NF P94-160-3 – May 1993
French Standard for Foundation Testing
Part 3: Parallel Seismic Method

1. Scope of application

The present standard is applicable to vertical foundation elements, including micropiles, driven piles (prefabricated or cast in-situ), bored piles, caissons, barrettes, diaphragm walls and sheet pile walls. The said foundation element may carry a superstructure.
The aim of testing the foundation by the Parallel Seismic Method is to establish the length of the foundation element, as well as the wave speed in its material.

2. General

2.1. Definitions
For the purpose of this standard, the following definitions apply:

2.1.1. Pile
The term "pile" is used to describe all the foundation elements specified above.

2.1.2. Seismic
Testing technique utilizing the speed of wave propagation caused by an impact applied to the pile.

2.2. Principle of the Method
The method consists of the following:
Drilling a hole, parallel to the tested pile, as close as possible and to a depth larger than the assumed pile length,
Inserting a suitable tube in the hole,
Lowering by stages a seismic receiver into the tube,
Producing an impact close to the head of the pile,
Measuring the elapsed time of the wave travel from the point of application to the current position of the receiver
Determining the depth of the pile toe and the wave speed in the pile material.

3. Equipment

In addition to the equipment necessary to drill the hole and insert the tube, the system consists of the following:
A hydrophone hanging on a communication cable with suitable means to establish the depth,

A sledge hammer of sufficient mass and an impact switch,
A system for displaying the signal received and measuring the elapsed time with an accuracy of 10^{-4} sec.

4. Operation method

4.1. Drilling of the parallel hole

The distance from the axis of the hole to the side of the pile shall be between 0.5 m and 1.5 m. The length of the hole shall exceed the assumed pile length by at least 5 m (Fig. 1).

4.2. Installation of the tube inside the hole

The tube shall consist of plastic material, with an inside diameter of not less than 40 mm, equipped with a waterproof plug at the bottom, grouted in the hole along its full depth. The plastic tube shall be filled with clean water.

4.3. Lowering the receiver inside the tube and measuring its depth relative to a reference level above the tube

The top of the tube shall be accurately surveyed for both location and level.

4.4. Producing the impact on top of the pile or on the superstructure

The blows shall be applied always to the same location on the pile or on the superstructure which it supports.
The position of the impact switch shall not be changed during the test.

4.5. Measurements

Measuring the time elapsed between the hammer blow and the arrival of the signal at the receiver shall be carried out at regular vertical spacings not exceeding 0.5m. If two series of measurements are performed, one on the way down and the other on the way up, the spacing may be doubled. The position of the impact switch shall not be changed during the test.

5. Accuracy

5.1. Position of the receiver

The depth of the receiver shall be measured with suitable means to a maximum uncertainty of 0.1 m.

5.2. Travel duration

The inaccuracy in measuring the wave travel duration shall not exceed 3.10^{-4} sec.

6. Presentation of the results

6.1. Graphic representations

The travel time of the impulse wave and the depth of the receiver are plotted in a graphic representation (in orthogonal or oblique coordinates) in which the respective speeds of the pile material (V_1) and the adjacent soils (V_2) are indicated.

6.2. Pile length determination

In homogeneous soil, and with the tube strictly parallel to the pile, the form of the curve representing travel time versus receiver depth depend on the position of the latter with respect to the pile:

a. Receiver opposite the pile

The difference Δt_1 between travel times measured at two positions of the receiver, Δz_1 apart, is uniquely due to the travel time of the wave in the pile material between these two positions.
The mean wave speed in the pile between these two measuring points is:

$$V_1 = \Delta z_1 / \Delta t_1$$

b. Receiver a little below the pile toe

The function relating the time duration Δt_2 and the wave speed in the ground is of a hyperbolic character. This hyperbola reaches its asymptote only sufficiently deep below the pile toe.

c. Receiver sufficiently deep below the pile toe

The difference Δt_2 between the travel times to two respective receiver positions Δz_2 apart is uniquely due to the travel time in the ground close to and below the pile toe.
The mean wave speed in the ground between these two measuring points is:

$$V_2 = \Delta z_2 / \Delta t_2$$

After correction ($t_0 = b/V_2$) of the seismic wave travel time between the tube and the pile in that part t(z) of the curve where the receiver is located opposite the pile (Fig. 2), the depth where the hyperbolic branch begins corresponds to the pile toe.
The uncertainty in the pile length determination is 5%. It can be improved if additional information is available.

7. Test report

The report shall, as a minimum, provide the following:

- reference to the present standard NF P 94-160-3
- the name of the firm that performed the test
- file number and date of testing
- implantation and location of the pile tested
- reference origin of level measurements, located above the tube
- distance **b** between the side of the pile and the axis of the tube placed in the hole
- graphical representation t(z) of the seismic waves arrival time vs. depth
- pile length and the uncertainty involved with the method
- the mean wave speed in the pile material (V_1) and in the soil adjacent to and below the pile (V_2)
- the expiration date for the tape measure calibration

- observation related to the performance of the test, including any events and operational details not envisioned in the standard and may have an influence over the test results.

8. Equipment verification

The instruments and measuring means are handled according to the requirements of the National Bureau of Metrology (BNM)
The position of the frame is verified before the beginning of the test
The whole chain of measurement: receiver, impact switch and recording instrument shall be verified at least every two years.

9. References

Mesure de la profondeur des foundations – Jean Hurtado – Revue Francaise de Geotechnique No. 6 – February 1979
Norme Experimental P 18-418: Beton – Auscultation sonique – Mesure du temps de propagation d'ondes soniques dans le beton

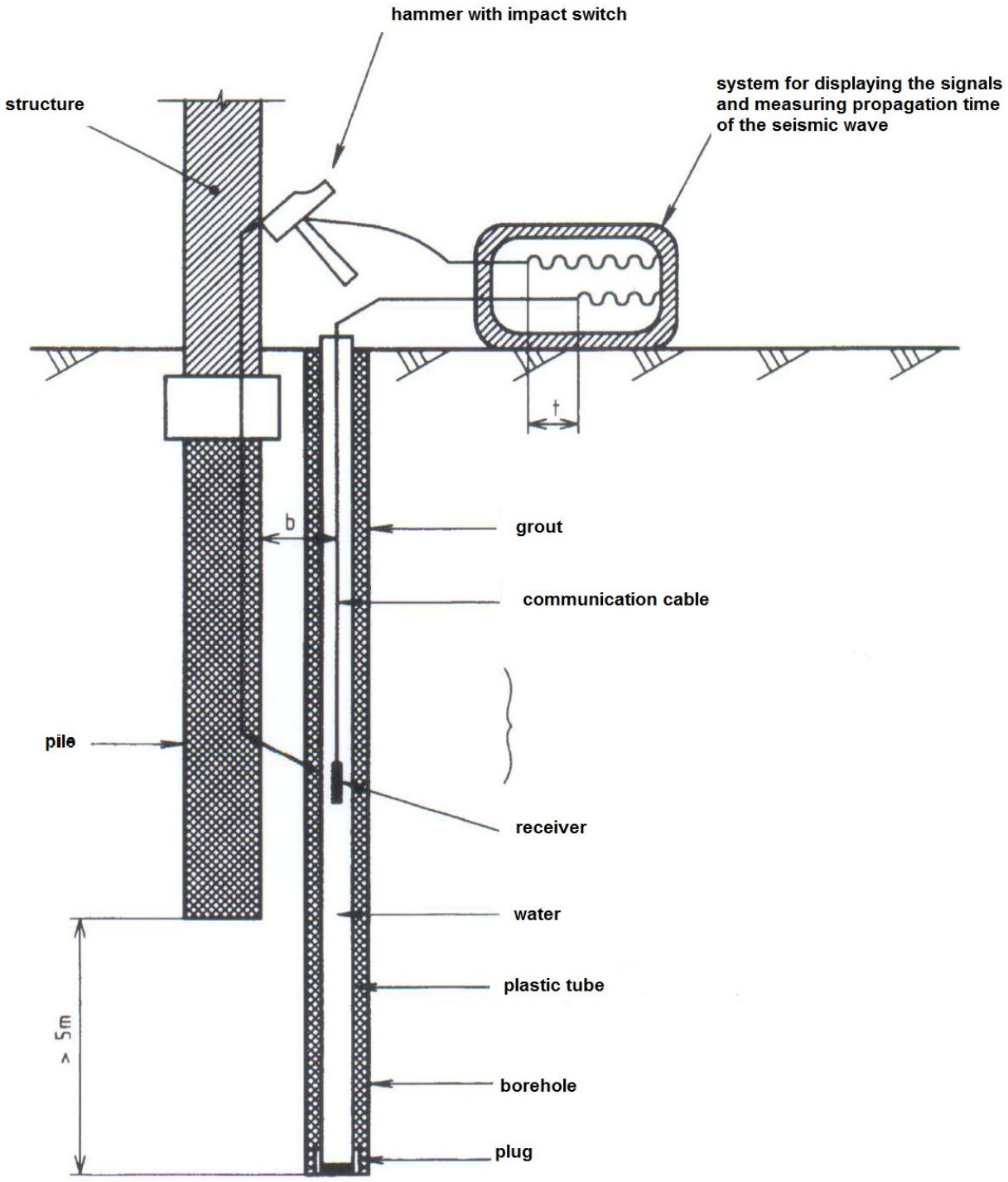

Fig. 1: Principle of the test

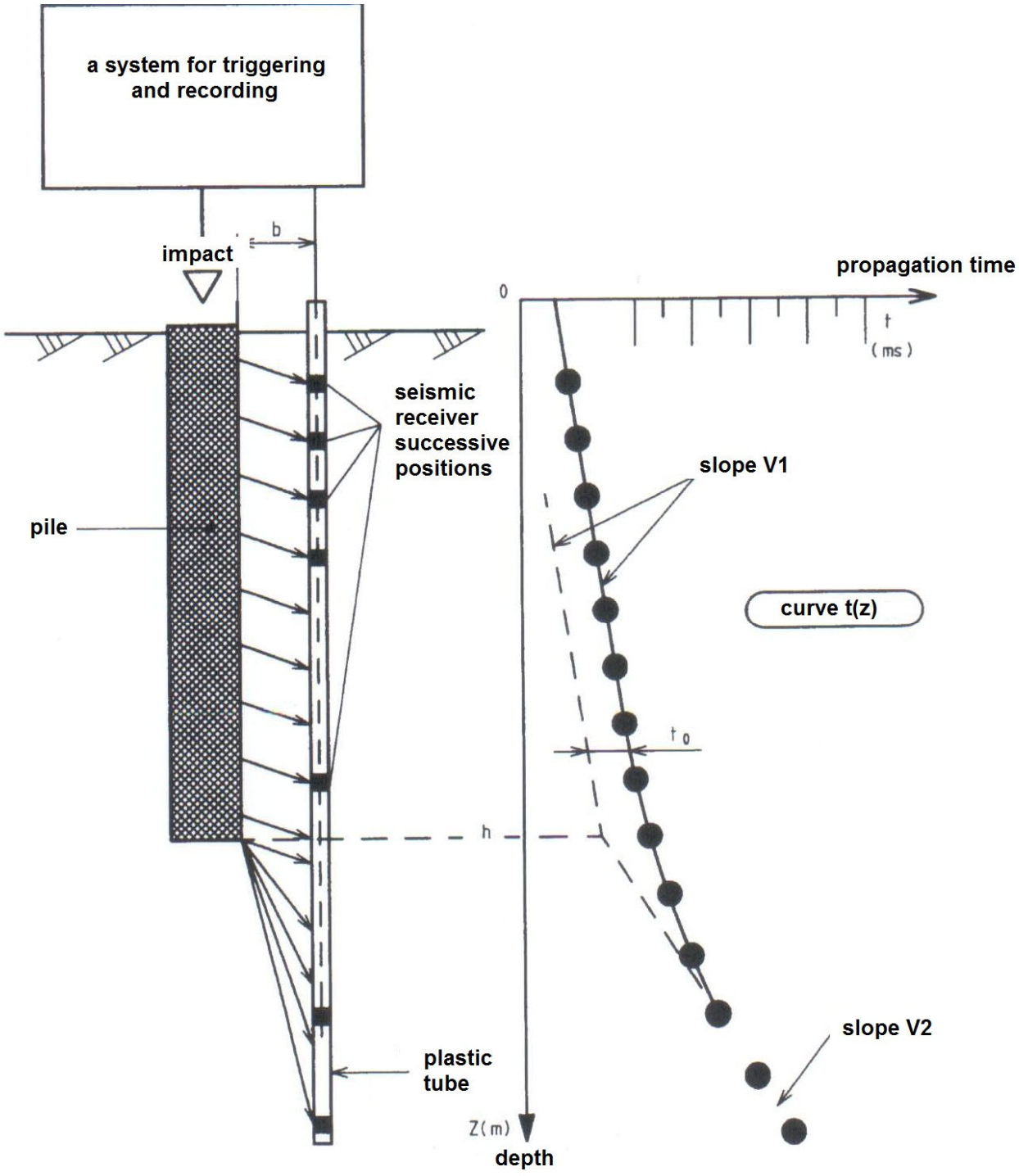

Fig. 2: Determination of the pile length in homogeneous soil