**a) Motive and purpose of monitoring measurements**

The motive is to investigate whether the kinematic model corresponds to reality. Specifically, there are three main purposes:

* movement of dam crest (δx = 0.01m)
* Permanent monitoring of vertical movements of the dam (δx=0.001 m)
* Permanent monitoring of horizontal movements of the dam (δx=0.001 m)

**b) Specification of monitoring object**

The monitoring object is a dam. On the face behind the reservoir, the dam height is 45.00m, 40.00m above the water (500.00 NHN) and 5.00m under the water. The water level of the reservoir is 536.00 NHN.

**c) Causes of the expected deformations**

Three main causes lead to the expected deformations:

* Reservoir water flow leads to horizontal movement
* The weight of the dam leads to vertical movement (subsequence)
* Temperature leads to the horizontal and vertical deformation of the dam

**d) Extension of presumably influenced region**

Presumably influenced region includes the dam itself and the areas around the two sides of the dam.

**e) Amplitude and orientation of the expected deformation**

As for deformation caused by water level & temperature, setting the top point in the middle of the dam crest as the reference point, the maximum deflection occurs in south east direction (0.030m for water level and 0.005m for temperature). As for rapid crest deflection and tilt deformation, deformation occurs both vertically and horizontally (with an amplitude 0.020m)

**f) Expected sequence of deformations**

Both daily and annually for water flow and temperature

Annually subsequence for dam itself

**g) Boundary conditions (e.g. accessibility, external influences like vibrations, heating, humidity, dust.)**

monitoring is limited to the dam itself and around the dam

sensors sensitive to humidity are not suitable for this monitoring

**h) Cost limit**

depend on the sensors and the work with the sensors

**i) Reference system, datum definition**

The reference system is local 2-d system, with the reference point on the top of the middle of the dam crest, and the normal north-south direction.

**j) Reliability of measurement system**

The reliability of the measurements is ensured by the reference system, control points and the measuring instruments (e.g. strain gauge and laser alignment).

**k) Spatial discretization: number and positions of measurement sites**

* Five measurement points on the crest of the dam, including the reference point
* Two measurement points at W1 and W2
* Two measurement points in the two gangway
* Several other points outside but around the dam

**l) Measurement quantities**

The movement of the crest, both horizontal and vertical (the coordinate difference between measurement points and reference points)

Subsidence of the dam (coordinate change of measurement points on top or inside the dam)

Horizontal movement of the dam (coordinate change of measurement points along or inside the dam)

Tilt of the dam (height difference between W1 and W2)

**m) Measurement interval: double of the expected movements**

daily temperature: 0.01m /day

water level/ annual temperature: 0.06m /year

deflection of the dam (center of crest and tilt): 0.04m /second

**n) Measurement accuracy**

movement of dam crest:

permanent monitoring of vertical movements of the dam:

permanent monitoring of horizontal movements of the dam:

**o) Measurement duration/period (periodical or duration of the influence and decay effects)**

* 2 weeks for daily influences of temperature and water flow
* 2-3 times every year for annual influences

**p) Sampling rate (temporal discretization)**

Daily temperature:

Annual temperature and water level:

**q) Acceptable epoch duration (temporal discretization)**

Let

Daily temperature:

Annual water level and temperature:

**r) Choice of measurement equipment /sensor system depends on l) to q), and indirectly on all other issues.**

1) Alignment, optical

* Accuracy: 0.2-1 mm
* Position: both sides of the dam
* Function: determine the movement of the dam crest
* Demands: Control points outside the dam

2) Hydrostatical leveling

* Accuracy: 0.001-3mm
* Position: outside the dam
* Function: determine the tilt deformation (height difference between W1 and W2)
* Demands: no special demands

3) Total station

* Accuracy: 1.5mm+2ppm (distance), 5”-10” (angle)
* Positon: around the dam, outside region of influences
* Function: determine the vertical movement of the dam (subsidence)
* Demands: enough measurement points

4) Mechanical plumbing

* Accuracy: 0.1-0.2mm
* Positon: the two gangway
* Function: monitor the movement of the dam
* Demands: Both direct and invert pendulum

5) Water level meter

* Accuracy: undetermined
* Positon: both sides of the dam
* Function: monitor the water level
* Demands: trigger the alarm in critical situations