# institute for building materials and structures

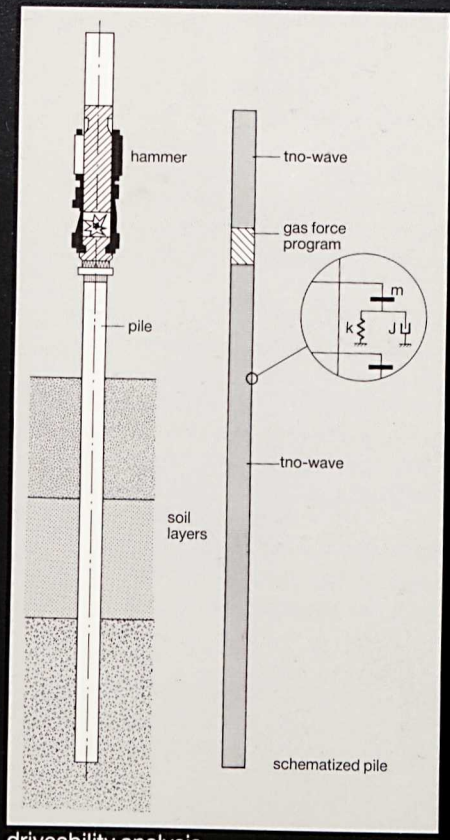
TNO

## foundation pile diagnostic system

onic integrity testing

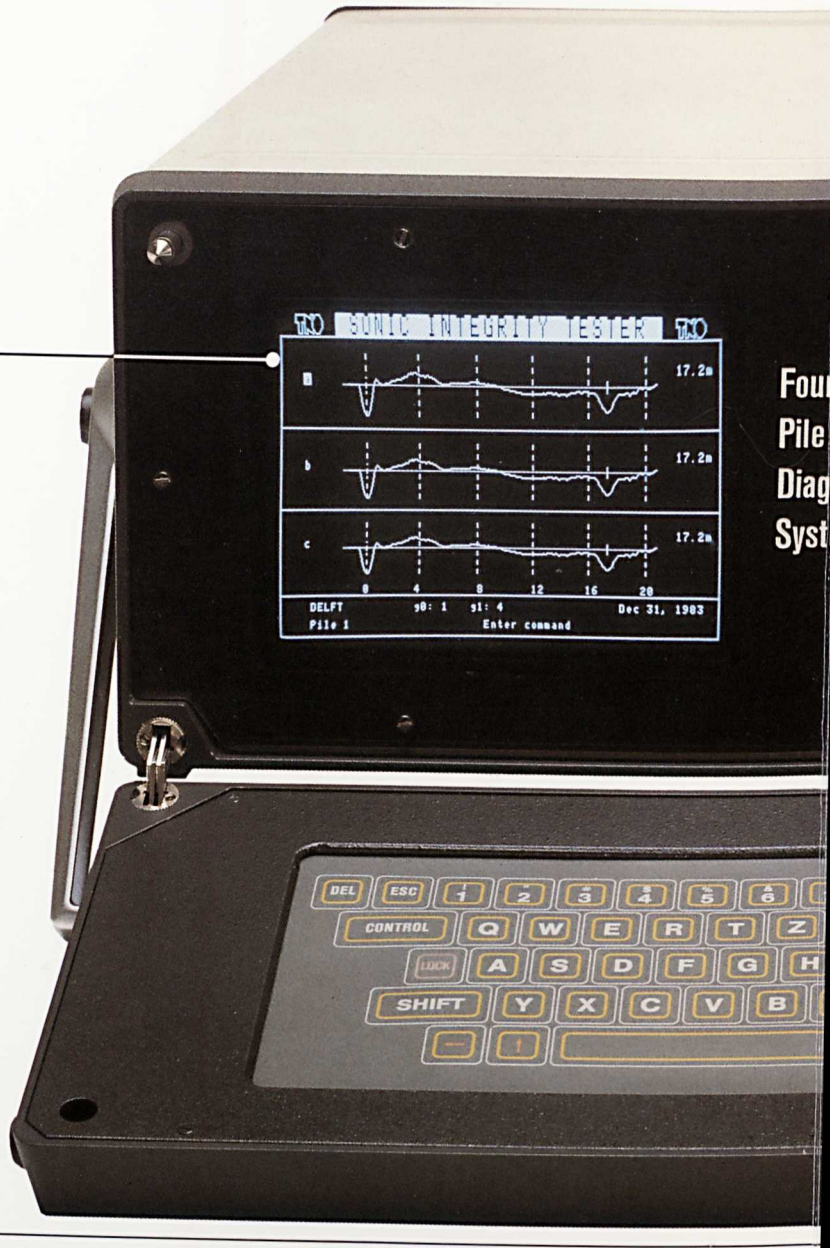
dynamic load testing

pile and hammer monitoring




driveability analysis

# foundation pile diagnostic system




*Conversational graphics display*

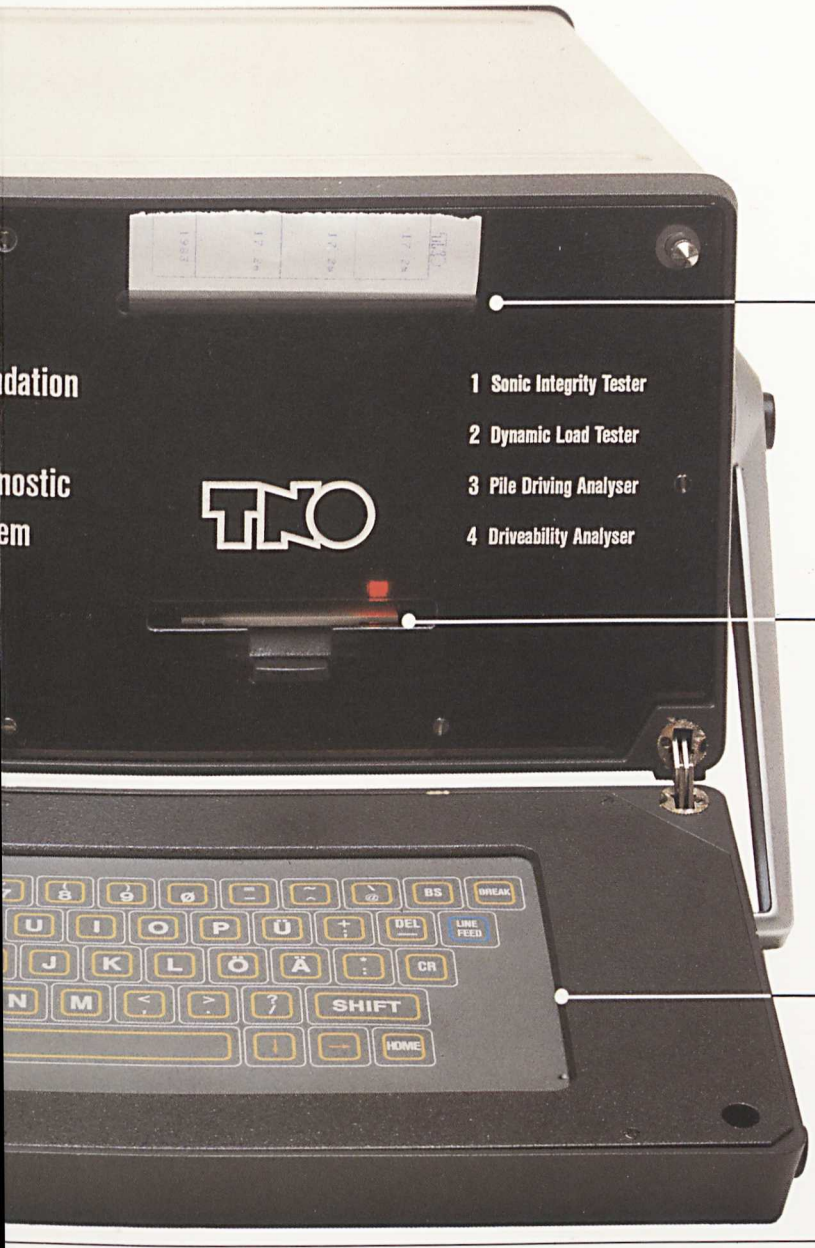
The *Foundation Pile Diagnostic System* is a portable measuring computer dedicated to pile testing, pile dynamics and soil dynamics.
Four different software packages are available, which let the instrument function as a:
- sonic integrity tester
- dynamic load tester
- pile driving analyser
- driveability analyser

All peripherals are built-in:
- conversational screen
- keyboard
- graphic display
- printer
- plotter
- data storage on diskette
- signal conditioners

Neither an external printer, plotter or terminal, nor a tape recorder for storage need to be used.
They may, however, be connected if desired.

*software packages*
The software packages 1-4 are in conformity with the state-of-the-art. As the software is entirely loaded from a diskette, new versions can be easily implemented to all systems in use.

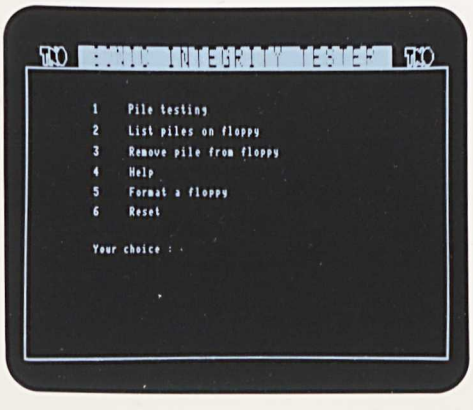
Future improvements and extensions to the programs will be made available to the community of users at regular intervals.

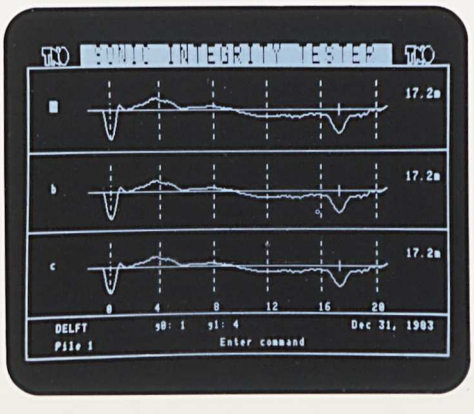



*Printer / Plotter*

*Diskette for program loading and data storage*

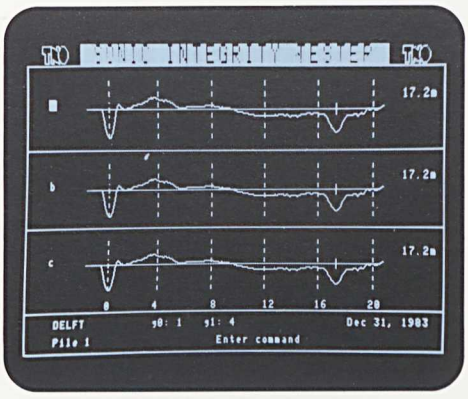
*Keyboard*



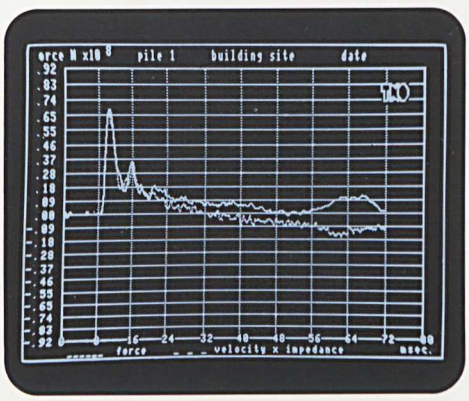




left:
*Menu-programming*

right:
*Fully annotated graphic display*
*Semi-automatic cursors*

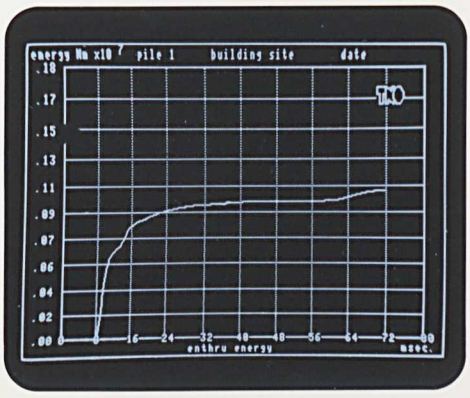



*Sonic integrity tester*
(software package 1)
The pile is hit with a small hammer, and one sensor is used to pick up the signal.
The display shows a reflectogram of the pile, in which cross-sectional variations and cracks are seen. They can be located using the semi-automatic cursors.
A simulation program (which asks for soil data) facilitates the quantitative interpretation of the signals.
Hard-copy output can be obtained at the site location from the built-in plotter.
Alternatively the stored signals can be plotted automatically on an office plotter, for reporting purposes.
Depending on site conditions, the test of each pile takes only a few minutes, so that it is possible to test more than 100 piles per day.
The information obtained by this type of testing concerns only the material of the pile and its integrity. It does not present data which could be used for the estimation of the bearing capacity.
If data on load bearing capacity is required then conventional load testing or dynamic load testing may be carried out.




*Dynamic load tester*
(software package 2)
A pair of accelerometers and strain transducers are connected to the pile top.
As an alternative to the accelerometers, an electronic theodolite which gives the pile displacement, can be used. A drop hammer or a pile driving hammer is used to give a transient dynamic load.
The signals are analysed, and the dynamic skin friction and toe resistance are obtained.
Under certain conditions the dynamic skin friction and the dynamic toe resistance can be translated to static skin friction and static toe resistance.
It requires:
- basic knowledge of the static and dynamic soil models, obtained from laboratory tests.
- derivation of the dynamic parameters from the correlation between static and dynamic load test results.

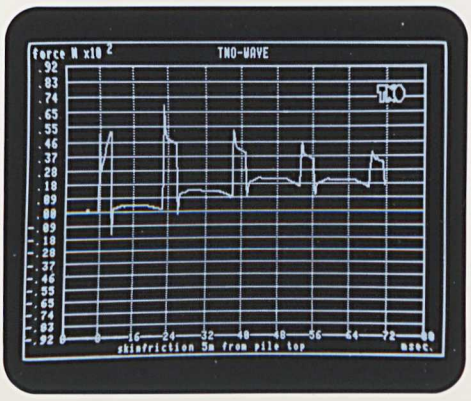
The test has to be performed after a period of rest, in which the soil is allowed to recover from the effects caused by driving, such as remoulding and building-up of pore-water pressures.




*Pile driving analyser* and *Hammer monitor*
(software package 3)
A pair of acceleration/strain transducers are connected to the pile to be driven.
During driving, the following data is derived and presented as a function of time, depth or number of blows:

*pile driving monitor:*
Stress, acceleration, velocity, displacement, enthru energy.
Dynamic skin friction and toe resistance, estimated static skin friction and toe resistance.
Driving record; how resistance, energy and stresses build up as a function of the number of blows, or as a function of depth.

*hammer monitor:*
Free-fall hammer:
Ram velocity, drop height, kinetic energy, efficiency.
Hydraulic offshore hammer:
Ram velocity, drop height, kinetic energy, potential energy, hydraulic pressure, hydraulic energy, airpressure, air pressure energy losses, efficiencies.




*Driveability analyser*
(software package 4)
Based on soil properties, hammer parameters and dimensions of the pile a driveability study can be made.
Figures for the expected blow count and for the dynamic resistances are obtained.
The program uses TNOWAVE, which is based on the wave equation theory and the method of characteristics. A library containing the parameters of a large number of pile driving hammers is included.
The program TNOWAVE allows the soil resistance to be modelled as (non)linear, dependent on displacement, velocity and acceleration. Also cross-sectional variations can be taken into account. For any desired level in the pile, data such as stress, displacement, velocity, acceleration, skinfriction, toe-resistance and travelling waves can be presented as a function of time.

# general specifications

*computer:*
Processor: Motorola MC68000
Memory: 256 kBytes
Analog in: 4 channel, 12 bits, computer-controlled gain

*peripherals:*
Graphics: 7" screen
Plotter: res. 256*512 dots
Diskette: 3,5", 512 kB
Keyboard: full alphanumeric character set

*options:*
- I/0 channel for alphanumeric terminal
- I/0 channel for communication over public data network
- IEEE-488 interface for external printer or plotter
- 1-channel telemetry for integrity tester
- 4-channel telemetry for driving analysis
- voice I/0 for integrity tester (to allow 1-man operation)
- 8-channel analog input, resolution 12 bits

*transducers:*
Integrity testing:
Accelerometer, range +– 50 g
Bearing capacity analysis:
optional electronic theodolite
strain gauge transducers, range 250 $\mu$ m/m
piezoresistive accelerometers, range 5000 g
Junction boxes with integral amplifier
Driving-analysis:
Bolted-on piëzoresistieve acceleration transducers and bolted-on strain transducers, range 5000 g and 2000 $\mu$ m/m.
Junction boxes with integral amplifier (underwater-versions of transducers and juncton boxes are available)

*environmental:*
Temperature: 5 – 40 deg C.
Humidity: 10 – 90 % R.H, non-condensing
Power: 220 volts +– 10 %, 120 watts, 50/60 Hz.

*physical:*
Dimensions: 48 cm wide, 54 cm deep, 20 cm high
Weight: 17.5 kg

Specifications may be altered and updated from time to time.

# our institute

The TNO-Institute for Building materials and Building Structures (TNO-IBBC) is one of the 35 institutes within the Netherlands *TNO-Organization for Applied Scientific Research.* This organization employs 4700 people, of which 900 are qualified scientists and engineers. *TNO-IBBC* has a background of expertise in building materials, structural mechanics and dynamics. 150 People are employed, of which 50 are university graduates.
Our group, dealing with *Structural Dynamics,* is specialized in fundamental research as well as in practical work on the subjects of structural dynamics, wind engineering, soil dynamics, pile dynamics, pile testing, reliability analysis and design of special measuring equipment.

*our partners*
TNO-IBBC does fundamental research on soil dynamics and pile-soil interaction in cooperation with the *Delft Soil Mechanics Laboratory* and the *Delft Technical University.*
A lot of valuable evaluation work has been done by *Cementation,* who represents our methods in the U.K. and Ireland.

*our experience*
In the early 70's TNO-IBBC developed equipment for the Sonic Integrity Testing of piles; this equipment is now in use in many countries, and has been accepted widely. More than 100,000 piles have been tested by this equipment.
In the past decade TNO-IBBC developed methods and computer programs for Dynamic Load Testing and Pile Driving Analysis, and many field tests onshore and offshore were performed, in many parts of the world. Fundamental research has resulted in dynamic soil models for the analysis of transient pile loading phenomena.
A thorough study on wave propagation in the pile-soil system led to the program TNOWAVE, based on wave equation theory and the method of characteristics. This program forms the basis of work on determination of pile shape, dynamic load testing and driveability.

*our attitude*
The institute's actual skills and the experience available may be called upon by any company. TNO-IBBC performs theoretical as well as experimental work, contract research, field-testing and trouble-shooting.
For the use and exploitation of the Foundation Pile Diagnostic System TNO seeks qualified and reliable partners, having adequate knowledge of the background and practicalities of the methods described, willing to make use of our training and support and prepared to keep in contact with TNO to exchange experience.
TNO will make an arrangement with partners defining mutual rights and, under certain conditions, exclusive right of use in a certain region. TNO will give adequate training service and support, either at site locations, by mail or by modern data communication methods such as facsimile and public data networks.
TNO will keep the software up-to-date using the results of their own research work, testing experience and user's comments.

*For further information please contact:*
Institute for Building Materials and Building Structures TNO

*visitors address:*
Lange Kleiweg 5
Rijswijk
the Netherlands

*postal address:*
P.O. Box 49
2600 AA Delft
the Netherlands
Contact: P. Middendorp, F.J. Reiding
Telephone: 31-(0)15 - 13 82 22
Telex 38270 ibbc nl
Telefax: 31-(0)15 - 14 54 44

For specific data and information about TNO please contact
Mr. Aad Lakwijk
TNO Guide for Trade and Industry
Schoemakerstraat 97
2628 VK Delft
The Netherlands
Phone 31-(0)-15-569330 ext. 2041
Telex 38071 zptno nl

Colofon:

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