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GEOTEKO is a group of companies in Poland offering solutions to complex geotechnical problems. GEOTEKO has over 25 years of experience working on over 5000 projects, with the likes of KGHM Polska Miedz S.A., ORLEN S.A., Metro Warszawskie, ARUP, ARCADIS, HOCHTIEF, KELLER, AARSLEFF, MENARD, BUDIMEX. GEOTEKO has taken part in road, railway, hydrotechnical, housing, energy, mining, environmental and landfill projects. GEOTEKO'S activities include:

- *Laboratory soil testing.*
- *Numerical modeling and geotechnical design.*
- *Field testing.*
- *Consultancy and training.*
- *Monitoring.*

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HOW GDS TRIAXIAL APPARATUS STRENGTHENS THE COLLABORATION BETWEEN LABORATORY TESTING AND NUMERICAL MODELLING

GEOTEKO's laboratory works closely with their numerical computation and modelling department, as well as with external clients performing similar calculations. This collaborative approach has many benefits for the laboratory and for those who use the laboratory test results. Direct communication between the designers and the laboratory enables:

- Calibration of the constitutive model selected for the analysed boundary problem.
- Adapting test programs to the project needs.
- Carry out on-the-spot analysis of test results and if necessary, change the program of subsequent studies.
- Optimization of the test costs (maximum ratio of information to test costs).

The finite element software used for the numerical analysis allows the user to implement many possible constitutive models that describe the behaviour of the soil, especially in the case of large projects where there is a large variation in ground conditions. To ensure the output from the laboratory is

both accurate and efficient, the laboratory must find solutions that automate testing where possible.

One of the most commonly used models in numerical calculations is the Hardening Small Strain (HSS) model. To determine one of the basic parameters of this model, the E_{ur} modulus (Figure 1), additional actions from the operator are required. The shear stage is required to be interrupted, after which, the value of the deviator stress needs to be reduced by several percent of its value and then resumed. Prior to purchasing the GDS system, such tests were performed manually in Geoteko's laboratory. Carrying out this test generated significant costs due to the additional time and engagement required from the operator.

GEOTEKO purchased a Triaxial Automated System (TAS) from GDS Instruments. The cell of this apparatus has internal connecting rods and top cap rigidly connected to the piston rod (the hybrid cell). To measure the shear wave velocity propagation in the soil, bender elements were installed to the top cap and base pedestal. The shear wave velocity value is used to evaluate initial stiffness of soil. (E_0) (Figure 1). Rigid construction of the cell gives the possibility of obtaining high quality results, especially deformation parameters over the full strain range as used for the HSS model.



GDS Instruments hybrid cells in 50kN load frames at Geoteko laboratory in Poland.

Using the GDSLAB automated software pre-shear function (Figure 2) to perform the triaxial tests during the unloading stage, does not require continuous operator involvement, saving both time and cost. Figure 3 shows examples of triaxial test results performed to determine parameters for the HSS model. In addition, the automated triaxial apparatus allows for performing non-standard load paths during shearing such as extension loading tests (Figure 4).

CONCLUSION

GEOTEKO has a close relationship between its laboratory and the department of modelling. The close cooperation of these two divisions, based on the high quality tests and calculation results, allows Geoteko to offer comprehensive geotechnical analysis services. GDS Instruments apparatus is used to select parameters for many ground constitutive models. Thanks to this apparatus and the experience of the laboratory staff, GEOTEKO carries out a number of non-standard tests conducted according to individual requirements from their clients.

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“The purchase of the GDS Instruments automated triaxial apparatus has allowed Geoteko to increase the efficiency of our laboratory. In addition, we have extended our cooperation with the numerical modelling department within our company as well as with the designers from external companies. As a result, we can grow and better understand the needs of our customers. We have found the new directions for development of our laboratory.” (Wojciech Tymiński – MSc (Eng), Laboratory Manager, GEOTEKO)

“Collaboration with the geotechnical laboratory that carries out tests in GDS’ automated triaxial apparatus has increased the quality of our services. High quality laboratory results are used to calibrate constitutive models, which is the basis for correct numerical analysis. Our cooperation continues to strengthen and we see its further development opportunities.” (Bartłomiej Bursa, Department of Numerical Analysis, GEOTEKO).

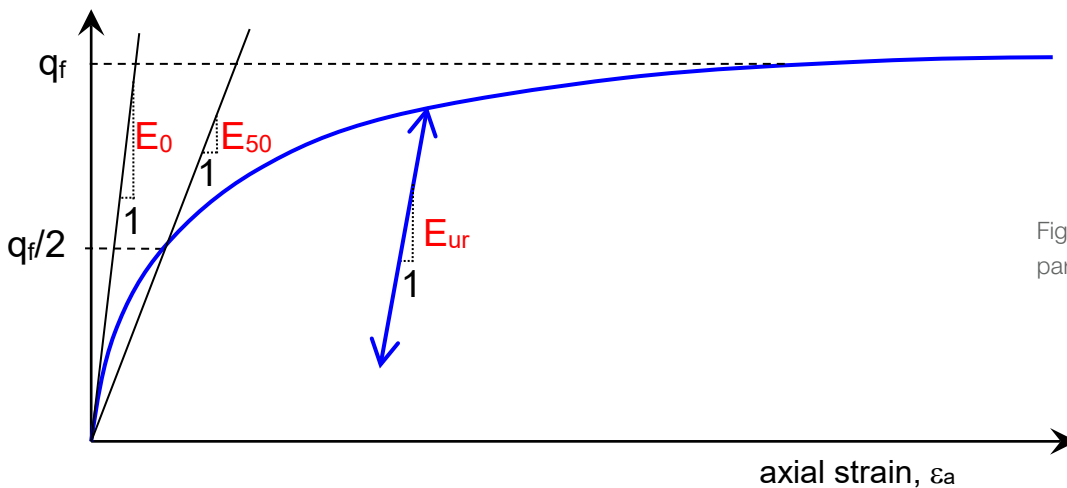


Figure 1 HSS Model parameters.

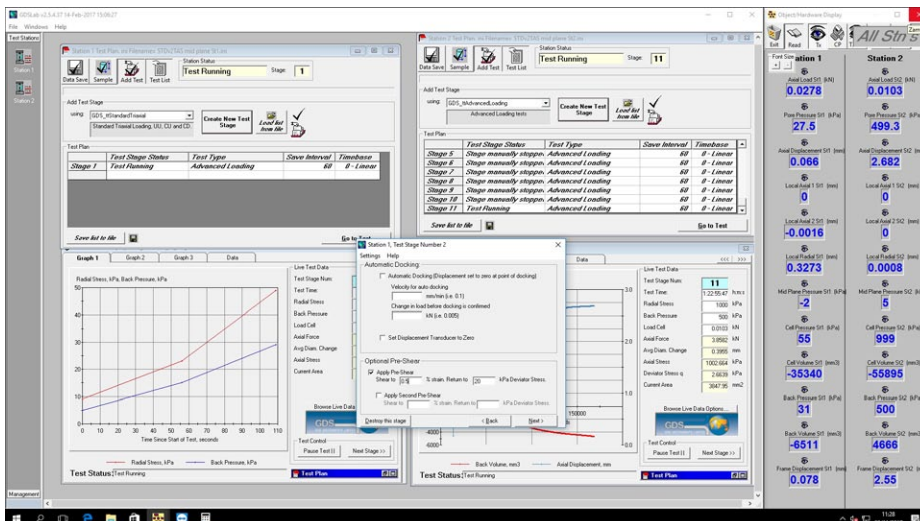


Figure 2 Pre-Shear option, GDSLAB software.

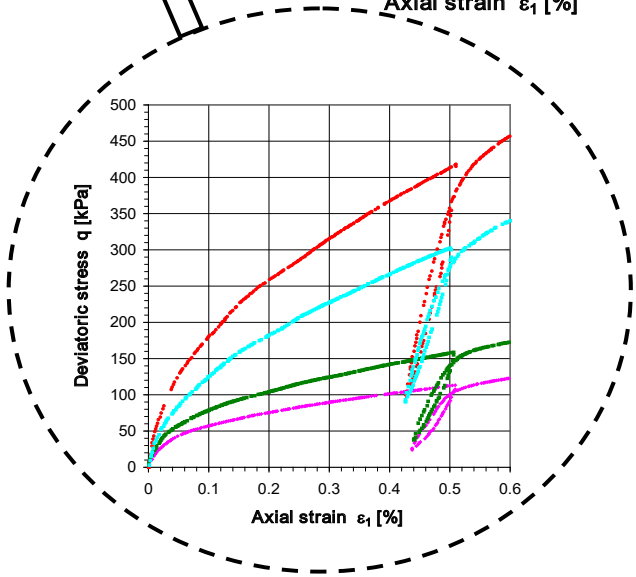
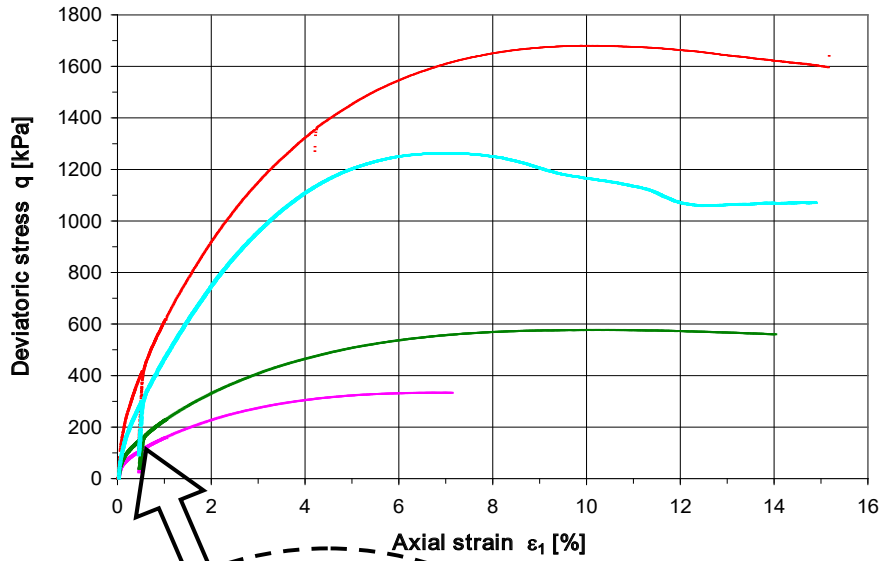


Figure 3 Stress/Strain characteristics for loading, unloading and reloading cycles. Tests for HSS Model parameters estimation.

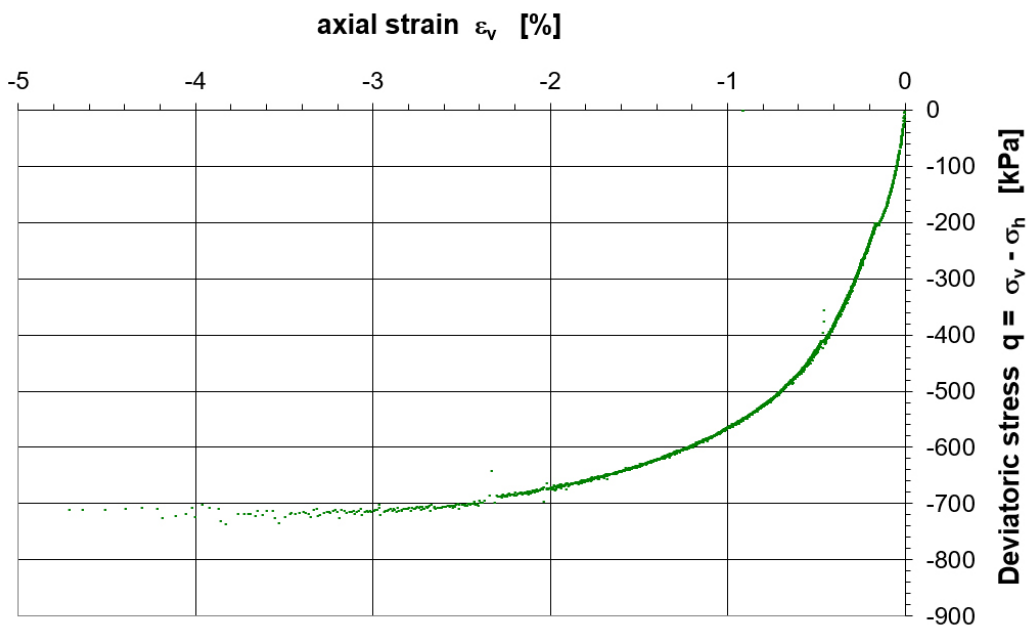


Figure 4 Stress/Strain characteristics from extension loading test.