Geotechnics is a very demanding field of engineering. In comparison to typical structural engineering (i.e. steel or concrete), the knowledge of material properties in geotechnics is very limited. These properties may significantly vary depending on the location, history, water and climate conditions. In order to create appropriate methods for design and ground investigation, soil – structure interaction is constantly being carefully studied and analyzed. In addition, increasingly advanced numerical models allow to accurately reflect the phenomena occurring in the ground. However, for safety reasons and to confirm the designer's assumptions load tests are carried out. Pile foundation load test provides valuable information, primarily on the structure settlement depending on the applied load. The load is transferred to the ground by the pile shaft friction and by stress from under the pile base. In order to accurately determine how the forces are being transmitted, structure is equipped with specialized measuring equipment, which measures strain of the individual sections of the pile. Then, by knowing the shortening of these sections, the dimensions of the pile (diameter) and the elasticity modulus of concrete, load distribution and sectional unit friction can be determined (Eq.1).

$$Q_i = \varepsilon_i \cdot E_{t;i} \cdot A_{t;i} \quad \text{[kPa]} \tag{1}$$

where:

ε_i – axial strain in section *'i'* of the pile core
$E_{t;i}$ – elasticity modulus (Young modulus) of the pile in section '*i*'
$A_{t;i}$ – pile cross section area in in section '*i*'

The values of *E* and *A* represent the stiffness of the pile and are not constant. These parameters change with depth and deformation, depending also on the pile installation technology and the soil condition. The research project aims to identify factors affecting the variability of the pile core axial stiffness. Static load test on instrumented piles are performed to determine side and base soil resistance distribution. In order to correctly determine this distribution, a proper material characterization of the pile is necessary, and that depends on many factors. Only a few attempts have been made in the whole world to solve this problem, and most engineers and researchers assume that the pile stiffness is a constant parameter. This is a misconception, leading to incorrect estimation of stress distribution in the ground. The project task will be to accurately identify factors that influence the stiffness variability and to determine the nature of that impact. In addition, it will be possible to develop a general method for actual pile stiffness determination.

As part of the project, it is planned to carry out a full-scale research in the form of specialized field tests. Static load tests on instrumented concrete piles are to be conducted (using vibrating wire technology, concrete embedded and retrievable extensometers). Structure monitoring with data registration will be carried out from the moment of pile installation in the ground. Identification of phenomena that occurs in fresh and curing concrete with the impact on residual forces emergence. It is also aimed to analyze the behavior of surrounding soil and its influence on the pile shaft - transfer of compressive or tensile forces. After carrying out the load test, piles will be extracted from the ground to perform detailed geometry measurements and concrete samples will be taken from several sections for elasticity modulus determination. The research is to be carried out in cooperation with piling contractors and organized on plots located near the currently under construction sites.
Numerical analyzes and simulations using the Finite Element Method will also be conducted. It is anticipated that a number of pilot static load simulations will be carried out under given ground conditions. In the computational examples, various types of pile core stiffness heterogeneity (such as nonlinear variation of concrete modulus – with depth and strain, non-homogeneous pile section, local weakening or enhancement etc.) will be addressed and phenomena causing residual force in the pile will be initiated in order to determine its influence on load distribution along the pile shaft.

Currently, more and more investment projects are located in complex ground conditions, due to that popularity of pile foundations highly increases. Dynamic development of structures monitoring is observed (so-called Intelligent Structures) and newer methods of measurement are used (fiber optics). However, some fundamental issues remain unresolved. Errors in estimating the load distribution along the pile shaft, caused by large simplifications, eg. not taking residual forces into account, can reach up to 50%. Realization of the research task will significantly affect the development of geotechnical structures instrumentation and contribute to further development of numerical models for construction foundation design. Understanding processes taking place equally in the ground and in the concrete will allow a more accurate determination of material properties and will also improve the quality and reliability of pile load test on instrumented piles. This, in turn will contribute to a more efficient design of pile foundation structures. With the development of deep foundations market, the demand for this type of research will continue to grow.