DETERMINATION OF UNDERGROUND GEODYNAMIC PARAMETERS

Down-Hole testing is a variant of Cross-Hole testing, in which a seismic wave is generated at the surface, near the borehole, in which the arrivals of the compression and shear waves are measured. The surface source is specially adapted to generate shear waves and compression waves. Results interpretation and restitution are similar to those for Cross-Hole testing. In case of a clear anisotropy, parameters determined this way can be notably different from parameters determined by Cross-Hole testing.

Down-Hole testing consits of measuring the travel time of compression (P) and shear (S) seismic waves between surface level and several levels inside a borehole, as shown in the figure below.

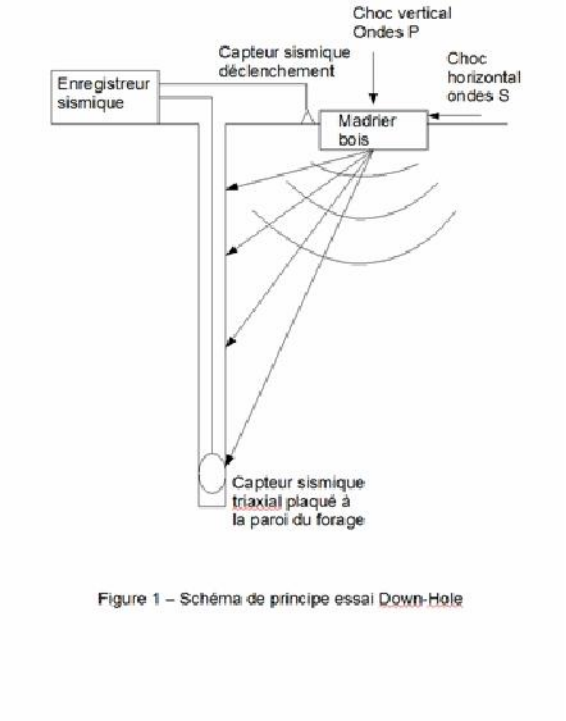


Figure 1 – Schéma de principe essai Down-Hole

Seismic waves are generated by the impact of a hammerhead on a wooden platform. P waves are generated hitting the platform vertically, while S waves are generated by hitting the platform horizontally. Moreover, for S waves, by hitting the platform on both sides, we reverse the polarity of the S waves, allowing a better identification. The hammerhead, equipped with a sensor, is connected to a recorder. The latter triggers the start of the recording (t0) allowing the measurement of travel times.

Seismic waves are measured in the borehole with a receiver probe of 70mm diameter, placed on the inside of the borehole via a mechanical anchoring system. The probes consist of three sensors, all oriented at 90° from each other (one vertical and two horizontal at 90° from one another). This layout allows a good identification of the P wave trains, acting principally on the vertical sensors, and of the S wave trains, putting principally a strain on the horizontal sensors. The receiver probe is connected to the seismic recorder.

The measures are taken at different depths, typically every meter or every other meter, so as to get a cross section of P and S waves velocities as a function of the depth.

The travel times of P and S waves allow us to determine the dynamic muduli, Young's modulus and shear modulus, as well as Poisson's ration depending to depth, such as:

$$G = \rho V_s^2$$
$$E = 2\rho V_s^2 (1 + \nu)$$
$$\nu = (V_p^2 - 2V_s^2) / 2(V_p^2 - V_s^2)$$

For this, we need to know or hypothesise on the density of the crossed ground.

Except when the borehole is made in a rock land and does not constitute a risk of rock slide or of trapping the probe, PVC protection tubes need to be inserted in the boreholes before placing the probe during Down-Hole testing. The tubes, of diameter lower than 80mm, need to be fixed to the borehole side walls with cement grout on the whole height. They must be blocked at the bottom and watertight. Connections between the tubes have to be screwed and glued.

Headquarters: Savoie Technolac - BP 306 - 27, allée du lac d'Aiguebelette - 73373 Le Bourget du lac Cedex
S.A.S. with 40,000 € capital - RCS Chambéry 508 761 079 00021 - APE 71.12B
Phone: + 33 (0) 479 250 140 Fax : + 33 (0) 479 625 104 info@innogeo.fr www.innogeo.fr

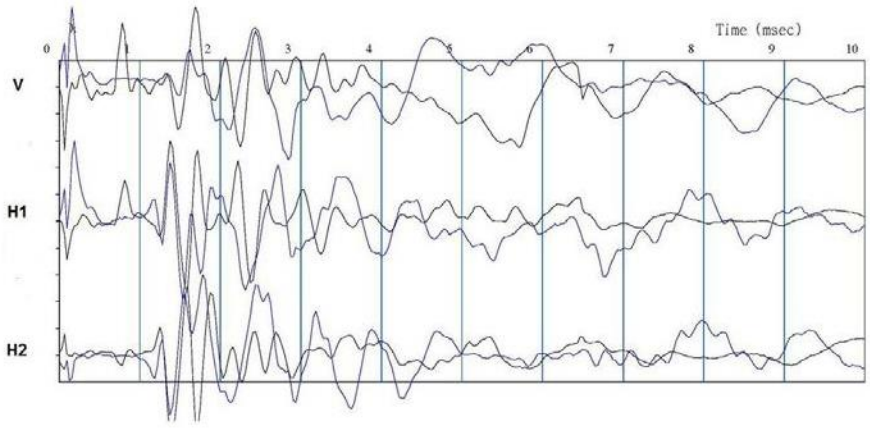
DOWN-HOLE TESTING – FACT SHEET

The injection has to be done from the dip tube at the base of the tube. Part of the quality of test results depends of the quality of the seal. The tests can be done at the earliest a week after drilling the boreholes so that the grout reaches a sufficient mechanical resistance. The boreholes must be protected at their heads and measured by three-dimensional triangulation.

When sounding at a rock land, it is possible to operate without sealing the PVC tube as long as there are no risk of getting the probes trapped. In that case, the borehole has to be of diameter lower than 80mm. It will have to be tubed at the top, if necessary, on the whole section likely to collapse. The inside diameter of the protective tube will have to be greater than or equal to 80mm to allow the probe to be placed. The part of the borehole with the tube cannot be subject to Down-Hole measures. The inside of the borehole will have to be controlled by video or sound imaging before proceeding to Down-Hole testing, so as to check the absence of risk. INNOGEO reserves the right to not operate in case of confirmed risk in the light of the logs. However, should the client wish to carry out testing despite the risk, they would have to agree to repay the trapped or broken probes.

The first meters of ground, generally deconsolidated, do not always permit quality signals. That is also the case for some grounds out of waterground table, such as alluvium. In that case, determination of velocities and dynamic moduli can prove impossible or not very precise. In that case, there could be less precision in the determination of the dynamic moduli than for the lower and more consolidated layers. Otherwise, because of the probes length, the last measure is taken at 0.5m of the bottom of the borehole. The definitions of the dynamic moduli are done level by level based on the average velocity of the P and S waves, between the surface and the measure level, and also based on P and S waves velocity obtained by the difference between two levels. The test results in the establishing of a seismic stratigraphy of the grounds around the borehole.

Receiver probe



Headquarters : Savoie Technolac - BP 306 - 27, allée du lac d'Aiguebelette - 73373 Le Bourget du lac Cedex
S.A.S. with 40,000 € capital - RCS Chambéry 508 761 079 00021 - APE 71.12B
Phone : + 33 (0) 479 250 140 Fax : + 33 (0) 479 625 104 info@innogeo.fr www.innogeo.fr