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Development, Installation and Maintenance of Fluid Level Settlement Devices

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16. ABSTRACT

I. Introduction

Settlement measuring devices of various designs have long been employed in foundation studies to reveal the subsidence of unstable native ground under embankments. The early models used riser pipes extending from the original ground through the full height of the embankment to the final surface. They required considerable maintenance throughout the construction period and their use was generally restricted to the more extensive investigations. With the development of the fluid level devices discussed herein, the field of settlement studies was expanded and during the past four years these devices have been used in a wide variety of applications involving many types of foundation conditions. The information derived from these installations has proven to be of value in both design and construction operations, as indicating the need for embankment surcharges, controlling the placement rate for embankments and surcharges, determining the appropriate time to remove surcharges or to drive piling or pour bridge abutments.

The purpose of these instructions is to disseminate information of general interest and to provide field forces with sufficient knowledge of the devices to assure proper installation and maintenance.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

INSTALLATION AND MAINTENANCE of FLUID LEVEL SETTLEMENT DEVICES

November 1959

MATERIALS & RESEARCH DEPARTMENT

DEVELOPMENT, INSTALLATION AND MAINTENANCE

of

FLUID LEVEL SETTLEMENT DEVICES

Part I - Comprehensive instructions

Part II - Outline of essential operations

Devices developed by..................Foundation Section
Under general direction of............A. W. Root
Work supervised by....................W. S. Maxwell
Instructions prepared by..............W. S. Maxwell

PART I

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INTRODUCTION AND DESCRIPTION OF DEVICES

I. Introduction

Settlement measuring devices of various designs have long been employed in foundation studies to reveal the subsidence of unstable native ground under embankments. The early models used riser pipes extending from the original ground through the full height of the embankment to the final surface. They required considerable maintenance throughout the construction period and their use was generally restricted to the more extensive investigations. With the development of the fluid level devices discussed herein, the field of settlement studies was expanded and during the past four years these devices have been used in a wide variety of applications involving many types of foundation conditions. The information derived from these installations has proved to be of value in both design and construction operations, as indicating the need for embankment surcharges, controlling the placement rate for embankments and surcharges, determining the appropriate time to remove surcharges or to drive piling or pour bridge abutments.

The purpose of these instructions is to disseminate information of general interest and to provide field forces with sufficient knowledge of the devices to assure proper installation and maintenance.

II. Description of Fluid Level Devices

The schematic diagram of attached Figure I illustrates a typical installation of a fluid level settlement device. The principle of operation is simply that of a hydraulic "U" tube in which the elevation of the standpipe overflow point is denoted by the level of the fluid column in the indicating unit. If the surface on which the standpipe unit is based should settle, the change in elevation of the overflow point will be accompanied by a corresponding change in the fluid column level in the indicating unit. This relationship will prevail as long as the indicating unit remains at a constant elevation. If the indicating unit should also settle appreciably, a correction must be applied to the graduated scale reading of the fluid column movement. The elevation of each indicating unit is determined at the time of installation by conventional survey leveling procedure and check levels are run periodically thereafter to disclose subsequent movement. To compensate for fluid lost by spillover as the standpipe moves down, or by leaks and evaporation, the system is refilled to overflowing immediately preceding each reading of the fluid level. The fluid usually employed in the devices is tap water but light oil may be substituted in areas subject to freezing temperatures.

Complete sub-assemblies and accessories including platforms, standpipes, indicating gages, connecting tubing and fittings are stocked by the Materials and Research Department. Posts for mounting the indicating units and porous material for placement around the standpipes will have to be furnished at the site under extra work authorized by Contract Change Order. The amount to estimate for the Change Order will naturally vary with the number of units involved but generally about $300.00 will provide for six to eight units including incidental contractor labor and equipment charges.

LOCATION AND INSTALLATION

III. Locating Standpipe and Indicating Unit Sites

The exact locations for these units are determined by the nature of the particular study, the location and design of structures, ramps and frontage roads in the immediate area, obstructions and potential damage for the run of connecting tubing, slope of the ground, and access to the indicating unit both during and following the construction of the embankments. The basic plan is to install the standpipe unit on the native ground at the start of earthwork construction, in a location which will place it under the maximum weight of embankment, and to position the corresponding indicating unit outside the toe of slope.

A primary control is the cross-fall of the ground surface between the site proposed for the standpipe unit and the location of the indicating unit. The elevation of the standpipe overflow point must at all times be within the elevation range covered by the fluid column tube of the indicating unit. To satisfy this requirement and still allow for future settlement of the standpipe, with a corresponding lowering of the fluid column in the indicating unit sight tube, the initial arrangement of the two units should place the standpipe overflow elevation near the top of the sight tube.

In the current model of these devices, the standpipe overflow point is 2.3' above the bottom surface of the wood platform on which it is mounted. The top of the sight tube in the indicating unit is 2.9' above the floor plate of the indicating unit cover box. Assuming the ground surface between the standpipe unit and the indicating unit to be perfectly level, the standpipe platform to be placed directly on the ground surface, and the floor of the indicating unit box also on the ground surface, the elevation of the standpipe overflow point will correspond to a point 2.9' - 2.3' = 0.6' below the top of the sight tube. With the average 2.3' sight tube length, an initial fluid level 0.6' below the top will permit a standpipe settlement of 1.7' with the fluid column still visible in the sight tube. It will also be observed that the initial 0.6' level of the fluid column below the top of the sight tube will allow for a sand bearing cushion beneath the standpipe platform and still retain the fluid column within the reading range of the sight tube. Unfortunately, such ideal conditions seldom occur in practice and thought must be given to other situations.

Where the ground surface at the site for the standpipe unit is lower than the site for the indicating unit, consideration may be given to several arrangements. Generally, it is not practical to lower the indicating unit box below ground surface and compensation for the elevation differential is best made at the standpipe site. The easiest method usually is to wait until sufficient fill has been placed to bring the standpipe site to the proper level. With this arrangement the device will be measuring the compression within the thickness of embankment beneath the platform plus the subsidence of the native ground. Furthermore, the effect of the full height of fill over the native ground will not be revealed because the standpipe unit is in the fill rather than on the native ground. Neither of these two conditions is significant in most instances because the fill under the platform seldom exceeds two to three feet. Where it is necessary to place a greater height of fill to reach the working range of the indicating unit some other layout of the units should be devised. Sometimes the indicating unit site may be shifted ahead or back parallel to centerline to take advantage of a more suitable elevation at the toe of slope, and the connecting tubing is then laid at an angle to centerline. In locations where only limited settlement is anticipated, the initial fluid level may be lower in the sight tube because the full working range will not be required. Occasionally the standpipes must be located in ravines and similar sites with rising ground on each side of the roadway under construction. Where this condition prevails it may be necessary to run considerable lengths of connecting tube parallel to centerline, until a place is reached where the terrain permits the indicating unit to be located at the proper elevation. Tubing runs approaching 1000' in length have been required in extreme cases.

Where the ground surface at the standpipe site is higher than at the indicating unit site the selection of alternate layouts may become more involved. For minor differences in elevation it is only necessary to set a long mounting post and mount the indicating unit at an elevation on the post where the top of the sight tube will correspond to the elevation of the standpipe overflow point. Raising the indicating unit in excess of about two feet above the adjacent ground surface makes difficult subsequent observations of settlement for the reason that fluid must be added at the top of the filler pipe for each observation. Where equipment is available, a trench sometimes may be excavated from the indicating unit to the standpipe site and the platform positioned in the trench at the required elevation to function with the indicating unit. This arrangement places the standpipe platform within the original ground rather than on its surface and the depth excavated should be the minimum necessary to accomplish the purpose. Obviously, the layout of the units depends on conditions at the job site and hard and fast rules cannot be established.

IV. Installation of the Standpipe Unit

As shipped, the standpipe unit is completely assembled and the base plate is drilled to coincide with the mounting holes provided in the assembled platform. Bolts for securing the standpipe to the platform are shipped inside the standpipe and may be reached by removing the pipe plug from the overflow wye. To prevent cracking of the cast base plate, care should be exercised to assure that the plate bears evenly on the platform and that the bolts are tightened uniformly. Selection and attachment of the proper tubing connector in the inlet tee completes the assembly.

The standpipe and platform assembly is positioned on its foundation in the manner illustrated in Figure I. The platform should have full bearing on its foundation and be free from rocking or tilting. The standpipe should be as nearly plumb as is practical and the 45° wye overflow must be within the elevation range of the indicating unit sight tube, in accordance with the preceding discussion of elevation differences. The sand leveling base shown under the platform in Figure I is for the sole purpose of providing a solid, uniform and full-bearing foundation. It should be of the minimum thickness required to satisfy these conditions and should be extended 0.5' beyond all edges of the platform to assure stability. Where the soil present permits leveling off for a suitable foundation, the sand base may be eliminated.

Assuming that elevation requirements will be satisfied, there are two optional procedures for setting the standpipe units. Using the first procedure, the unit is set directly on the native ground at the start of grading operations and the connecting tube is laid in a protecting trench to the toe of slope. The purpose of this trench is to afford physical protection and its depth will depend on the type of construction equipment in use. Sheepsfoot rollers will make necessary a deeper trench to protect the tubing from the penetration of the studs than will rubber tire compactors, and heavy equipment will require deeper trenches than will light equipment. This procedure possesses several disadvantages. The standpipe is fully exposed to damage during the period required to bring the fill up to the top of the standpipe, the equipment must work around the standpipe to leave a hole for the porous backfill, and the tubing in the shallow trench is subject to damage by blades or bulldozers spreading the fill. At best there is some interference with construction activities during placement of the first four feet of fill and in some localities there is the hazard of vandalism where apparatus remains exposed over extended periods.

The second and preferred procedure is to allow the embankment to attain a height of about 2' and then excavate a trench to the original ground level from the toe of slope to the point where the standpipe is to be located. The platform and standpipe are installed in the end of the trench and the tubing carried out along the trench bottom to the toe of slope and thence to the indicating unit. The trench is backfilled for its full length except for a distance of about 2' from the standpipe unit to allow space for the porous material. This method provides a pocket to keep the porous material confined around the PMP cover pipe and furnishes ample protection to the standpipe and the tube to permit full area construction operations, with the sole exception of a small zone directly over the standpipe. This is soon covered as the embankment increases in height, or a protecting mound of fill material may be bulldozed over the standpipe and porous material if working space is limited and equipment must maneuver over the immediate area.

Using either procedure, the tubing trench should be on the most direct line between the standpipe unit and the indicating unit permitted by local conditions, and the standpipe should be left exposed for the introduction of water and the checking of operation until after the indicating unit is installed and the system completed in all details. The PMP cover pipe and the porous material are not placed until a later time.

V. Initial Installation of the Indicating Unit

While the indicating unit assembly may be mounted on a tree or similar fixed object, in most locations it is necessary to set a 4" x 4" or 4" x 6" post at the site previously selected for the unit. The strength of the post and the installation details will depend upon the particular wind, weather and foundation conditions prevailing or likely to occur in the locality. It is essential to provide a stable mounting which will not sink or loosen in the ground with climatic changes. As has been stated, the indicating unit must be mounted at such an elevation that the fluid column with the system filled to the overflow will be within the working range of the sight tube, and preferably within the upper 0.5' of the tube. Probably the most practical method of initially locating the box on the post is to hand level from the standpipe overflow point to the post. The box should be only tacked to the post until after the system is charged with water and checked for operation in the manner to be described.

Each of the indicating unit boxes is provided with a locking hasp and a combination padlock to discourage tampering by unauthorized persons. Although the combination is included with each lock, the directions are repeated here for record purposes. To open the lock, turn the dial right two or more whole turns and stop at 24, then turn left one whole turn past 24 and stop at 30, then turn right to 4 and pull shackle open.

VI. Installation of the Connecting Tube

Ordinary refrigeration type copper tubing has been used on the majority of installations now in service but experiments are in progress with various plastic tubings. While copper may eventually be replaced by plastic, the installation and operation of the devices will remain unchanged. The size of the tubing is dictated by the length of run. Small tubing results in sluggish flow through the system on long runs and makes it difficult to define the correct reading. Large tubing on short runs often gives a surge and bounce back of the column that may affect the accuracy of the reading. Generally, 1/4" tube is used for runs of less than 75 feet, 5/16" for runs over 75 feet, and 3/8" for distances over 300 feet. Considerable slack is left in the tubing placed in the trench to allow for movement as the ground sinks under the weight of the fill, and when working in rocky terrain the tubing must be bedded and covered with fine material by hand methods prior to backfilling with materials that may damage the soft tube.

The tubing may be laid on a level plane or with a sag below level, but not with humps above a level plane because air pockets will form in the humps. To allow for full scale reading of the sight tube, the elevation of the tubing must not be higher at any point than the elevation of the standpipe tee or the bottom of the indicating unit sight tube. Care must be exercised to assure water-tight joints at connections and to eliminate sharp kinks, bends or indentations in the tubing that may impair its mechanical strength or restrict flow of the fluid. It will be observed in Figure I that the connecting tube is unsupported and vulnerable between the standpipe unit and the trench, and that it passes over the edge of the wooden platform. A cushion of fine soil must be packed around the tube and between the tube and the platform for the support and protection of the tube.

VII. Filling and Checking the System

After the standpipe has been seated on its foundation, the indicating unit secured temporarily in the approximate location on the post, and the two units interconnected with the tubing, the next step is to fill the system with fluid and check the general operation. It is assumed for this discussion that the fluid consists of ordinary tap water.

Because the bulk of the water will normally be in the standpipe portion of the system, it is usually faster to remove the plug from the top of the overflow wye and to fill the system from this end rather than to run all of the water through the filler pipe, sight tube and connecting tube. After the system is filled to where the water in the standpipe stands at the overflow point, all connections are checked for leaks and the level of the water column in the sight tube is read as a temporary value. The filler pipe in the indicating unit box is then filled with water which is allowed to flow through the system, in the reverse direction from above, until the sight tube column comes to rest. This level is read and compared with the first reading, and a visual inspection is made at the standpipe to see if the water level is again at the overflow point. A third check operation is performed in the same manner introducing water at the filler pipe. If the three readings are in agreement and the water is standing at the prescribed point in the standpipe each time, it may be assumed that the system is free of air and in proper working order. The plug is replaced in the top of the overflow wye fitting and drawn up snug but it is not necessary to apply thread compound or to make this connection water tight. These checks and readings are only to assure that the system is in good working order and do not constitute the basic initial readings of the device.

The sole purpose of the filler pipe cover cap is to prevent the entrance of foreign matter between readings. This cap must be completely removed when adding water at either the standpipe end or the indicating unit end of the system, and when taking observations on the fluid column in the sight tube. When replacing the cap it is only necessary to engage two or three threads. Excessive tightening not only makes difficult later removal after rust has developed, but also affects the level of the sight tube fluid column. As the cap is turned down on the threads the entrapped air frequently exerts a pressure on the surface of the fluid column sufficient to force it to a lower level.

In the foregoing discussion it is assumed that the indicating unit is at such elevation that the fluid level comes to rest within at least the upper 12" of the sight tube, and preferably the upper 6". If lower than this point, the box should be moved down on the post. Conversely, if the sight tube is full of water and the surface fails to show at all in the tube, the box may be so low that the water level is standing in the filler pipe. The box should then be raised on the post until the surface of the indicating fluid column is within the sight tube range. While conditions sometimes may require that the water level remain low in the sight tube, this is to be avoided where it is practical to move the box.

After establishing the correct height for the indicating unit, the box should be securely nailed to the post and its elevation should be determined by a survey party without undue delay. A brass plate marked "Elev. Ref." is attached to the inside surface of the box bottom piece to designate the location for the level rod when taking the reading. Bench marks for indicating unit elevation control should be located as far from the zone of probable disturbance as is practical, and must be tied for periodic checks to other benches of unquestioned stability far removed from the working area. Experience has proved hubs, right-of-way monuments, railroad rails, culvert headwalls and similar "solid objects" within the field of operations to be very unsatisfactory.

VIII. Installation of PMP Cover Pipe

The purpose of the PMP cover pipe is to prevent fill material from blocking the overflow of water from the standpipe, to allow air to reach the standpipe water column, to provide a storage space for the overflowing water until it is dissipated in the porous material, and to provide physical protection for the standpipe unit and the tube connection.

It will be noted that a slot has been formed in the lower end of the PMP by means of two parallel torch cuts and that the stock has been left in place to form a flap. The slot is to accommodate the connecting tube and the flap is to provide additional protection for the tube. When installing the PMP, this flap is bent well back to prevent it from striking the tube and the PMP is lowered down over the standpipe until its bottom edge is resting solidly on the wood platform. The flap of the PMP is then bent back down slightly to rest on the soil cushion packed around the tube as outlined under Topic VI. This helps to keep the porous backfill now to be placed from entering the slot and filling the space around the base of the standpipe. With the completion of this operation a mound of embankment material 2" to 3" in height is placed around the outer perimeter of the PMP at the lower end, to keep it from shifting when the porous backfill is dumped around it.

IX. Porous Material Around PMP Cover Pipe

The amount of porous material to be placed around the PMP cover pipe frequently is dictated by local conditions. This material generally is purchased from commercial sources having established minimum loads without premium or delivery charges and an extra ton or yard may often be order for what the delivery charge would be for a smaller load. There is no maximum limit for the amount to be placed at each standpipe and the minimum would be enough to completely surround and cover over the PMP cover pipe, i.e., about one cubic yard. The best practice is to have several units ready for porous backfill before ordering the material and to then divide a load among these units.

Conventional dump trucks are most commonly employed to transport the porous material and the accepted practice is to back the truck up to the unit and discharge the material directly alongside and over the PMP. Some provision must be made to brace the PMP against the impact and thrust of the material as it spills from the truck and this is usually accomplished by holding against the top of the PMP with a long-handle shovel until the material has surrounded the pipe. Although the placement of the porous material completes the actual settlement device installations, vigilance must be maintained while the embankment is brought up around the unit. The porous material around a standpipe must remain intact and not be spread out or intermixed with the embankment material. Scrapers, blades or bulldozers should spread the fill against the porous material but should not cut into it, and equipment should not be allowed to pass directly over the unit until ample cover is in place to protect it from damage. Because of the penetration of the studs, more cover is required where sheepsfoot rollers are in use but about two feet should be sufficient under most conditions. Adequate flagging to safeguard against damage by construction equipment is important.

READING DEVICES AND RECORDING DATA

X. Initial Fluid Level Reading

While the procedure for filling the system with water and checking for leaks and overflow has been outlined under preceding topics, the initial reading to be permanently recorded is not determined until the porous material is in place around the standpipe. This method assures that the platform is seated under the load of the porous material and eliminates erroneous readings due to shifting of the platform or standpipe. Provided that the installation has not been open to the atmosphere long enough for evaporation to have materially reduced the volume of water in the system, the fluid level in the indicating unit sight tube should have remained very close to where it was at the completion of the filling and checking operations described under topic VII. A difference of two or three hundredths of a foot on the sight tube probably denotes a slight seating of the platform but movement in excess of this amount should be investigated before proceeding with the initial reading determination.

Assuming that the device appears to be in good working order, the filler pipe is filled with water and this water is allowed to flow through the system until the fluid column in the sight tube comes to rest. The graduated scale is then read at a point corresponding to the surface of the fluid column. This operation is repeated three times and if the three readings agree with each other the value is recorded as the initial reading. The reasons for the three readings and their interpretation is discussed under topic XII.

Because it will not be possible to later check for error, it is essential that the initial reading be accurate.

XI. Additional Initial Data

In addition to the date and the initial fluid level reading, record the height of fill above the native ground, the height of fill over the platform and pertinent data on the installation. Suppose, for example, that two feet of embankment in place had been trenched to the native ground surface, the platform was founded on the ground and the porous material was placed. A notation stating simply 2' of fill over area, platform on OG and porous material around standpipe, or similar statement, would be suitable for future reference. Note also length of tubing runs over 100' in length and the elevation of the indicating unit.

XII. Check Readings

Check readings are taken in accordance with the schedule established for the project. In the absence of specific instructions, the usual practice is to read the fluid level movement each week or with each 5' increase in height of fill, whichever occurs first.

The procedure for the fluid level check readings is essentially the same as for the initial reading. The filler pipe is filled with water which is allowed to flow through the system until the sight tube column comes to rest and the reading of the graduated scale is noted. A second charge of water is added and a second reading obtained in the same manner. If the two readings are identical this value is accepted as being valid and is entered in the permanent notes. If there is a definite differential between the two readings the procedure is repeated until two identical readings are obtained.

The reason for two or more check readings is to make certain that the water level in the standpipe has reached the overflow point identified in the attached Figure I. If, for any reason, water has been lost since the previous reading date, the level of the water in the standpipe will have dropped to a point below the overflow point. Then, if the first charge of water is not sufficient to replace the loss and cause the level to again reach the overflow point, a false value denoting only a raise of level within the standpoint will be read. Two or more identical readings assure that the overflow point has been reached. It is not necessary that each charge of water be a full filler pipe quantity. Any amount which will effect a definite increase in the height of the standpipe water column will suffice and the operator is expected to exercise judgment in making the readings.

Elevation checks on the indicating units involve more time and labor than do the fluid level checks. With the exception of definitely unstable native ground areas, movement at the indicating units is normally considerably less than at the standpipes and checks every 15 to 30 days usually furnish sufficient information.

Bearing in mind that the purpose of both the fluid level readings and the elevation checks is to ascertain the settlement pattern, it will be obvious that readings will be required at more frequent intervals where definite and consistent movement is occurring than where there is little or no movement registered between readings. In most instances the rate of settlement is greatest during filling operations and tends to taper off when filling ceases; therefore, if construction is halted in a given area for an extended time period it is not necessary to continue frequent readings after the taper off is defined. Readings should be resumed concurrent with construction operations.

XIII. Surface Elevation Reference Points

Because the fluid level device indicates only the movement of the surface on which the standpipe platform is founded, supplemental devices are required if it is desired to ascertain the movement at the embankment surface. These supplemental devices usually consist of elevation reference hubs formed by pipes, rods, or long wooden stakes driven along the shoulders or in the median on the same stationing as the standpipes beneath the fill. The elevations of these references are determined in the usual manner by survey parties and check readings are made as required to disclose movement, every 30 days in most cases until movement stops. The differential between the native ground settlement and the surface movement represents compression within the embankment.

Every effort should be made to establish the surface references as soon after the embankment reaches final grade as is feasible. Where the current contract provides only for rough grade earthwork with completion of the facility under a subsequent contract, the surface references should still be set and read during the period between contracts. In case of cessation of operations over extended periods, as through the winter in northern locations, it is well to set ample references to reveal the effects of heavy rains on the new embankment.

XIV. Data Computations and Recording

The level of the indicating unit fluid column is read directly on the graduated scale. Assuming no movement of the indicating unit assembly between fluid column reading dates, the differential in fluid column levels will represent the true settlement of the embankment standpipe unit. If survey party checks on the indicating unit disclose a change in its elevation, the settlement indicated by the fluid column readings must be adjusted for this movement. When the indicating unit has settled to a lower elevation, the amount of this settlement is added to the settlement determined by the fluid column readings.

Example

6-5-58	Fluid level	2.69	Indicating Unit Elev.	132.64
6-10-58	" "	2.61	" " "	132.61
	Differential	.08'	Movement	.03'

Adjusted settlement of standpipe unit .08' + .03' = .11'

Conversely, the amount of any rise in the indicating unit is subtracted from the fluid column differential. In areas of very soft mud, peat, marsh lands and similar embankment foundations, a raise or heaving of the native ground outside the toe of slope is not uncommon; however, such conditions usually require special foundation treatment and specific construction procedure and control beyond the scope of these instructions. No significant rise of the indicating unit occurs on the vast majority of construction projects. If such a change in elevation is noted the reason for such movement should be investigated and reported to the resident engineer.

Elevation determinations for the indicating units and the surface references involve only conventional calculations common to all survey leveling operations. The usual practice is to tie in all settlement investigation elevations to the regular job control bench marks. Although the fluid column levels are normally recorded as read directly on the scale, in certain instances it has been desirable to reconcile these values with job elevations. For this reason the graduated scale is so positioned in the indicating unit that the zero end is at the elevation reference plate.

The following information must be recorded for each settlement device:

1. Date of reading.
2. Fluid column level as read on the graduated scale.
3. Accumulated differential in fluid column levels.
4. Elevation of the indicating unit.
5. Accumulated differential in indicating unit elevation.
6. Adjusted total settlement, i.e., Item 3 corrected for movement recorded under Item 5.

7. Total height of the embankment, to the nearest foot, above the surface on which the standpipe unit was founded. This surface will generally be the native ground.

8. Concise notations relative to increasing or decreasing the weight of the embankment as construction in progress, idle period, weather shut-down, surcharge placement or removal, etc.

PRECAUTIONS

XV. Effect of Temperature Differential

While the standpipe and the tubing covered by the embankment are not subject to rapid and frequent temperature change, the indicating unit located outside the toe of slope is directly affected by climatic conditions. Where a wide differential in temperature occurs during the course of a day, as cool early mornings and hot afternoons in desert areas, some expansion of the indicating unit fluid column may be observed. The degree of such expansion usually is not of consequence and the slight inaccuracy in readings caused by such temperature variations often may be overcome by taking all check readings during the morning hours and using water of approximately the same temperature as that contained in the system. If erratic readings attributed to temperature changes persist, a check may be performed by introducing enough fresh water to displace the heated water occupying the portion of the system exposed to the weather. For current models of standpipe and indicating units, the standpipe contains 0.56 qt. and the indicating unit 0.42 qt., a total of 0.98 qt. of water. Calling this one quart of water and adding one quart for each 100' length of 5/16" copper connecting tube, a charge of two to three quarts should completely fill the average assembly, displace the existing water and provide a uniform temperature throughout.

XVI. Effect of Rising Water Table

In certain instances where the ground water table is close to the native ground surface, the ground water may rise under heavy embankments until it permeates the lower portion of the fill and eventually reaches the standpipe overflow elevation. Thus, the standpipe water can no longer overflow and the settlement device becomes inoperative. A specially designed closed system installation is available for these conditions.

XVII. Recording Assumed Data

Only actual readings and computed values based on these readings are to be recorded. In the absence of an actual reading the notation NR should be entered in the appropriate space on the standard report form. To assume that any value is the same as was reported for a previous date and to record such assumed values or use ditto marks is incorrect and misleading.

Examples of erroneous data have been especially noted in the reporting of the check elevations for the indicating units. As discussed under Topic XII, fluid level readings are normally taken more frequently than are the survey elevations and there is a tendency to either copy the preceding indicating unit elevation or to employ ditto marks for the dates on which only the fluid level was actually read. This indicates that the elevation of the indicating unit was also checked when in fact, it was not. The attached report specimen illustrates the correct reporting procedure.

XVIII. Keeping the System Clean

Failure to replace the filler pipe cover cap immediately after taking fluid level readings has led to trouble on several installations. Large insects and bugs have become lodged in the sight tube, and dirt accumulated in the filler pipe has been carried into the sight tube by the water introduced to check the fluid level. Dirty water obtained from streams has caused deposits on the inside wall of the sight tube that have made it difficult to observe the fluid column. The plastic tubing tends to discolor under some climatic conditions and every effort should be made to keep it clean and clear by using clean water and keeping the cover cap in place. Furthermore, blockages in the connecting tube caused by foreign matter can seldom be cleared sufficiently to permit proper operation of the device.

APPLICATION OF DATA

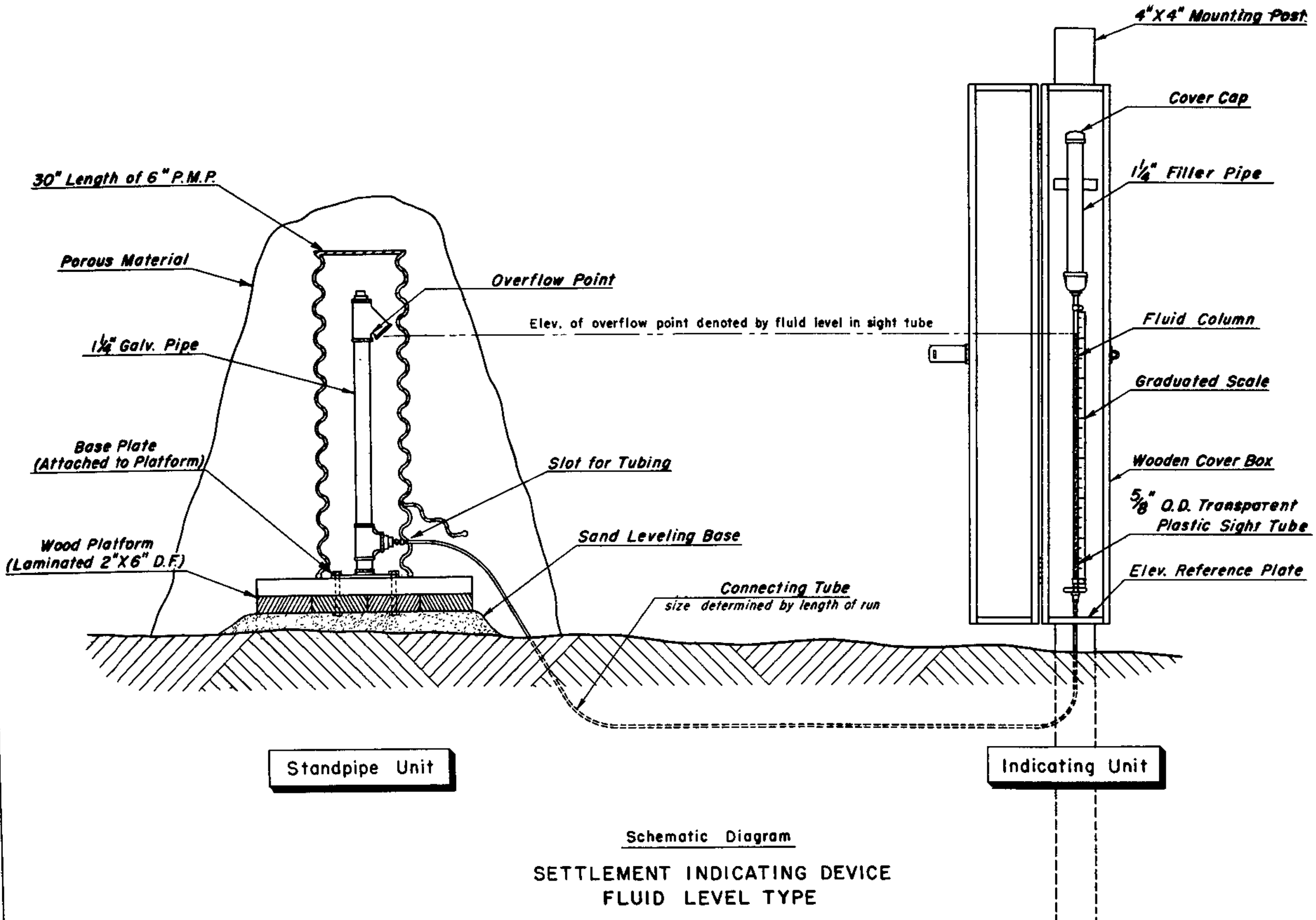
XIX. Duration of Reading Period

Where surcharges are contemplated, the movement during construction of an embankment is of primary interest; thereafter, the movement is noted for determining when to remove the surcharge.

In the case of longer range studies of step-offs at structure approaches and similar investigations, the movement after the embankment is at grade is the principal concern.

For ascertaining the appropriate time for driving bridge piling or pouring abutments in the fill, the movement during the waiting period prescribed in the Special Provisions is essential.

Regardless of the type of installation or the critical control period, the readings of the devices should be carried on as scheduled at least throughout the life of the contract, and longer if significant movement is discernible. The usual practice is to increase the time interval between readings as the movement decreases and to continue checks over a period of several years after the completion of the contract.



Schematic Diagram

SETTLEMENT INDICATING DEVICE
FLUID LEVEL TYPE

Division of Highways
Materials and Research Dept.

FIG. I

MATERIALS AND RESEARCH DEPARTMENT SETTLEMENT DATA

Readings by D. G. Hawkins Contract 59-6VC11-F Dist., Co., Rte., Sec. VI-Ker-58-D,E

A	B	C		D		E		F	G
		Fluid Level		Indicating Unit		Settlement		Fill	
Location	Date	Read.	Change	Elevation	Change	Period	Total	Height	Remarks
281+00 ℄	9-24-59	1.37	0.26	N/R		0.26	0.44	50'	
	10-7	1.37	0	1030.91	0	0	0.44	50'	
	10-23	1.29	0.08	N/R		0.08	0.52	50'	
336+70 Rt. H.P.	9-23	2.18	0	N/R			0.18	48'	Unit P
	10-7	2.18	0	1245.53	0	0	0.18	57'	
	10-23	2.16	0.02	N/R		0.02	0.20	57'	
371+15 50' Rt.	9-23	1.46	0.02	N/R		0.02	0.52	92'	
	10-7	1.42	0.04	1413.55	0	0.04	0.56	103'	

"A" Stationing, line and offset of standpipe to nearest foot.
"B" Day, month and year of readings reported on this sheet.
"C" Fluid level reading and change since last previous reading.
"D" Indicating unit elevation actual check reading and change since last previous reading. If actual elevation check is not made on subject date enter "NR" in elevation column. Do not use ditto marks nor assume elevation has remained unchanged since previous reading.
"E" Settlement indicated by change in fluid level corrected for change in the indicating unit elevation, i.e., the algebraic sum of "C" and "D" changes. Consider downward changes of the fluid level or the indicating unit elevation as minus quantities and upward changes as plus quantities.
Period refers to settlement since previous observation. Total indicates the accumulated total to date.
"F" Height of fill at the time of the readings to the nearest foot above initial ground level. Generally determined from slope staking. If less than value previously reported note reason, as surcharge removed, etc.
"G" Notations covering surcharges, time of reaching rough grade, status of operations, etc.

Form T-2006

Fig. II

PART II

Outline of essential operations for the installation and maintenance of settlement devices.

Purpose

The purpose of settlement devices is to reveal the settlement of the surface on which the standpipe platform is founded, usually the native ground foundation under embankments.

Reference: Topic I.

Operating Principle

The devices discussed herein operate on the hydraulic "U" tube principle employing water in most instances; anti-freeze and water, or light oil may be used in areas subject to freezing.

Reference: Topic II and Figure I.

Contract Change Order

A complete stock of all components is maintained by the Materials and Research Department. A Contract Change Order will be required to furnish porous material, indicating unit mounting posts, equipment to excavate tubing trenches and incidental hand labor at the installation site.

Reference: Topic II, page 2.

Assistance

The Materials and Research Department will render direct assistance upon request. Notify this department two weeks in advance of when the contractor proposes to start operations in the immediate area of the installations.

Locating Units

The standpipe unit platform is normally founded on the native ground and positioned to be under the greatest height of finished embankment. The indicating unit is placed outside the toe of slope.

Reference: Topics III, IV, V.

Elevation of Units

The bottom of the indicating unit box and the standpipe platform should be at approximately the same elevation. In any case the elevation of the standpipe overflow point must be within the range of the indicating unit sight tube with allowance for settlement.

See Topic III for details.

Connecting Tube

The connecting tubing must be on a uniform grade between the standpipe and the indicating unit, and especially without humps sufficient in height to cause air pockets.

Reference: Topic VI.

Initial Filling

The system must be completely filled with the liquid and checked for absence of air, general operation, leaks and reproducibility of readings before the cover pipe is installed.

Reference: Topic VII.

Porous Material Around Standpipe

The porous material serves two purposes: air venting the standpipe and receiving the overflow liquid. Pea gravel, filter material or concrete aggregate are satisfactory. Use a minimum 1/2 c.y. at each unit and preferably 1 c.y.

Reference: Topic IX.

Initial Reading

The initial reading is taken after the porous backfill has been placed around the standpipe unit. It is essential that this reading be accurate and that the procedure outlined under Topics VII, X and XII be followed without deviation.

Reference: Topic X, XI.

Subsequent Readings

Periodic readings must be carried on at least throughout the life of the contract on a schedule arranged by the Materials and Research Department.

Reference: Topic XIX.

To offset any loss of liquid by evaporation, leak or spill-over, a quantity of water is added for each reading and allowed to flow through the system until the fluid column in the indicating unit comes to rest. Two identical readings must be obtained to assure that the system is full to the overflow point.

Reference: Topics II, XII.

Indicating Unit Elevation

This elevation must be determined at the time of installation and checked periodically thereafter during the construction period.

Reference: Topics II, III, V, VII, XII.

Surface Reference Elevations

Surface references should be established on the surface of an embankment at the time of reaching rough grade, or at any grade elevation if extended cessation of construction operations is anticipated.

Reference: Topic XIII.

Bench Marks

All bench marks must be established at least 150 feet outside the toe of embankment slopes, or on solid piling. Refer to Topic VII, page 8.

Computations

Refer to Topic XIV.

Reporting Data

The manner of reporting data will depend on whether the devices have been installed for general information or for construction control. Check with District Office and with Bridge Department if structure approach embankments are involved. Copies of all reports should be forwarded to the Materials and Research Department.

Reference: Figure II.

Precautions

Take readings at such times as will minimize temperature differential. Record only actual readings and elevations. Use clean water.

Reference: Topics XV, XVI, XVII, XVIII.

Air bubbles in the system invariably cause erratic operation and invalidate the data. If the system is opened for any reason after the initial installation caution must be exercised to remove all air after the reconnection is completed. It may be necessary to apply pressure. Contact the Materials and Research Department for advice.