Earth embankments are massive structures that inherently have movements and seepage. Consolidation of the embankment and the foundation occurs most rapidly during construction and at a lesser rate for an extended period of time thereafter. The initial filling and its accompanying saturation may temporarily accelerate the consolidation of the upstream section of the embankment, and initial filling will also cause downstream seepage to develop. Consolidation of the embankment and the foundation is accompanied by transverse and longitudinal movements that may result in transverse and longitudinal cracks. The predicted amounts of consolidation, movement, and seepage should be determined by analyses during the design stage. These analyses should be reviewed at the end of construction, and modified if the as-constructed engineering characteristics are different from those assumed during design. For instance, changes in the foundation treatment or achieving a higher percent of maximum density than was specified may result in less consolidation, movement, and seepage than were computed during the design stage. There are no standard guidelines that can be applied to the tolerable amounts of movements and seepage, as each embankment has its own characteristics; however, it is often helpful to compare data from similar structures with similar foundation and abutment conditions. The analyses and comparative data should be used to establish the benchmark norms; however, the inspectors, instrumentation personnel, and evaluators should always be on the alert, even before the benchmark norms are reached, for adverse trends in data plots, cracks, seepage concentrations, boils, evidence of piping, sinkholes, and other signs of distress.
Preparation

The initial filling represents a critical testing of the embankment. The preparation for the initial filling should include a review of: the design reports, the construction records, the operations manual, and the instrumentation data obtained during construction and during the intermediate time since the embankment was completed.

Particular emphasis should be given to data obtained during temporary impoundments or longer-term lower impoundments. All springs and weeps that existed before the dam was constructed and that developed during any impoundments should be located on the ground, numbered, and plotted on large-scale maps; the discharges should be measured and plotted against pool elevations and rainfall.

Adequate staffing should be arranged for inspection of the dam, for reading the instruments, and for plotting the data. To conserve manpower on large projects, the instrumentation data should be transmitted to computers with plotting printout capability at the job site. Lighting should be set up for that portion of the dam and downstream area that is to be monitored on a 24-hour basis. A spare set of instrumentation readout devices should be purchased and site-tested, as critical data could be lost through failure of a readout device during the monitoring program. A check inclinometer should be installed in stable ground on the abutment (preferably in bedrock), and the accuracy of the readout device should be verified by taking readings in the check inclinometer each time readings are scheduled for the site inclinometers.

On-Site Inspection

The inspection force should include lead personnel who have a thorough understanding of the embankment design and construction. The lead personnel should hold training sessions for the entire force to explain: the design of the embankment, the operations manual, the locations and purposes of the instruments, the monitoring program, the performance of the embankment to date, and the duties and schedules of each inspector.

Personnel should be taken into the field and shown each instrument and each monitoring point. The operation of all measurement and recording devices should be explained, and each instrumentation reader should make trial runs with the measurement and recording devices. The embankment and downstream area should be inspected by the entire party, and current defects such as cracks, depressions, and so on, should be noted and photographed. Possible signs of distress should be thoroughly explained, and the most vulnerable locations for potential distress should be pointed out. Individual members of the inspection team should be thoroughly oriented on the importance of their observations, which may indicate distress not detected by the instrumentation.

Instrumentation Data

The validity of the instrumentation data should be checked constantly. Instrumentation readers should take a check reading anytime there is significant divergence from the previous reading. When significant movements are indicated since the last inclinometer reading, the accuracy of the readout device should be verified in the check inclinometer, and additional inclinometer readings should be obtained. Alignment and settlement data from surveys are especially subject to errors, particularly on long embankments. Site observations are helpful in evaluating data. For instance, if the alignment survey data indicate a spread of 0.5 ft (15 cm) between the upstream and downstream crest monuments, there should be a wide crack in the crest. Cross checks should also be made between inclinometer data and survey data.

The schedule for obtaining instrumentation data and for site observations should be based on site conditions and the filling schedule. For most projects, a reasonable schedule may initially require: daily readings on all piezometers, relief-well discharges, and spring discharges; twice-daily walk-over inspections of the embankment and downstream area; weekly readings on inclinometers and extensometers; and monthly surveys of alignment and settlement monuments. As the filling continues, the monitoring schedule should be revised to meet the needs of the evaluators. On rapid-filling projects, such as pumped storage, the instrumentation readings must be obtained at a much more frequent rate.

Evaluation

Evaluation of the data should be made daily. Abnormal data should not be discarded until they are proven to be erroneous. The data evaluation must give due consideration to the geological site conditions and the embankment design; and, in this context, the data should be projected to determine the ultimate condition or worst-case condition. For instance, a rise in the downstream valley-bottom piezometers at various intermediate pool levels should be projected to the scheduled operation pool levels to determine whether excessive uplift would exist at those levels. Further projections of the piezometric levels should be