is set at the proper depth.

After the paver passes, the inspector must make sure the slab is the correct thickness by making a random check with a probe. The inspector must also make sure that the pavement is the proper width so that any correction can be made before the concrete sets up. (see inspector checking depth on previous page)

When slip form paving on conventional unreinforced concrete, the tie bars for the longitudinal joint are generally inserted after the flat pan drag has passed. This prevents the bars from being vibrated out of place. (When slip form paving on continuously reinforced concrete, no tie bars are necessary.) Some contractors have an arrangement whereby a rotating notched disc attached to the paver sets tie bars. When the tie bars are positioned in the notches, the rotating disc places them in the plastic concrete every 18 inches along the centerline at the required depth of half the pavement thickness.



## FILL IN THE BLANK(S)/CIRCLE THE CORRECT WORD(S):

**2-14.** Tie bars are placed at _____ foot intervals along the centerline and to a depth of (1/2 / 3/4) the thickness of the pavement.

**2-15.** Tie bars are made of (deformed / smooth) steel that is (5/8 / 1/2) inch in diameter.

Some contractors have a person standing on the back of the paver who places the tie bars at the proper interval and depth along the centerline. In both cases, the inspector must check to make sure that the tie bars are set at the proper spacing and depth.

(photo on previous page)

**2-20.** initial

## CIRCLE THE CORRECT WORD(S)

**2-21.** transverse

**2-16.** When the tie bar is placed properly, the centerline should divide the tie bar (evenly / unevenly).

**2-17.** The tie bar lies across the centerline in a (skewed / perpendicular) position.

Trailing at the rear of the slip form paver are the edgers, one on each side of the pavement. These devices smooth out and square off the edges of the pavement to the correct dimensions.

The inspector must periodically check with a straightedge to see that the edger is working properly. He must check to see that the edges are squared off and that the slump does not exceed ¼ inch in the 6-inches from the edge. If

the edger is creating a slump in excess of that specified, downward pressure on the edger can be adjusted to allow more concrete to remain at the top edge. In the picture above, an inspector is checking to see that the edger is operating properly.

## FILL IN THE BLANK(S):

**2-18.** The allowable slump at the edge of the concrete is _____ inch (es) in _____ inch (es).

## CIRCLE THE CORRECT WORD:

**2-19.** The edger (can / cannot) be adjusted to correct a slump that is outside of allowable limits.

The inspector's duties concerning joint setting, cleaning, sawing, and filling are the same as for conventional pavement.

Following the edger is the longitudinal tube float. As shown below, the float on this machine is set at 45-degree angle to the centerline. When additional water is needed for finishing, it comes out as a fine mist from the small sprinkle holes in the sprinkler above the round float. The inspector should check to see that there is no water dripping from the sprinklers and that there is no visible water on the surface of the concrete. The float makes three or four passes back and forth in order to smooth the pavement off and leave it at the desired grade. Also attached to the longitudinal float machine is a burlap drag. This burlap drag provides the initial concrete finish.

**2-24.** one (1)

**2-25.** 2 1/2

**2-26.** are

**2-27.** moving

**2-28.** per project plans

**2-29.** ¼; 6

**2-30.** tube-type

**2-31.** transverse tines

## CIRCLE THE CORRECT WORD(S):

**2-20.** A burlap drag provides the (final / initial) texture on concrete pavement.

The final finish for concrete pavement is obtained through the use of transverse tines. When slip form paving, a separate machine equipped with metal tines follows behind the longitudinal float. The tines on this machine are located on ½" centers and should make 3/16" deep grooves in the concrete (Specifications state the minimum depth shall be 1/8 inch). The inspector must check the tine machine to see that the tines are spaced correctly and that they groove the concrete to the correct depth. He must also make sure the tines groove the concrete for the full width of the pavement.

## CIRCLE THE CORRECT WORD(S):

**2-21.** Final finish is obtained by (transverse / longitudinal) tines.

The final phase of the slip form operation is curing. The curing procedure for slip form pavement is the same for conventional pavement. White pigmented liquid curing compound is distributed by a separate curing machine at the rate of at least 1-gallon per 100 sq. feet. The inspector must see that this requirement is met. He does this by checking the number of drums used to cover a certain distance.

## FILL IN THE BLANK(S):

**2-22.** The maximum number of square feet to be covered by one gallon of curing compound is _____.

A curing machine in operation is shown below; it should be a separate machine as pictured. Note the uniform coverage on the top and sides of the pavement.

One common problem encountered when applying the compound is stopped-up nozzles. The inspector must make

sure that the contractor's men keep the nozzles free of lint and fines so that an even application of the compound is possible. In addition, the inspector must see that the compound is agitated in the machine and that all of the concrete (both top and sides) is covered with the white curing compound so the surface will cure uniformly.

## CIRCLE THE CORRECT WORD(S):

**2-23.** The sides of the concrete (should / should not) be coated with curing compound.

**2-18.** ¼; 6 (six)

**2-19.** can

The inspection duties for slip form pavement pertaining to roadway layout, concrete placement, equipment adjustment, vibration, finishing, joints, final finish and curing are much the same as for conventional pavement. Of course, since stationary forms are not used, form inspection is not necessary.

Let's review

## FILL IN THE BLANK(S):

**2-24.** The minimum slump allowed on slip form paving is _____ inch(es).

**2-25.** The maximum slump allowed on slip form paving is _____ inch(es).

## CIRCLE THE CORRECT WORD(S):

**2-26.** Tie bars (are / are not) used in slip form paving on non-reinforced concrete.

**2-27.** Slip form paving uses (moving / stationary) forms.

**3-1.** three (3)

## FILL IN THE BLANK(S):

**2-28.** Transverse contraction joints are placed _____ in non-reinforced concrete.

**2-29.** A slump of not more than _____ inches in _____ inches is allowed at the edges of slip form pavement.

## CIRCLE THE CORRECT WORD(S):

**2-30.** (Tube-type / pan-type) vibrators are permitted in slip form paving.

**2-31.** (Burlap drag / Transverse tines) produce(s) the final finish for the pavement.

# CHAPTER III: TESTING

## ACCEPTANCE TESTING

Concrete pavement is accepted on the basis of thickness and compressive strength of hardened concrete cores, and conformance to surface tolerance requirements. The Materials Laboratory will determine thickness and compressive strength; you as an inspector must check conformance to surface tolerance requirements.
Pavement is accepted on a lot basis. The pavement is subdivided into separate lots consisting of approximately 5334 sq. yards of concrete pavement placed continuously except for overnight or other minimal discontinuation. Ramps may be set apart as separate and individual lots. Acceleration or deceleration lanes, wedges, or other variable width sections may be included in other lots provided total quantity of paving does not exceed 7500-sq. yards. Three production units will be randomly selected from each lot for strength determination tests.

A reduction in unit price of concrete pavement will be assessed for all yardage represented by each lot that does not attain the specified compressive strength.

The pavement is also divided into separate lots for the determination of acceptable tolerance of thickness. These units will be established based upon paving widths as follows:

| Pavement Widths | Unit Length |
|---|---|
| 1. 0.0 to 24.0 ft. | 1000 ft. |
| 2. 24.1 to 36.0 ft. | 750 ft. |
| 3. 36.1 to 48.0 ft. | 500 ft. |

One core will be taken per unit. If the thickness is not deficient more than 0.2 inches and not more than 1 inch, additional cores will be taken to establish the payment for the unit. Areas such as intersections, ramps, entrances, crossovers, etc. are grouped together to form a lot, although small irregular areas can be included with the roadway.

Pavement areas showing excessive surface deviations must be corrected prior to acceptance. After surface tolerance requirements are met, payment is based on the average thickness and compressive strength. However, pavement showing major deficiencies in thickness, strength, or surface finish must be removed and replaced by the contractor at his own expense.

**2-22.** 100

**2-23.** should

Air and slump determinations shall be made by the contractor at a frequency established to insure the quality of the concrete being placed, but not less than three of each test evenly distributed during the full day's work. If additional slump or air tests are deemed necessary during a day's pour to ensure uniformity, then these tests shall be run. An inspector's job is not complete by performing the minimum number of tests required.
Concrete, which does not meet the minimum slump and air content requirements of the specifications, will be rejected.

## CIRCLE THE CORRECT WORD(S):

**3-1.** The minimum number of slump tests that shall be done for a full day's work is (7 / 3).

**3-5.** foot plates

Concrete may be rejected based on slump and air tests; however concrete is accepted on the basis of conformance to surface tolerance requirements, pavement thickness, and compressive strength. These tests are in most instances conducted by the laboratory. The laboratory obtains the necessary cylinders from the project engineer and obtains the needed cores for testing thickness. The inspector must mold the cylinders needed for testing in accordance with the testing manual.

**3-6.** handles

# SLUMP TESTING

The slump test is used to verify concrete consistency. The slump for all Portland Cement Concrete Pavement shall not be accepted which has a slump value greater than 2 ½ inches. Concrete failing to meet this requirement will be rejected.

The slump test must be in accordance with GHD-27.

The slump will be checked at least three times for one day's work. The slump test is usually run at the same time as the air content test.

If it appears that the concrete is too stiff or too soupy, the consistency is off; this calls for additional slump testing. The slump test indicates variations in water content, aggregate gradation, or air content as well as errors in batching. Of these variations, a change in water content has the most pronounced effect on slump. If the concrete is outside of the allowable slump control limits, the inspector is to advise the contractor to bring the mix within the required ranges.

Sampling shall be done in accordance with GSP-17 contained in the Department's Sampling Manual.

A good way to collect a sample for the slump test is to place a wheelbarrow or other suitable receptacle at the end of the discharge chute of the mixer.

# FILL IN THE BLANK(S):

**3-2.** A receptacle should be placed under the _____ of a mixer to collect the sample.

The following sampling requirements should be followed:
1. Use the sample within 15 minutes after collection.
2. Protect the sample from the sun and wind until used.
3. Remix the sample with a shovel the minimum amount to ensure uniformity.

# CIRCLE THE CORRECT WORD(S):

**3-3.** A slump test sample (should / should not) be used 30 minutes after it is collected.

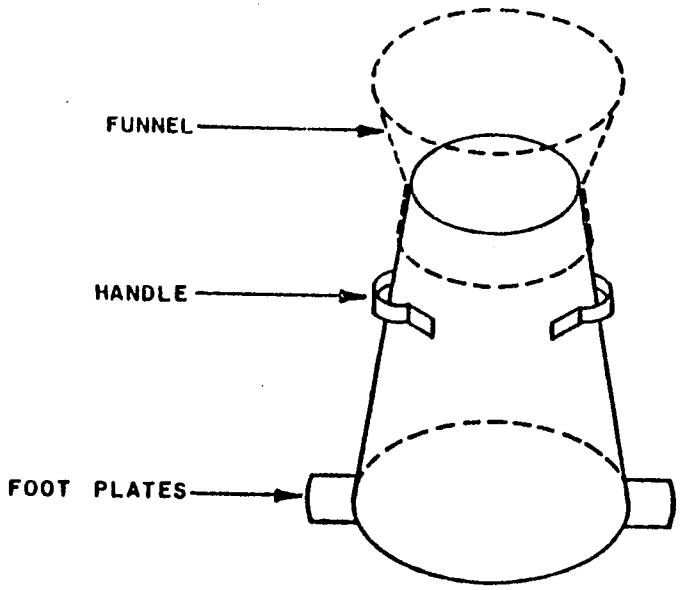
**3-4.** A slump test sample (should / should not) be placed in the sun until used.

**3-9.** volume

**3-10.** 25

**3-11.** on

Now, let's look at the equipment you use for the slump test. You use a 12-inch high metal mold like the one shown below. It must be mortar tight.



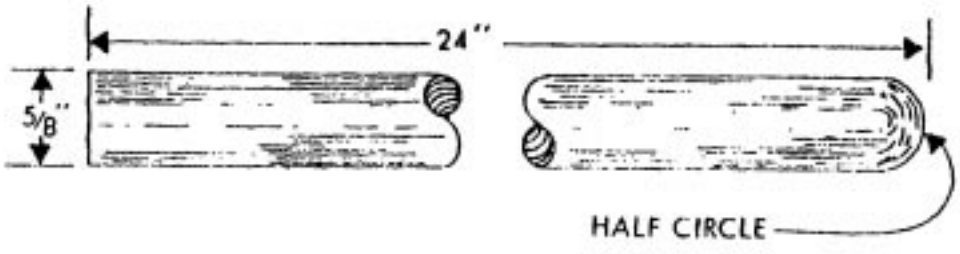

The mold must be provided with footplates. By standing on the foot plate you can hold the mold down firmly against the nonabsorbent baseboard. The handles near the top of the mold are used to lift it off the concrete specimen. A funnel should also be provided with the mold. The funnel will aid in filling the cone, eliminate spillage, and reduce the time required for the test.

## FILL IN THE BLANK(S):

**3-5.** To hold the mold down firmly, you stand on the _____.

**3-6.** To lift the mold you use the _____.

You also need a tamping rod. It is a 5/8-inch diameter rod, 24" long, with one end rounded to a hemispherical tip. Do not use a reinforcing bar as a tamping rod.




**3-2.** discharge chute

**3-3.** should not

**3-4.** should not

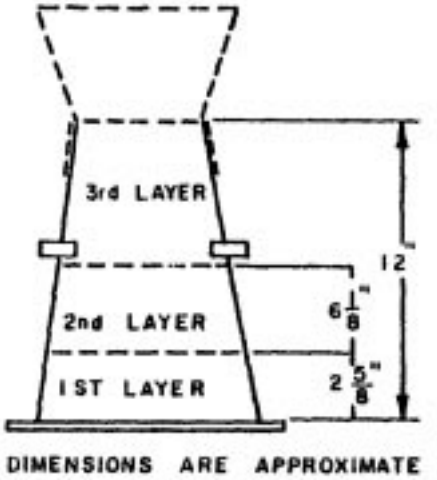
Here's how you run the test. Start by dampening the slump mold and placing it on the baseboard. Do not leave any water standing on the baseboard. The mold must be held firmly in place during filling by standing on the two foot plates.

## CIRCLE THE CORRECT WORD(S):

**3-7.** The slump mold should be (wet / damp / dry).

**3-8.** The foot plates should be attached to the (mold / baseboard).

Place the funnel on the mold. Then place the fresh concrete evenly in the funnel with a hand scoop. Mold the sample in three successive layers. It is important that each layer be of approximately equal volume.




Each layer must be rodded with the tamping rod 25 times. The funnel remains on the mold while rodding.

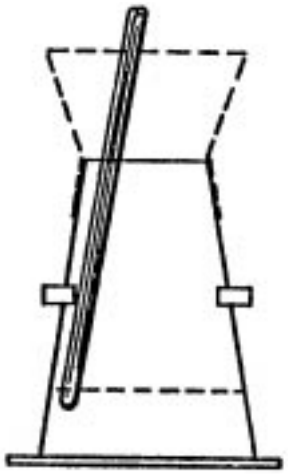
# FILL IN THE BLANK(S):

**3-9.** All 3 layers are of equal _____.

**3-10.** Each layer is rodded _____ times.

**3-11.** The concrete is rodded with the funnel _____ the mold.

The strokes must be distributed uniformly over the cross-section of each layer. It will be necessary to incline the rod slightly. This will consolidate the mixing near the edge of the cone for the bottom layer.



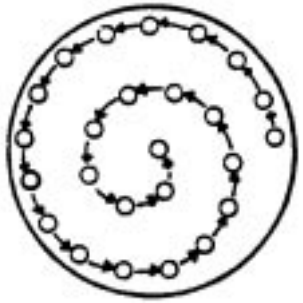
**3-7.** damp

**3-8.** mold

## CIRCLE THE CORRECT WORD(S):

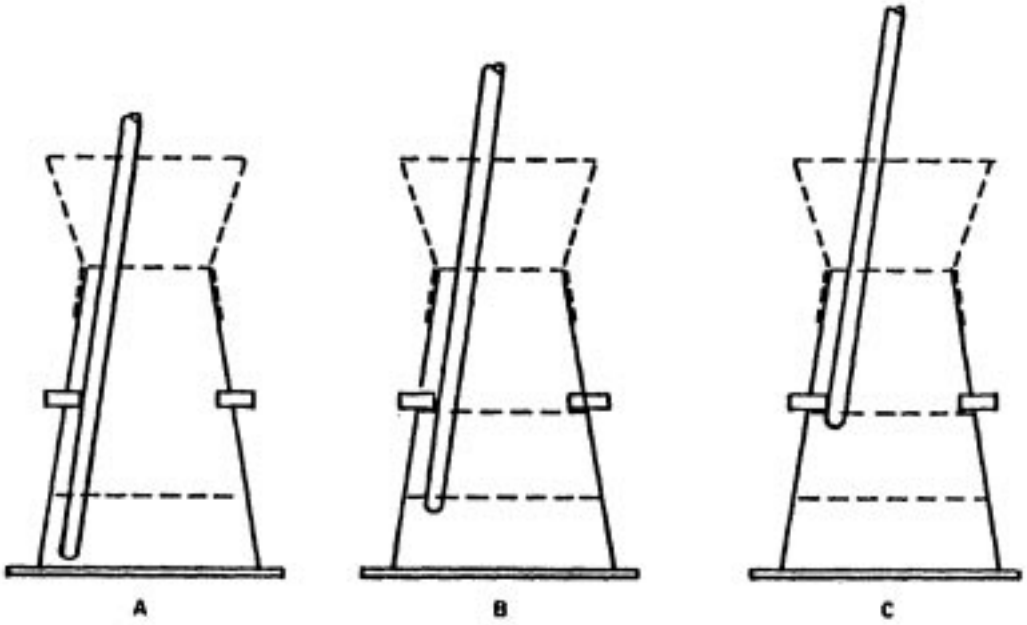
**3-12.** The rod should be inclined towards the (edge / center) of the mold.

Approximately half the strokes should be near the edge. The remainder of the strokes should be in a spiral pattern near the center.



The bottom layer should be rodded throughout its depth. The remaining layers should be rodded throughout their depths so that the strokes just penetrate the layer beneath.

**3-16.** straight up



## CIRCLE THE CORRECT WORD(S):

**3-13.** The drawing above that illustrates how the bottom layer should be rodded is (A / B / C).

Heap the mix above the mold on the last layer before rodding. Maintain an excess of mix at all times while rodding. When rodding is complete remove the funnel and strike off the excess concrete with tamping rod. Use a rolling, screeding motion across the top of the mold.

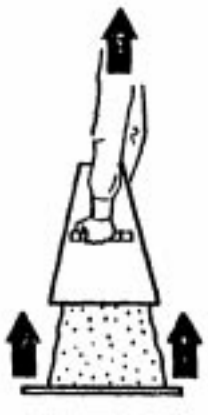
## FILL IN THE BLANK(S):

**3-14.** Strike off the excess concrete from the top of the mold with a _____.

**3-15.** Strike off the excess concrete with the funnel _____.

**3-12.** edge

Then remove the mold immediately. To do this you stand directly over the mold. Grasp the two handles and carefully raise the mold straight up. Do not rotate or move it sideways. The mold must be raised in approximately 5 seconds.



## CHOOSE THE CORRECT WORD(S):

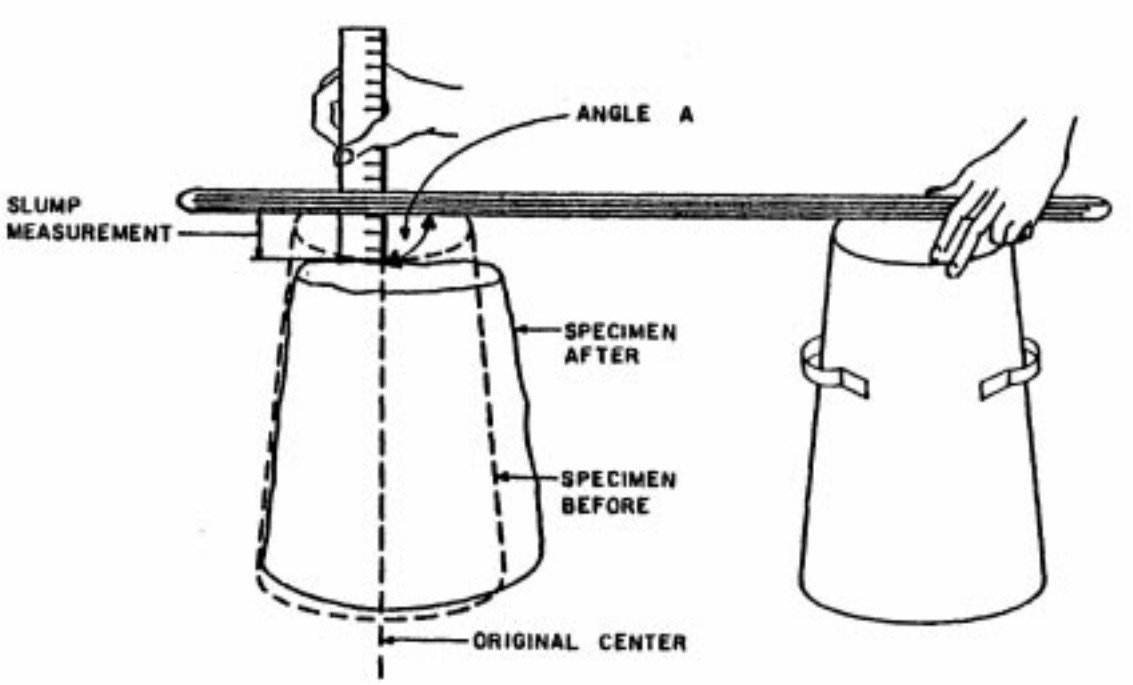
**3-16.** You should raise the mold which of the following ways?
a. sideways
b. in a rotating manner
c. straight up

Now you are ready to measure the slump.

Set the mold on the baseboard next to the specimen. Lay the tamping rod on the top of the mold so that it projects horizontally over the specimen. Hold the rod so that it does not roll off. Measure straight down from the underside of the rod to a point on top of the specimen. This point must be directly above the original center of the specimen. Read the ruler to the nearest ¼ inch.

**3-20.** consistency

**3-21.** water



## CIRCLE THE CORRECT WORD(S):

**3-17.** When the measuring ruler and tamping rod are positioned properly, angle "A" in the picture would be approximately (45 / 90) degrees.

**3-18.** Measure straight down from the (bottom / top) of the tamping rod to a point directly above the (present / original) center of the specimen.

There is a maximum time limit on the slump test. The entire operation from the start of the filling through the removal of the mold shall be carried out without interruption and shall be completed within 2 minutes.

Always clean the concrete from the equipment immediately after each test. Use a brush or cloth and some water for this purpose.

You should record the slump measurement to the nearest ¼" for central mix, transit mix, and dry batch concrete on the Roadway Inspector's Daily Report. The slump measurement for transit mix concrete is also recorded on the D.O.T. 319.

## CIRCLE THE CORRECT WORD(S):

**3-19** You record the slump measurement to the nearest (1/4 / 1/2) inch.

**3-13.** A

**3-14.** tamping rod

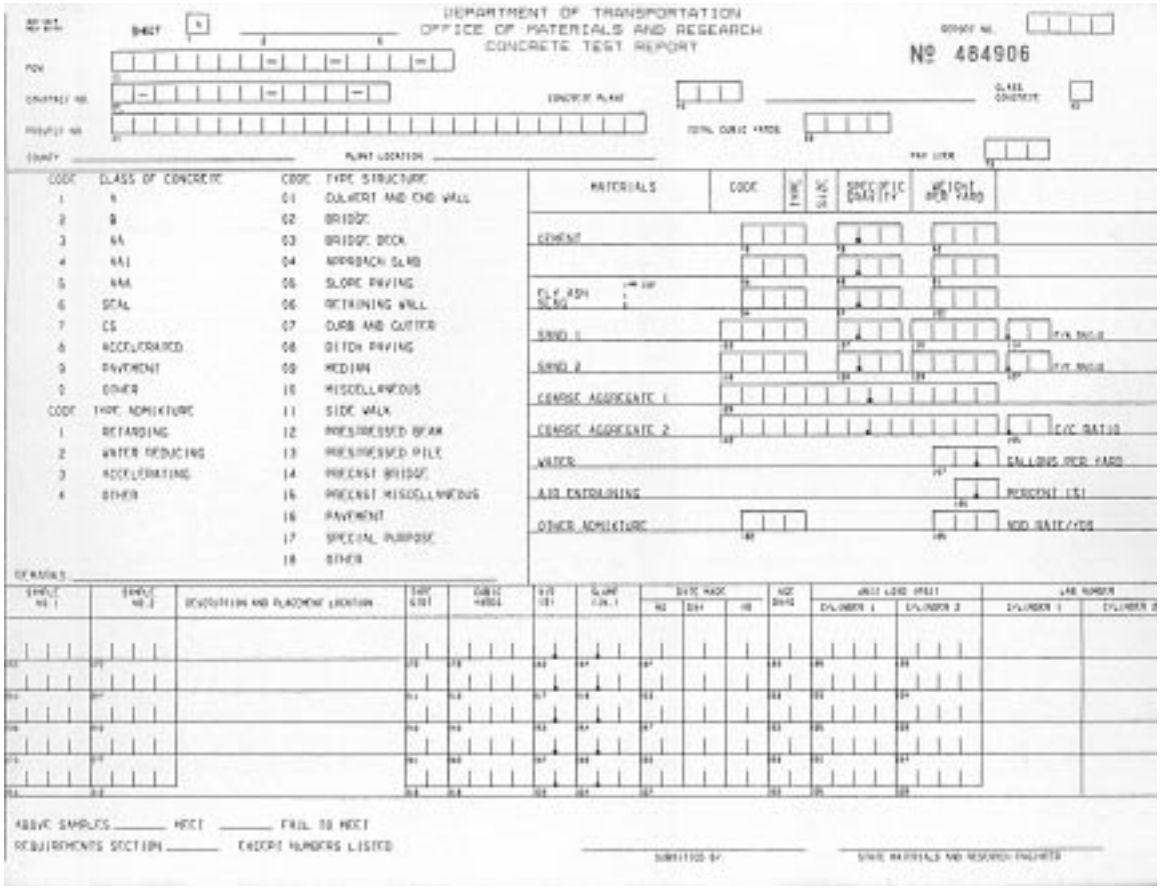
**3-15.** off

**3-33.** is

**3-34.** 28

**3-35.** 112

A DOT 319 Form is shown below:




Let's see if you learned anything about running a slump test.

## CIRCLE THE CORRECT WORD(S):

**3-20.** The slump test is a measure of (consistency / cement content).

**3-21.** A variation in (water / cement) content has the most effect on slump.

**3-22.** Slump tests at the job site are usually used for (verification / acceptance) of the concrete mix.

## FILL IN THE BLANK(S):

**3-23.** The slump and _____ tests may be run on different portions of the same sample.

**3-24.** The tamping rod used for a slump test has a _____ tip and is _____ inch in diameter.

**3-25.** The concrete should be placed in the mold in _____ layers of _____ volume and rodded _____ times per layer.

**3-26.** While rodding, the rod should be inclined towards the _____of the mold.

**3-27.** Half the strokes should be near the _____ and the remainder in a _____ pattern near the center.

## CIRCLE THE CORRECT WORD(S):

**3-28.** All layers should be rodded (halfway through / throughout) their depth.

**3-29.** Remove the mold from the concrete by pulling it straight up and (rotating / not rotating) the mold.

**3-30.** Measure from the underside of the rod to a point directly above the (center / original center) of the specimen.

## FILL IN THE BLANK(S):

**3-31.** The slump test must be complete within _____ minutes.

## CIRCLE THE CORRECT WORD(S):

**3-32.** The time is measured from the (start / finish) of the filling of the mold to the (start / finish) of the removal of the mold.

**3-17.** 90

**3-18.** bottom; original

**3-19.** 1/4

A slump range is specified for each "class" and "type" of concrete. If the batch of concrete falls outside the slump range required by the Specifications, adjustments have to be made in the amount of mixing water to be used. Although such adjustments are the contractor's responsibility, it may prove helpful to know how to adjust the slump.

## CIRCLE THE CORRECT WORD(S):

**3-33** The amount of mixing water (is / is not) directly related to the slump of the concrete.

Rule of Thumb

| Slump Change = | Water Change |
|---|---|
| + 1 inch = | + 1 gallon / cu. yard concrete |
| - 1 inch = | - 1 gallon / cu. yard concrete |

Let's say you are working with "Type B" concrete with a slump requirement of 1 to 2 ½ inches. You may mix a 7 cu. yard batch using 140 gallons of water. You run a slump test that shows test a 6-inch slump.

## FILL IN THE BLANK(S):

**3-34.** The number of gallons of water you would reduce the mix by in order to get a 2-inch slump is _____.

**3-35.** The total number of gallons you would use is _____.

**3-36.** 25

**3-37.** closed

**3-38.** should

**3-39.** runs out of the petcock

# AIR TESTING

Air tests must be run to see that the proper amount of entrained air is in the concrete. As you learned previously the proper amount of air entrainment ensures the workability and durability of the concrete mix. The air tests are run using the pressure method. This method of text covers determination of air content of freshly mixed concrete. This method is adequate for all concretes except concrete containing lightweight or highly porous aggregates. Air tests on concrete containing highly porous or lightweight aggregates must be conducted in accordance with GHD-32, Air Content of Freshly Mixed Concrete by the Volumetric Method.

The apparatus shall consist of the following:
1. Material container
2. Lid Assembly
3. Tamping rod
4. Strike off bar
5. Carrying case

The picture below shows the entire apparatus.

**3-22.** verification

**3-23.** air content

**3-24.** rounded; 5/8

**3-25.** three (3); equal; 25

**3-27.** edge spiral

**3-28.** throughout

**3-29.** not rotating

**3-30.** original center

**3-31.** two (2)

**3-32.** start; finish

Test Procedure
Place concrete to be tested in material container (1) in three equal layers. Rod each layer 25 times, performing slump test. Tap the outside of the material container after each layer of concrete is rodded. Excess concrete should be removed by sliding strike off bar across the top flange, using a sawing motion, until container is just level full. Wipe lip of container clean of all sand and mortar. Close main air valve on top of air receiver. Open both petcocks on top of lid.

## CIRCLE THE CORRECT WORD(S):

**3-36.** Each layer of material must be rodded (25 / 50) times, as it is placed.

**3-37.** The red colored air valve must be (closed / open).

**3-43.** ½"

Place lid (5) on material container and close the four toggle clamps (6). Pour water into funnel (7) until water comes out petcock (8) in the center of lid. Jar meter gently until no air bubbles come out through center petcock. Close both petcocks (8 & 9).

**3-44.** should not

## CIRCLE THE CORRECT WORD(S):

**3-45.** C, A, B, D, F, E, G, H, I, J

**3-38.** The four toggle clamps (should / should not) be closed.

3-39 Water should be poured into the container until it (is half full / runs out of the petcock).

Close air bleeder valve (10) in end of air receiver and gently pump air into receiver until gauge hand (12) comes to the vicinity of the red line. A little to one side or the other will make no difference as long as the hand has gone past the initial starting point.

## CIRCLE THE CORRECT WORD(S):

**3-40.** The gauge hand (should / should not) be in the vicinity of the red line.

Tap the gauge gently with one hand and at the same time, crack bleeder valve until gauge hand rests exactly on the initial starting point. Then quickly close bleeder valve. Open main air valve between air receiver on the material container. Jar container slightly when pressure is on, to allow for possible arrangement of particles. Tap gauge gently until hand comes to rest. This reading is percent of air entrained.

In cases where voids in the aggregate are appreciable and it is desired to deduct their volume from the measured air content, deduction can be determined by placing the amount of each size of aggregate used in the test in the material container, filling the container with water and completing the regular determination for air content. This reading is the aggregate correction factor.

Your Air Meter should be checked for accuracy on a regular basis. The method for performing a field check of you meter is found in Vol. 1 of the Field Sample and Testing Manual under GHD-26.

## CIRCLE THE CORRECT WORD(S):

**3-41.** You will find the procedure for field testing your air meter in (GHD-26 / GHD-17).

Always close main air valve before releasing pressure from either material container or air receiver. Failure to close valve will cause water to be drawn into air receiver and future measurements will be in error. Should water be drawn into air receiver, open bleeder valve in end of the receiver and tap lid so that the water runs out the bleeder valve. Several strokes of the pump handle will blow out the last traces of water.

## CIRCLE THE CORRECT WORD(S):

**3-42.** If water is drawn into the air receiver future measurements (will / will not) be in error.

The main air valve has a clutching device in the knob which allows the handle to slip, preventing application of excess pressure to valve needle and seat. If, after extensive usage, the clutch should loosen, close the valve as far as it will go and give the split-nut on top a fraction of a turn clockwise. This will give added friction to the clutch and assure positive closure of the needle valve without damage. The gauge hand should not exceed ½" beyond red line limit. Release pressure on meter before opening toggle clamps.

# CIRCLE THE CORRECT WORD(S):

**3-43.** The gauge hand should never exceed (1/2" / ¾") beyond the red line limit.

**3-44.** The toggle clamp (should / should not) be opened before pressure on the meter is released.

Let's review

**3-45.** The major steps in running an air test are listed below. Place them in the correct order.

| | |
|---|---|
| _____ 1. | A. Rod each layer of material 25 times |
| _____ 2. | B. Close main air valve (red colored) |
| _____ 3. | C. Place concrete in material container |
| _____ 4. | D. Close four toggle clamps |
| _____ 5. | E. Pump air into receiver |
| _____ 6. | F. Pour water into funnel until water comes out of petcock |
| _____ 7. | G. Tap gauge gently until hand comes to rest |
| _____ 8. | H. Jar container while pressure is on |
| _____ 9. | I. Read gauge to get percent of air entrained |
| _____10. | J. Clean all your equipment |

**3-48.** 1/8 inch

**3-49.** 14

**3-50.** 2/10 inch

**3-51.** 100

**3-52.** six (6)

## SURFACE TEST (ACCEPTANCE)

As soon as the concrete has hardened sufficiently, the inspector checks the surface of the pavement and approach slabs for conformance to surface tolerance requirements. Acceptance of the concrete pavement is based in part on conformance to surface tolerance requirements; therefore, surface testing is an important part of the pavement inspector's job.

## CIRCLE THE CORRECT WORD(S):

**3-46.** Surface testing is done for (verification / acceptance) purposes.

The mainline riding surface shall produce a Roughness Index Value which does not exceed 65 for each travel lane. These tests shall be conducted in accordance with procedures outlined in GHD-93. These tests shall be conducted before transverse contraction joints are sealed. Lanes less than ½ mile in length which are added to mainline pavement shall meet the roughness index requirements of ramps.

## CIRCLE THE CORRECT WORD(S):

**3-47.** Mainline riding surface shall meet a Roughness Index of (56 / 65).

Mainline pavement may be subjected to rolling straightedge tests in addition to testing by GHD-93. These tests shall be conducted in the wheel paths of each lane. Areas found to deviate from the plane of the rolling straightedge by more than 1/8" in 10 feet shall be corrected. The engineer, at his discretion, may request use of the Rainhart Profilograph to aid the use of a rolling straightedge in isolating locations of individual bumps or depressions.

**3-40.** should

**3-41.** GHD-26

**3-42.** will

## CIRCLE THE CORRECT WORD(S):

**3-48.** Deviations of more than (1/8 inch / ½ inch) in 10 feet will be corrected.

Ramps, acceleration lanes, and deceleration lanes shall produce a Roughness Index Value of 14 inches/mile as tested by the Rainhart Profilograph in accordance with procedures outlined in GHD-78. In addition, individual bumps or depressions exceeding 2/10 inch from the blanking bank on the profilograph trace shall be corrected.

## CIRCLE THE CORRECT WORD(S):

**3-49.** Ramps shall produce a roughness index of (14 / 55) inches per mile.

**3-50.** Individual bumps or depressions exceeding (2/10 inch / ½ inch) shall be corrected.

**3-55.** completely

**3-56.** dry

Planing or other approved methods shall correct pavement not meeting the preceding requirements.

For Class I and Class II roads, the approach slabs and 100 feet of the roadway approaching each end of the bridge shall be subjected to smoothness tests using the Rainhart Profilograph. A profile index value shall be determined in accordance with test method no. GHD-78, using the 1/10" blanking band. Profiles will be obtained in safety areas to within 6-feet of barrier or curb line. The profile index shall not exceed 15 for each wheel path. In addition, the surface shall meet a 1/8-inch in 10-foot straightedge check made transversely across the approach slab or pavement structure.

## CIRCLE THE CORRECT WORD(S):

**3-51.** (300 / 100) feet of the roadway approaching a bridge will be tested for smoothness.

**3-52.** Profiles will be obtained in safety areas to within (10 / 6) feet of the barrier or curb line

It shall be the roadway contractor's responsibility to meet the profilograph readings at the joint between the

approach slab and roadway pavement. Final riding surface shall comply with section 430.04 and section 500 of the Specifications. Bumps with a profile base line of 5 feet or less may be corrected with a bump grinder. All roadway surfaces and approach slabs that are planed shall be subject to retesting using the profilograph to insure the profile index does not exceed 15. All corrective action for riding quality shall precede final surface texturing.

## CIRCLE THE CORRECT WORD(S):

**3-53.** It is the (roadway / bridge) contractors responsibility to meet the roughness requirements at the joint between the roadway and the approach slab.

Expansion joint installation shall be delayed and the joint temporarily bridged to facilitate operation of the profilograph and planning equipment across the joint wherever feasible.

It shall be the responsibility of the contractor to schedule profilograph testing. Requests for testing shall be made at least 5 days prior to need. The contractor shall insure that the area to be tested has been cleaned and cleared of all obstructions.

**3-46.** acceptance

There will be no additional payment for required planing or grinding to bring pavement into compliance with the specifications.

**3-47.** 65

In no case shall bar cover on concrete paving or approach slabs be less than 1½ inches after planing or grinding.

## CIRCLE THE CORRECT WORD(S):

**3-54.** Reinforcing steel shall never be covered with less than (1½ inch / 1 inch) of concrete after grinding.

# FINAL SURFACE FINISH

According to Specifications, the final surface finish on PCC pavement will have grooves an average depth of .035 inch with a minimum depth of .018 inch. This depth is to be checked in accordance with GHD-72. Therefore, let's take a look at this testing procedure.

The apparatus needed shall consist of the following:

1. Sand spreading tool consisting of a 2 ½" diameter flat disc with a 1/16" thick hard rubber disc of the same diameter attached to one face and a short dowel serving as a handle attached to the other face.
2. Metal cylinder with a volume of 1.5 cu. inches as calibrated with a burette reading to .1 ml to the nearest ml.
3. Natural silica sand from Ottawa, Illinois graded to pass a 50 sieve and retained on a 100 sieve.
4. A ruler,12-inches long with markings in divisions of every 0.1 inch.
5. Wire brush and soft hand brush.

Fill the cylinder to the top with dry sand and gently tap the base of the cylinder three times on a rigid surface. Add more sand to fill the cylinder again to the top and level the top with a straightedge. The pavement surface selected for test must be dry. If the concrete pavement has not been subjected to traffic, scrub the test surface with a wire brush to remove any loosely bonded particles or curing compound that will be worn away by a small amount of traffic. Otherwise the pavement surface should be swept with a soft hand brush.

# CIRCLE THE CORRECT WORD(S):

**3-55.** The cylinder should be filled (half / completely) full with dry sand.

**3-56.** The pavement surface must be (wet / dry) when the test is accomplished.

Pour the measured weight of sand on the test surface and spread it with a rubber disk spreading tool into a circular patch with the surface depressions filled to the level of the peaks. The sand spreading tool should be kept flat on the surface and moved in a circular motion. Avoid losing any sand, especially during windy conditions. Sand used for one test should no be reused for another test.

## CIRCLE THE CORRECT WORD(S):

**3-57.** The sand (should / should not) spread in such a way as to fill the depressions to the level of the peaks.

**3-58.** Sand (may / may not) be used for more than one test.

Let's review

## FILL IN THE BLANK(S):

**3-59.** The surface finish shall be a minimum depth of _____ inches.

**3-60.** The cylinder used to measure the sand for the surface test must be filled _____

**3-61.** The diameter of the sand patch must be measured in _____ or more places.

**3-62.** The diameter measurement of the sand patch shall be to the nearest _____ inch.

**3-53.** roadway

**3-54.** 1 ½ inch

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**3-57.** should

**3-58.** may not

**3-59.** 0.018

**3-60.** completely full

**3-61.** four (4)

**3-62.** 0.1