www.assessingtheunderworld.org

Assessing The Underworld
An Integrated Performance Model of City Infrastructures

ASSESSING THE UNDERWORLD

Monitoring geotechnical assets with Time Domain Reflectometry

G. Curioni, D.N. Chapman, L.J. Pring, A.C.D. Royal, N. Metje
University of Birmingham, School of Engineering, Department of Civil Engineering

For more information please contact Giulio Curioni:
g.curioni@bham.ac.uk @giuliocurioni

1. Introduction

Many geotechnical assets (e.g. earth dams, embankments, reinforced walls, pavements) have been constructed decades ago and have been deteriorating over time. Replacement of ageing geotechnical assets can be prohibitively expensive, hence monitoring and maintenance (when required) is often the preferred option. Several techniques can be used for this purpose. This work shows the potential of using Time Domain Reflectometry (TDR) for monitoring changes in the geotechnical properties of the soil.

2. Time Domain Reflectometry (TDR)

Measured parameters

TDR (Figure 1) is used to measure the soil electrical properties, i.e. the apparent dielectric permittivity (K_a) and the bulk electrical conductivity (*BEC*). From K_a the *volumetric* water content (θ) of the soil can be measured.

Main features

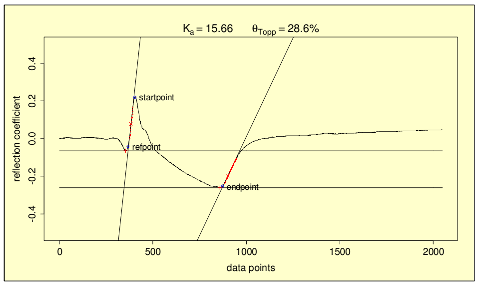
- Used in continuous long-term monitoring to measure water content at point locations, both spatially and with depth.
- Well suited to detect changes with time.
- If combined with other techniques (e.g. Electrical Resistivity Tomography, ERT), TDR measurements can be scaled up to the site scale.

Recent developments

In recent years TDR has been shown capable of measuring the soil *gravimetric* water content and dry density after soil-specific calibration.

a)

c)



b)

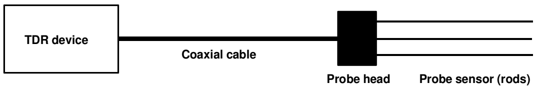


Figure 1: a) the TDR unit, multiplexer and 3-rod probe used in this study; b) schematic of the TDR system without multiplexers and c) example of TDR waveform analysis in soil.

3. Development of a new TDR methodology

a)

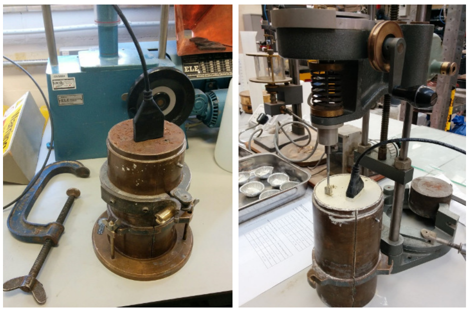
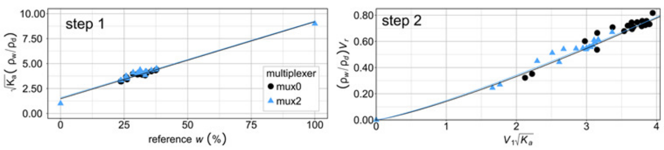


Figure 2: a) Laboratory TDR calibration combined with standard compaction and b) the fitting steps required to develop the soil-specific calibration.

b)

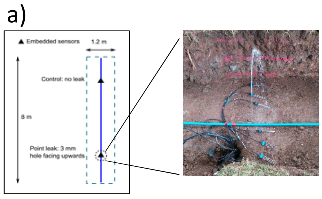


- A new improved TDR methodology has been developed that allows more accurate measurements of both soil ***gravimetric* water content (*w*)** and **dry density (ρ_d)** after soil-specific calibration.
- The calibration consists of taking TDR measurements during a standard compaction test (Figure 2a) and applying two separate fitting procedures (Figure 2b).
- From *w* and ρ_d important parameters related to soil strength can be calculated (e.g. the **degree of saturation**).

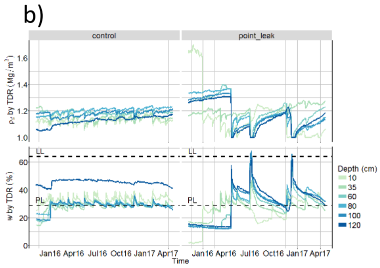
4. A flag system approach for geotechnical asset condition monitoring

- The TDR method was tested at a field test site developed at Blagdon in collaboration with Bristol Water (Figure 3a). A leaking pipe was used to saturate the soil during controlled experiments.
- The soil water content around the point leak (Figure 3a) approached its Liquid Limit (LL) during three leak tests (Figure 3b) indicating potentially significant loss in strength.
- The TDR measured a slight increase in ρ_d over time demonstrating it can detect small changes due to settlement (Figure 3b).
- Figure 4c shows a flag system approach based on parameters directly measured by TDR. **Early warnings could be sent based on predefined parameter thresholds prompting for inspections and/or interventions.**

a)



b)



c)

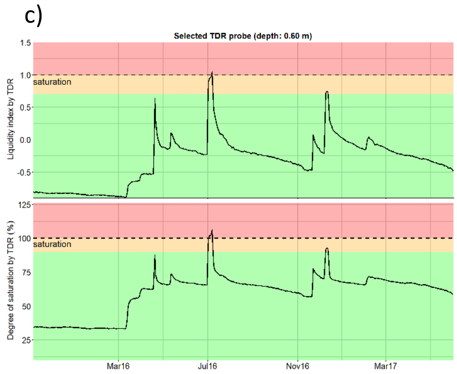


Figure 3: a) Schematic of the Blagdon field test site; b) measured ρ_d and *w* by TDR over time and c) proposed flag system approach for soil condition monitoring with TDR.

5. Conclusions

It is proposed that TDR could be used for long-term condition monitoring of geotechnical assets and for providing early warnings based on thresholds of the measured parameters.

TDR could be used alone or in combination with other geophysical techniques such as ERT for monitoring larger areas.

UNIVERSITY OF BIRMINGHAM · UNIVERSITY OF BATH · EPSRC Engineering and Physical Sciences Research Council · Newcastle University · British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL · UKWIR · UNIVERSITY OF LEEDS · The University Of Sheffield. · UNIVERSITY OF Southampton