

Internal Vertical Movement Devices and Foundation Base Plates

General Considerations- Internal measurement devices generally consist of two major types: those that are placed within a structure during construction or as it is being build, and after construction within a drill hole. The devices are used to measure total or relative horizontal, vertical, or rotational movements or differential movements in any desired plane. Vertical movements, which indicate settlements of the embankment, are commonly the result of consolidation of foundation soils or embankment materials. Internal vertical movement (IVM) devices and base plates (BP) are installed within or below a structure during construction to monitor these movements. The settlement plate installation (SP) can be installed during construction or after construction using a drill hole to measure foundation settlement.

Description of system- Internal vertical movement and base plate devices used a simple combination of two different sizes of steel pipe. A 2-inch diameter pipe was used as the main standpipe and a 1 and ½-inch diameter pipe was used as the sliding or measurement point. The IVM measurement points were installed in either 5 or 10-foot intervals based on the height of the embankment. At each measurement point a two-foot long piece of steel channel iron was attached to the 1 and ½-inch steel pipe and placed against the previously compacted embankment materials. All open joints between the two different sizes of steel pipe were sealed with oakum.

Base plates were made from similar materials as the IVM. The base plate measuring point was typically installed at the contact of the foundation materials and the embankment materials being constructed. The base plate measurement point consisted of 1½-inch steel pipe with a two-foot piece of steel channel iron attached to it. Attached to the steel channel perpendicular to the steel pipe were two, 2 feet by 2 feet and ¼-inch thick steel plates. The plates were installed against the natural ground surface where the settlement is measured. Two-inch diameter steel pipe was than extended to the surface of the embankment as it was being constructed. The open joints between the two different sizes of steel pipe near the measurement point were sealed with oakum. All other pipe joint were screwed together completely.

When it is necessary to get foundation settlement data and a base plate installation is not possible to install, than a settlement plate can be used. A settlement plate 3-feet by 3-feet by ½-inch is installed at the contact of the foundation materials and the embankment materials. The plate is surveyed for station, offset, and elevation and than it is covered by one foot of sand. The embankment is then constructed without the problems of a riser pipe being in the way of construction equipment. Once the dam has been constructed, drilling should be conducted using a

hollow stem auger with a minimum inside diameter of 2-inches should be used. Drill to contact the embedded steel settlement plate. During drilling, the vertical alignment of the drill rig must be monitored by surveying or some other means making corrections to the drill rigs' vertical alignment as necessary. Drill to locate the top of the settlement plate. Once the plate has been located, install 1-inch schedule 80 PVC pipe coupled together with internal couplings, to the top of the steel settlement plate. Wash the hole if necessary to allow the PVC pipe to rest on top of the steel plate. Install 1/4-inch steel pipe inside of the 1-inch PVC pipe, this steel pipe must rest on top of the steel plate. Use standard pipe couplings to couple the 1/4-inch pipe together to reach the steel plate. The smaller pipe must be sticking above the surface of the 1-inch PVC at the collar of the drill hole once it has been installed. The smaller pipe will be used to take all future measurements and the length of the pipe installed from the finished surface to the top of the steel plate must be measured during installation. The measured length is used to calculate the elevation of the settlement plate after installation is completed. Pull the hollow stem auger and PVC pipe back from the top of the settlement plate approximately 1-foot and backfill the drill hole with 1-foot of sand-bentonite mix above the settlement plate. If water is encountered in the drill hole, bentonite grout should be used instead. The bentonite is used as a grout seal so that the will not enter the PVC pipe above the bottom 1-foot zone. Pull the auger increments and grout the hole from the bottom to the top. Make sure that the pipes do not rise during grouting or auger removal. Hole completion should consist of cutting off the 1-inch PVC pipe below ground surface, cutting off the 1/4-inch steel pipe 4-inches above the PVC pipe and installing a manhole cover.

Taking of readings. - Monitoring of IVM's and BP's is accomplished on a designated schedule by lowering the reading probe attached to a survey tape into the riser pipe and successively stopping at each cross arm location, starting with the uppermost cross arm. The probed is lowered just past the cross arm and then lifted until the latches make contact with the cross arm device. Attach a safety rope to the probe before placing it into the IVM pipe.

The original elevations of the cross arms are compared to the present elevations to determine the settlement of the measuring point or base plate. Always check the probe for complete closure before entering the probe into the installation. Check the value of probe constant so that it is the same as for previous surveys. The constant is the distance from the zero point of the survey chain to the top of the pawls on the probe. The pawls are the point where the measurements are made too. Make sure that the end loop on the survey chain is not loose or broken.

The measurements consist of the depth from the top of the pipe to the measuring point where the latches against the 1 and 1/2-inch

pipe section. This distance is then recorded. Each cross arm is then measured in the same manner progressing downward. The probe shall be removed from the pipe by lowering it to the latching plate (which closes the probe) at the bottom of the pipe. Remember to remove the safety rope as you are removing the probe. The elevation of the top of the pipe must then be determined from an off-dam reference benchmark and then the pipe cap is replaced. Original elevations at the various levels of the vertical movement device are obtained during the installation of each cross arm unit. Elevations are commonly determined to an accuracy of 0.01 foot.

Monitoring of settlement plates requires standard differential-leveling techniques. The termination points of the pipes from the settlement plates are surveyed for current elevations. The settlement of the plate would be the same as the settlement of the 1/4-inch pipe on the surface. The rate or amount of settlement would be the difference between the initial elevation of the plate and the current elevation.

Problems with Taking of Reading Internal Vertical Movements, Base Plates, and Settlement Plates. - The biggest problem with taking of reading for these settlement devices occurs when the settlement probe refuses to come out of the installation. This can occur because of three reasons: (1) the probe will not latch or close correctly; (2) the installation has become plugged; or (3) the survey chain attached to the probe breaks. When the probe does not latch, the measuring pawls will catch against the end of the 1-1/2-inch-diameter measuring pipes. The reasons for the probe not latching could be caused by incorrect adjustment of the pawls spring causing incomplete closure, or build-up of silt on the latching plate not allowing enough distance for the probe to close completely and latch. A safety rope made of 1/16-inch-diameter parachute cord should always be attached to the probe in case the survey chain breaks. This cord, if not removed at the same time the probe is removed from the installation, can also cause the probe to stick.

Settlement plates if installed terminating at a manhole, can have the surface settle enough that the measuring pipe will push against the lid or cover of the manhole. This will require that the measurement pipe being cut off.

Maintenance. - The torpedo measuring device must be kept clean and free of grit. It is suggested that the measuring device be disassembled as far as practicable, cleaned or flushed with clear water after each day's readings and oiled. The measuring tape should be carefully dried and inspected for kinks and breaks. An application of silicon grease on the tape will retard corrosion. If the pawls on the torpedo probe refuse to latch when the torpedo has reached the latching assembly at the bottom of the riser pipe, a section of 1/2-inch pipe, 2 feet long or longer, can be slipped over the tape and safety rope and lowered by a wire

into the installation until it rests on the probe. This added weight should latch the probe so that it can be removed.

Some IVM devices corrode or become plugged with silt necessitating periodic cleaning. Such cleaning can normally be accomplished by jetting with water under high pressure or through use of chimney brushes for pipe sidewall cleaning.

Silt enters the installation at the measurement locations or cross arms and settles to the bottom. During jetting, use a 1/2-inch-diameter PVC pipe lowered to the bottom of the hole so the silt will be lifted out by the rising water. The corrosion will build up on the interior of the pipes. The type of pipe used in IVM and BP installations is black iron pipe, which will rust or corrode with time. Brushes will remove this corrosion for the time being, but with time the corrosion builds up again within the installation requiring the cleaning of the installation to be needed.

Settlement plates require either the cutting off of the steel 1/4-inch pipe because of foundation heaving or adding to the steel pipe because of foundation settlement.