

# LOADTEST

## The Loadtest Settlement and Prediction Method for Piles



It is common knowledge that foundations carrying constant loads settle in accordance with time from loading. In consequence the final displacement at a given load is a function of the time.

Some test loads, according to widely used specifications, are held for short periods, others for long periods. The result is that load displacement results as commonly presented, are erratic.

If one supposes that loads can be held fully constant at each stage and that the time deformation relationships can be accurately defined and projected to define its asymptote, then the final and unique load / settlement relationship can be established for a full range of loads.

This is what engineers seek to know, but such knowledge has not been obtainable in the past for practical reasons - namely insufficient loading times and inherent inaccuracies in both load and recorded deformation.

Loadtest overcome these difficulties with the use of three computer programs and a complementary system for practical on-site load testing, which allows high grade testing and analysis to be carried out.

**TIMESET**<sup>®</sup> can model the displacement behaviour of a foundation element under a constant load with great accuracy, allowing the final settlement at infinite time to be determined by extrapolation. This permits the definition of unique behaviour of a pile under load in a way, which has not previously been possible. The method is described in detail in "*A Method of analysis of stress induced displacement in soils with respect to time*", England, M., Deep foundations on Bored and Auger Piles, BAPII Ghent, A.A.Balkema June 1993, p241-246.

**CEMSET**<sup>®</sup>, the name which has now become synonymous with the prediction program, is based on known or measured soil parameters or alternatively on comparison with other similar cases. CEMSET is based on and developed from the paper "*A new method for single pile settlement prediction and analysis*", Fleming, W.G.K., published in Geotechnique 42, No 3, 411-425, 1992. The method uses two hyperbolic functions to characterise the skin friction and end bearing behaviour plus a model to allow for the elastic shortening.

**CEMSOLVE**<sup>®</sup>, the back analysis program, has been proven to be an exceptional analysis and diagnostic tool. It can not only be used to derive soil parameters from tests much more reliably than was previously possible, given high quality data, but also it can be used to look in a detailed way at efficacy of the various techniques employed for pile or barrette installation.

**LOADING SYSTEMS** Based on equipment and software developed specifically, they are, not only an order of magnitude better in terms of accuracy and have very necessary advantages in terms of safety, but can also reveal more of the geotechnical information.

### System evaluation

#### 1. More informative load tests

The foundation design parameters for a given site and founding stratum can be determined from a suitable preliminary load test. In situ strength, stiffness and reaction time of the founding strata and their effects on foundation behaviour can be derived without the use of expensive load measuring devices within the structure of the foundation body.

It is easy to discover inappropriate design parameters by appropriate site tests. This allows designs to be verified or made more economical and efficient.

Foundation behaviour follows from installation practice as much as from SI conditions; the parameters that can be derived from load testing are one stage better in most cases than SI.

#### 2. Piling Equipment Design.

Piling equipment design is an obvious candidate for investigation. New tools for cleaning bored pile bases have been developed and self-cleaning under-reaming tools to improve pile performance.

#### 3. Improved Construction technique.

The relative merits of a variety of pile and barrette construction techniques can be explored. For example, the high efficiency of displacement piles is easily demonstrated in certain soils.

The technique therefore has implications for pile selection and related job economy. Unsuitable or inefficient construction techniques, such as those which may inadvertently cause loosening of soil around a bored pile shaft or the presence of soil debris at the base, can often be detected.





#### 4. Advancement of design methods.

The ability to arrive at soil reaction parameters on a much broader basis than previously means that, for example, bearing capacity coefficients and friction factors may be derived from real rather than theoretical considerations, and the range of natural variation to be expected with such methods in a variety of soils can be assessed.

#### 5. Soil stiffness importance recognized.

The stiffness of soils can be determined. This is an important parameter usually missing from site investigation findings. The behaviour of soils surrounding and below the element under test after its installation can be characterized in time and under load. This provides a better and more useful design assessment than can otherwise be achieved.

#### 6. Settlement and time relationship made clear

The time relationships for any founding soil can be explored and it can be determined whether total or effective stress design methods are appropriate to any given case. Load tests may thus have applications beyond those, which one would normally expect. The time model allows the duration of application of loads to be reviewed, so that the most economic test schedule can be defined.

#### 7. Application to other foundation types.

The method can easily be applied to other foundation and similar problems with little modification; for example, surface foundations are even simpler to deal with than piles. The method appears to have good potential for extension into the field of pile group behaviour.

#### 8. Significance of the foundation behaviour under load.

The method can be used to forecast or analyze the behaviour of piles or barrettes, which are to be or have been base-grouted, and to demonstrate the mechanics of this method of construction and its effect very clearly.

#### 9. Unique behaviour revealed.

Once the unique and definitive pile behaviour can be determined, the merits of other load testing methods may be assessed. Shortcomings of all other testing are critically exposed and the limitations in any situation become apparent.

#### 10. Partial factoring methods.

The technique has profound implications for all factoring methods, which are used to derive acceptable performance from ultimate states. This applies to both conventional Factors of Safety and Partial Factors as they are now operated and it introduces soil stiffness as a parameter, which is as important as ultimate capacity.

#### 11. Invaluable diagnostic tool.

When piles are carefully loaded and deflections measured much can be deduced if the performance of the pile is in some way anomalous. Poor end bearing or shaft friction capacity can be identified and even on occasions cracks or other structural problems can be inferred.

#### 12. Effect of cyclic loading

The analysis of displacement in time can provide the means to assess degradation of skin friction due to cyclic loading. Since each sequential cycle can cause additional displacement, this may be compared to the expected deformation which would have resulted if the load had been held constant for the equivalent time period.

A limitation that should be emphasised is that in order to derive accurate parameters from load tests, displacements must be carried to a stage where virtually all shaft friction and a reasonable proportion of base resistance has been mobilized. Likewise it is fundamental that loads in Maintained Load tests should be held truly constant at each stage.

Perhaps the most important aspect of this technique is that it has an important bearing on the general understanding of foundation behaviour. Multiple definitions of failure are no longer necessary and only cause confusion. The definition of failure reverts to the unique statement by Terzaghi to the effect that continuing indefinite settlement for no further increase of load represents failure. This is unequivocal.

The method equally applies to spread foundations, piles and barrettes. It will become an important tool of site investigation yielding data which is really pertinent to foundation design, unlike present practice which often concentrates on strength testing for bearing capacity, in contrast to stiffness and deformations.

