4-16.1 Slip-Form Method

Spread concrete is consolidated by vibration or a combination of vibration and tamping. Internal vibration may be performed by either horizontal tube or multiple spud-type vibrators. The location of vibratory units and their operating amplitude and frequency is not a hit and miss proposition. The contractor should not be allowed to indiscriminately alter the location of vibrators without the technical advice of the paver manufacturer. Tube-type vibrators are required to have not less than 5,000 impulses per minute and internal spud-type not less than 7,000 impulses per minute unless modified by the manager. Frequency may be checked by the use of a vibrating-reed tachometer which, when placed in contact with the vibrator, will vibrate at the same frequency as the vibrator. The frequency may then be read on a scale in revolutions per minute and directly compared to standard spec 415.3.1.3.

The slab is shaped behind the vibrators by a conforming plate or oscillating screed that is adjustable for various crowns. A preliminary surface finish is imparted to the concrete through this shaping action. Following these screeds or plates, the concrete is given a final mechanical toweling, usually by a pan float.

The finished slab should be checked for proper crown as soon as possible after start up of paving operations and periodically thereafter.

In conjunction with this operation, it is appropriate to note several aspects of slip-forming that are frequently the subject of discussion. The first of these is edge slump. Since edge slump is to some extent a function of the mix consistency, it is necessary to use relatively stiff concrete, with a slump less than 2-1/2 inches. In addition to mix consistency, the method and length of trailing form has some effect on edge slump. Different types of pavers employ different forming methods, but it has been conclusively shown that long lengths of trailing forms are not necessary to prevent this slumping; indeed, longer lengths may be a contributing factor. A rule of thumb is to use the shortest length of trailing form that will give satisfactory results.

Standard spec 415.3.11.8.4 permits an edge slump tolerance, exclusive of edge rounding, of 3/8 inch or less where an adjacent lane or ramp is not to be constructed, and 1/8 inch or less where an adjacent lane or ramp is to be constructed. Edge slump greater than these figures should be corrected before the concrete hardens.

The paver should push a roll of concrete about 6 inches high ahead of the strike off so no low areas with deficient density result. On super-elevated sections, the roll should be about 12 inches high. The correct depth of concrete should be checked at three or more points across the slab width. A finishing bridge will allow taking measurements.

The inspector should check that the centerline tie bars are being inserted at the correct alignment, spacing, and depth. Normally, a mechanical inserter is required, but the engineer may approve manual insertion.

Bent steel reinforcing tie rods will be mechanically inserted at this time into the sides of the slab if curb and gutter or adjacent slabs will be poured later. Check for correct longitudinal spacing and depth from top of slab and that they are parallel with top surface of the pavement so they do not protrude or bulge the surface. The steel should be in full contact with the concrete with no voids below or around the rod. After the concrete hardens, the inspector should make sure the contractor straightens the bent rods so that they are as straight as possible.

Concrete with a slump which is too low can also create problems. Because of the relatively large area of the screed on slip-form pavers, very low maximum unit pressures can be developed on the concrete under the screed. Thus, when low slump concrete with less than 1 inch slump is used, the paver has a tendency to float up above the desired grade. The contractor may need to employ additional measures to provide grade control and maintain a smooth pavement.

Rain can produce severe damage to a slip-formed pavement. Although the contractor is responsible for any rain damage, the potential severity of this damage in a slip-form operation is reason for the inspector to be especially conscious of forecasted rain. The specifications require the contractor to have adequate protective covering material, including side forms, for use as pavement protection in case of rain. The inspector should ensure that such materials are available. The contractor is allowed to refinish rain-damaged portions of pavement by re-dragging or re-tining the concrete while in the plastic state. Refer to CMM 4-24.

4-16.2 Form Method

Consolidation of the concrete is usually accomplished by the use of mechanical finishing equipment. The specifications permit the use of vibratory equipment as an option to the mechanical finishing equipment. In the

construction of continuously reinforced concrete pavements, the use of vibratory equipment is required.

4-16.2.1 With Mechanical Finishers

The contractor will adjust the transverse finishing machine screeds to produce the crown in the pavement. The finished slab should be checked for proper crown as soon as possible after start up of paving operations and periodically thereafter. The screeds are normally tilted to improve density and finish of the concrete. The front screed is usually tilted about 1/8" and the rear screed is usually flat or only slightly tilted.

For oscillating screeds, the stroke and forward speed are adjusted for the mix. For stiff mixes, the stroke is long and rapid and the forward speed slow, so as to work up mortar for finishing. For softer mixes, the stroke of the screed is short and slow and the forward machine motion more rapid to prevent work up of too much mortar and water to the surface. The wheels of the finisher should be clean and not riding on concrete on the forms.

4-16.2.2 With Vibratory Equipment

The vibratory equipment for general consolidation of the pavement concrete is of two types: the internal or spud type and the external or pan type. The internal type consists of a series of spud vibrators, having a minimum of 7,000 impulses per minute arranged on a framework that permits control of the depth and angle of insertion into the concrete. The pan-type vibrator is generally a cellular, T-shaped bar, whose under surface is elliptical in shape. It should be slightly shorter than the pavement width so as not to come in contact with the side forms. It is required to have a minimum of 4,000 impulses per minute, unless modified by the engineer. The vibrator pan acts across the pavement as a unit, and the direction of the vibratory impulses is vertical. To be uniformly effective there should be a slight excess of concrete ahead of the pan at all times to ensure that it is in full contact with the concrete surface.

Both types of vibratory equipment are operated attached to either the mechanical spreader or the finishing machine. The vibrating is done after strike-off and preceding the screeding of the concrete and only when the machine is in forward motion. To preclude over vibration of the concrete, the vibration is limited to one pass of the machine, unless directed otherwise by the engineer.

The vibratory screed is a modification of the pan-type vibrator and is intended principally for use in hand finishing operations, where hand finishing of concrete pavement is permitted. It may be either a metal or wooden screed to which is attached a small power unit which provides the vibratory action to the screed. It is used to strike off and consolidate the concrete. It should be restricted to not more than two passes, each pass being made with a uniform forward motion. The second pass should be made with a slight roll of concrete in front making sure the screed is held firmly to the forms so a smooth, uniform surface results. It should not be permitted to remain in one position long enough to bring an excess amount of mortar to the surface. The screed should be held at right angles to the surface with the screed in full contact.

Vibration, when properly controlled, is a very effective means of attaining well-consolidated concrete. However, the uncontrolled use of a vibrator may result in bringing an excess of mortar to the surface, which generally is detrimental to the production of sound concrete. Where the general consolidation of the pavement concrete is by the finishing machines, the hand operated internal spud vibrator can be used to good advantage in consolidating the concrete at locations where the use of the finishing machine is restricted, such as connections to a bridge deck, around manholes, at transverse joint dowel assemblies, or along the forms. Honeycombed concrete is objectionable at these locations, and the proper and judicious use of a vibrator can help to achieve thorough consolidation.

When using an internal type hand vibrator, the vibrator head should be slowly inserted into the concrete and withdrawn before over vibration of the concrete occurs. It should then be moved to a new location and the procedure repeated until the desired area has been completely vibrated.

The operating frequency of external pan vibrators, internal tube vibrators and internal speed vibrators can all be checked with a vibrating reed tachometer available through the region office. The tachometer gives a frequency reading in revolutions per minute, which is equivalent to vibrations per minute or impulses per minute.

Where the general consolidation of the pavement concrete is performed with vibratory equipment, the slump of the concrete is limited to a maximum of 2-1/2 inches. However, when the mix design or the type and gradation of the aggregates produce a workable or plastic mix, the slump may often be reduced without creating serious finishing problems.