Example 10 (1977) - Zoned rockfill dam with inclined core of moraine till

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAIN OBJECTIVE</th>
<th>MAIN BENEFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction control and performance monitoring</td>
<td>Verify new design concept</td>
<td>Design verified and reduced cost</td>
</tr>
</tbody>
</table>

**BACKGROUND AND DESCRIPTION OF PROJECT**

Monitoring programs often have more than one function. For example, for an embankment dam instrumentation systems used for construction control may be used as well for long-term performance monitoring. Likewise, a monitoring program may yield benefits other than to simply document performance. This is illustrated by the following example.

A rockfill dam, completed in 1976, had a height of 129 in, crest length of 400 m and a total volume of 4.7 million cubic meters. It had a thin core of moraine till, sand filters, fine-grained rockfill transition zones and coarse rockfill shells. The design of the core was a compromise dictated by the amount of suitable moraine at the site, the desire to have a thin core to permit rapid dissipation of excess pore pressure during construction, and the desire to reduce the chances of arching in the core.

**FACTORS THAT INFLUENCED THE DESIGN OF THE MONITORING PROGRAM**

At the time, this dam differed significantly in concept and size (40 percent higher) from the existing dams in Norway. It was also the first of a number of rockfill dams of comparable height that were planned for construction in the future. Thus, the dam was thoroughly instrumented not only to verify satisfactory performance but also to provide a design basis for the future dams.

Appraisal of the stability and performance of a zoned dam depends on knowledge of pore pressure build-up and dissipation, leakage, and relative movements of different materials or zones within the dam. Total stress measurements were included in order to study arching conditions and potential for hydraulic fracturing in the relatively thin core.

**SCOPE OF INSTRUMENTATION**

The instrumentation program for Svartevann Dam, Figure 1, was designed to provide measurements of the following parameters: (a) displacements of the surface and within the body of the dam, (b) seepage through the core, and (c) internal stresses, i.e., pore water pressure and total earth pressure in the core and filter zone.

The instrumentation comprised 141 surface monuments, 8 settlement reference plates along the crest, 28 strain meters for measuring internal strains, 4 inclined and 4 horizontal inclinometer casings for measurement of internal displacements, and one leakage monitoring station. Altogether 30 pore pressure piezometers were installed in the dam to monitor construction pore pressures and the gradients across the core during operation of the dam. A total of 60 total stress cells were installed for monitoring soil stresses in the core and filter zones. Near the right abutment and crest where tensile stress may occur, and in the region of core-shell stress transfer these instruments were placed in rosette groups to permit determination of the principal stresses and directions.

**MOST SIGNIFICANT INFORMATION DERIVED FROM THE MONITORING PROGRAM**

No unexpected results of any significance were observed during construction or operation of the reservoir although the total settlement of the dam was somewhat larger than predicted. Measured pore pressures in the core were modest and dissipated rapidly. Leakage was small.

In the stability analysis of the dam it had been recognized that if high construction pore pressures occurred and did not dissipate quickly it might have been necessary to flatten the upstream slope. Therefore, preparations were made in the base of the dam to enable a change in the upstream slope as can be seen in Figure 2. However, upon reviewing the measurements obtained during the first two construction seasons, it was concluded that this was not necessary. This decision was based on the measured pore water pressures and in-situ measurements of the shear strength of the rockfill determined from plate loading tests. The consequence of this decision was a reduction in construction time and a significant savings in the cost of the dam.

**REFERENCE:** (DiBiagio et al. (1982)).