ANALYTICAL AND EXPERIMENTAL ANALYSIS OF LARGE FLAT JACK DEFORMETERS

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ABSTRACT

The design, construction and study of the behaviour of large concrete dams usually require several technical studies to be carried out in order to assure that safety conditions are achieved. The preliminary work includes field studies to perform rock mass characterization in order to evaluate the material properties of the site where the dam will be constructed. One method currently used to evaluate rock mass deformation modulus is the Large Flat Jack (LFJ) test.

The large flat jacks are made of two thin steel plates welded around the edges. Each flat jack has two pipes, one for oil filling and the other for air bleeding, and two electric connectors for the cables of the four deformeters installed inside the jack. The LFJ is inserted into a narrow slot previously cut with a diamond disc machine in the exposed rock surface inside an underground test adit. The LFJ is then pressurized with oil to about 100 bar using a hydraulic pump. The resulting rock deformation is measured normal to the installation slot. The rock mass deformability is evaluated from relationships between applied pressure and the measured deformation. The LFJ opening is measured by four internally mounted deformeters.
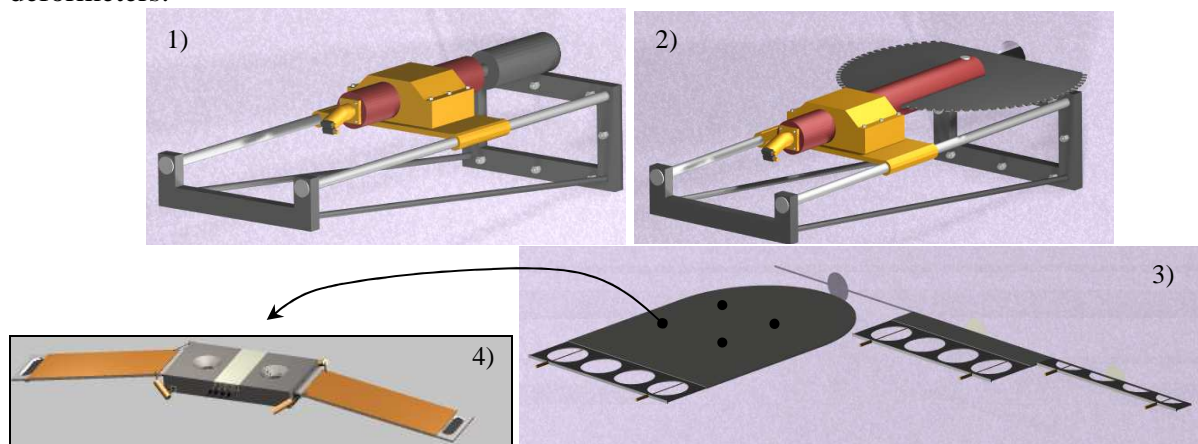
Figure 1: LFJ test equipment: 1) opening the hole; 2) opening the slot; 3) inserting the LFJs on the slot; 4) and its deformeter.

Each deformeter consists of a main body and two cantilever flat steel springs welded to it. The deformeter is fixed to one of the plates and the tips of the flat springs are pressed against the inner face of the other plate. During use the plates follow rock deformation increasing the gap where the deformeter is installed thus providing a way to measure local deformation. The two flat springs are instrumented with four strain gages forming a full Wheatstone bridge. The output signal of the bridge is a measure of the rock deformation.
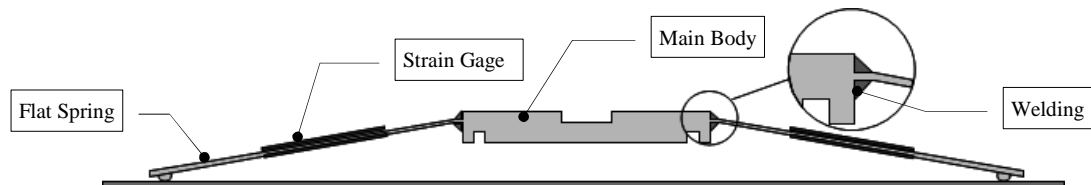

Figure 2: Deformeter.

The LFJ has been subjected to some improvements during the years and is still used nowadays as a standard test to characterize the rock mass deformability. Recently some efforts have been made to evaluate and improve the measurement quality of the LFJ technique and in particular the deformeters by analyzing the constituent components and the measurement chain.

This communication starts with the description and applications of the LFJ test for rock mass characterization and ends with the study performed on the deformeters. Two models to characterize the deformeter behaviour are presented and the results of a sensibility analysis made with those models are shown. One was obtained taking into account that the flat springs that constitute the elastic elements of the deformeters are subjected to large deflections and another, obtained from the first one by applying appropriate simplifications, assuming small deflections. The first model has no closed form analytical solution and has to be solved numerically. The second has an analytical solution and should be used for behaviour prediction under appropriate conditions. Both models take into account the Wheatstone bridge behaviour, the strain gage position and angular misalignment on the flat spring to estimate the displacement-voltage coefficient. It was found that both models produce similar results in terms for deformed shapes and for estimated displacement-voltage coefficients. A sensibility analysis showed that the quantities with more impact in the deformeter coefficient are: flat spring effective length and thickness; and position of the strain gages. Other factors like strain gage rotation and coefficient of friction were found to have a much lesser impact on deformeter behaviour. The analysis also provided additional data for future designs and to better understand the differences usually found among deformeters coefficients obtained from the calibration process.

Two deformeters taken from the production line were geometrically characterized for subsequent analysis with the models. The estimates of the displacement-voltage coefficient obtained with both models were compared with the results obtained through the established calibration procedure. Some differences were noticed leading to further refinements. It was found that the fillet weld size and the clamping achieved by the weld were contributing significantly for these differences. A new parameter termed 'fillet weld size' was introduced in both models. Model parameterization was performed taking the obtained deformeter coefficient from the experimental data as the conventional true value. The results obtained provide adequate predictions for the fillet weld size.