

Huggenberger application note, April 2018

## Lesotho, Katse Dam: refurbishment of Pendulum Measurement Systems

The Katse Dam, constructed during the first phase of the Lesotho Highlands Water Project, is a 185m high double arch concrete dam with a crest length of 710m. The geological formation of the Katse dam area is characterized by the existence of almost entirely basaltic, nearly sub horizontal, lavas flow deposits. The main discontinuities are composed of sub horizontal shear zones and flow contacts, layers of basalt and some sub vertical stress relief joints.



Figure 1 Katse Dam in Lesotho

After main construction work was completed, a set of direct and inverted pendulums, partially equipped with manual operated and partially with automatic pendulum measuring devices not originating from Huggenberger AG, has been installed.

In the year 2017 Huggenberger was awarded to supply new VDD3V4 type telependulum measuring systems in replacement the old equipment. Three of these units have been installed on inverted pendulums and seven units on direct pendulums. All devices for monitoring the direct and inverted pendulums are to measure also vertical displacements relative to the pendulum fixing point. Therefore the wires are equipped with a special cone-shaped component. The technology of the VDD3V4 telependulum readout device allows to detect the vertical position of the cone with an accuracy within 0.05mm, for horizontal x- and y-direction and 0.1mm for the vertical z-direction and thus allowing 3D-monitoring of all the direct and inverted pendulums.



Figure 2 Katse dam: The small black cone mounted to the wire is for detecting vertical displacements of the pendulum wire



Figure 3 Example: Optical coordiscope type KK84D



Figure 4 example from other project: telependulum system mounted on the study support system (below to the left the digital display of the x, y and z- wire position,)

Huggenberger telependulum measuring systems measure the pendulum wire coordinates within a range of 150 x 60 mm automatically, contactless and continuously. Light sources in the instrument cause a shadow of the pendulum wire which is detected by bright-dark sensors. The exact position of the pendulum wire is determined from the position of the light sources and the shadow focal points. The small cone, which is attached to the wire for measuring the vertical deformations, influences the width of the shadow relative to the vertical position of the cone. This allows to detect automatically the vertical displacements of the dam foundation within a range of 20mm and with an accuracy of +/- 0.05mm.

The instruments can be installed without removing any parts of a pendulum system and are easily aligned to the correct measuring axis and in the correct horizontal inclination thanks to the stable universal support system.

Begin 2018, Mr. Urs Marti, Huggenberger's technical director, supported and supervised local technical staff of the dam operator on the installation and data acquisition of the VDD2V4 systems and made an instruction for operating and maintenance.

Long term high accurate performance of these systems lead the client to select Huggenberger's telependulums. Huggenberger greatly thanks Lesotho Highlands Development Authority for appointing us with this contract and highly appreciated to work with their local team.

Reference: Behaviour of Katse Dam (author Fabokoane Vinvent Mota), proceedings conference Dam Monitoring and Surveillance, September 15-18, 2008 Stellenbosch University