ICSE-6 2012

Development of a Durable Bridge Scour Monitoring System based on Time Domain Reflectometry

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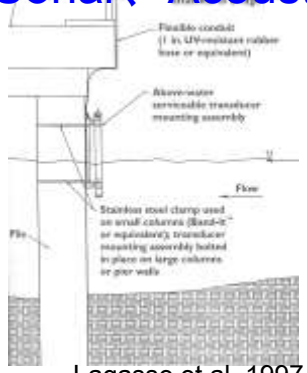
Outline

- Introduction
- TDR basics/ review
- Development of TDR scour sensing waveguide
- Data reduction: calibration and measurement
- Pilot field installation and evaluation
- Future study

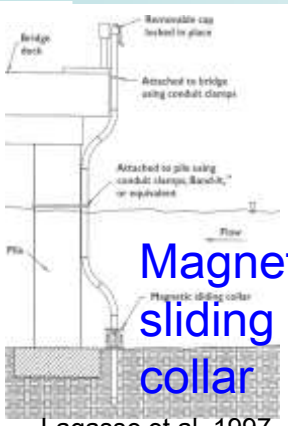
Introduction

Introduction

Sonar、Acoustic



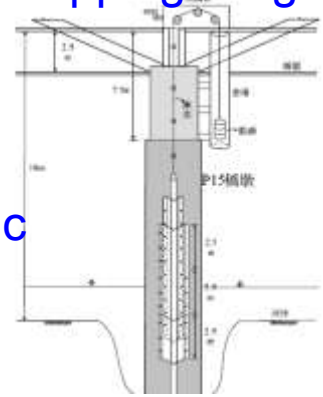
Lagasse et al. 1997



Magnetic sliding collar

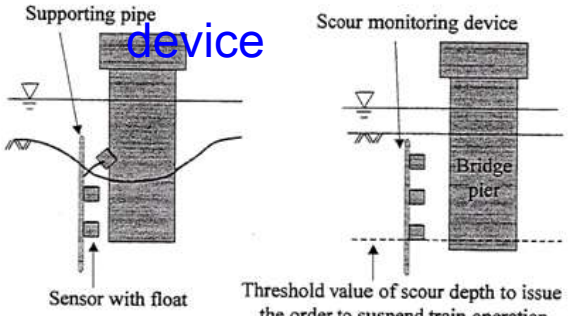
Lagasse et al. 1997

Dropping weight



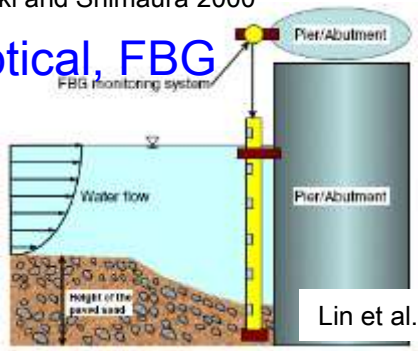
經濟部水利規劃試驗所2004

Float out device



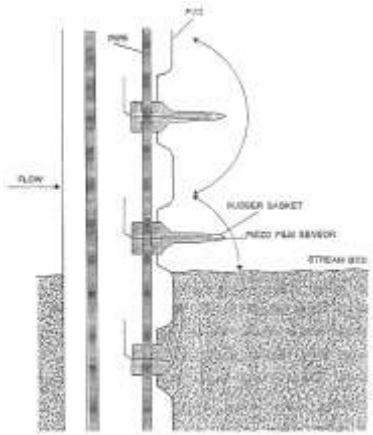
Suzuki and Shimaura 2000

Optical, FBG



Lin et al. 2005

Piezoelectric film



Lagasse et al. 1997

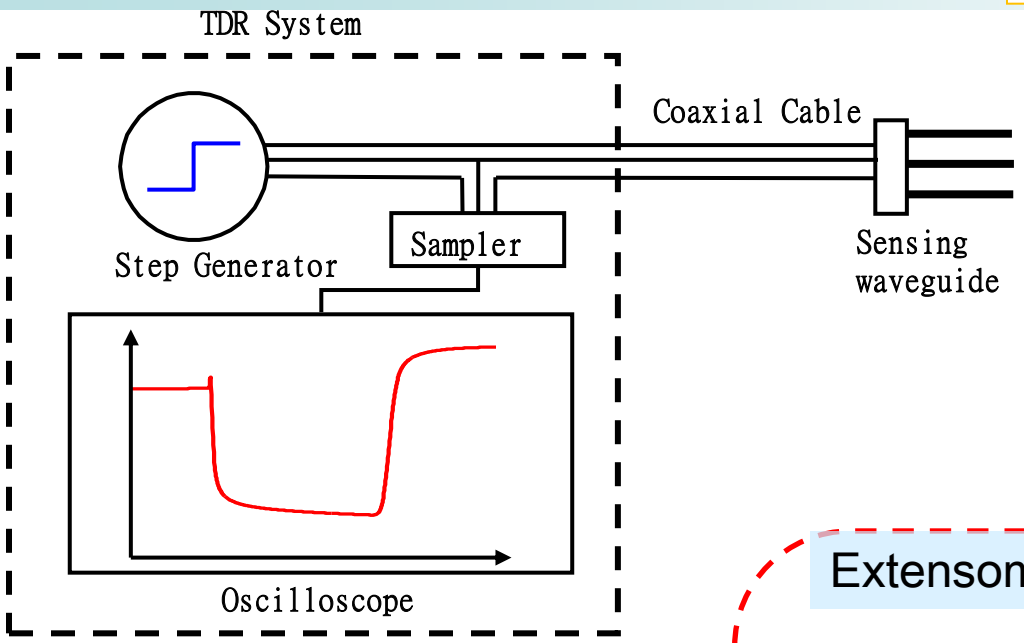
Feasibility for Taiwan

1. Durability
2. Economy

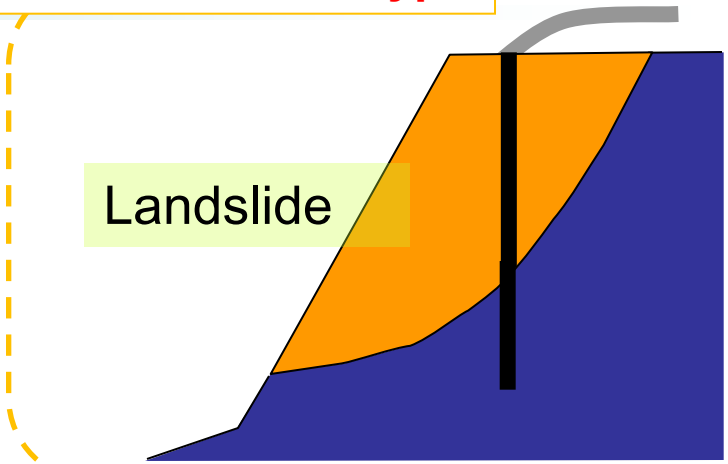
Possible Solution：

→Time Domain Reflectometry (TDR)

TDR basics



Cable deformation type

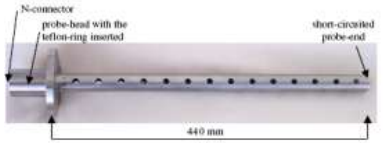


Interface type

Extensometer

Rain gauge

Water level

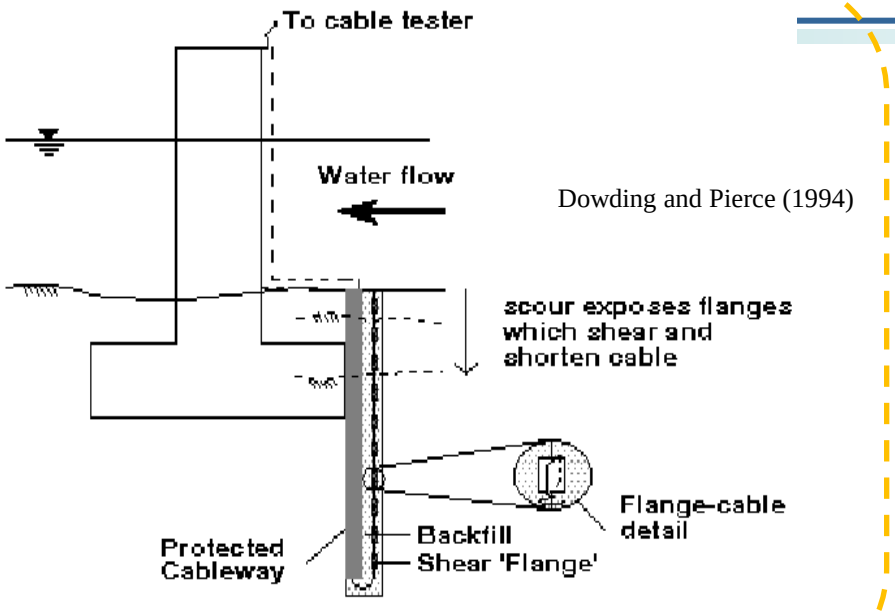


Dielectric type

Water content

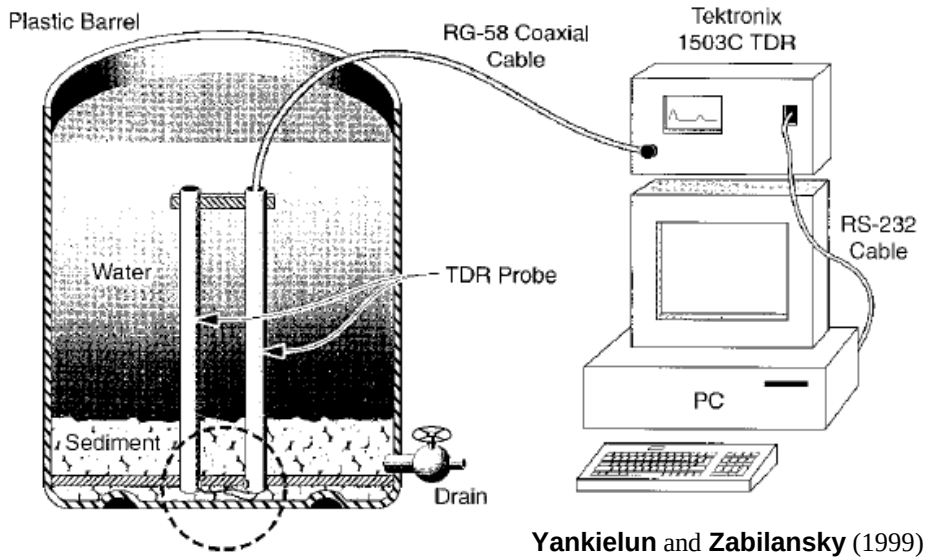
Suspended sediment concentration

TDR scour review



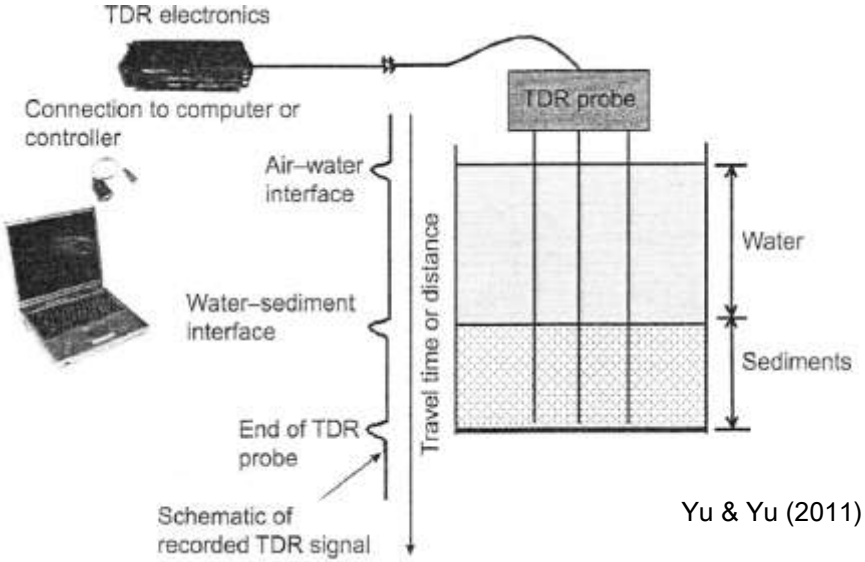
Dowding and Pierce (1994)

Max scour & Hard installation



Yankielun and **Zabilansky** (1999)

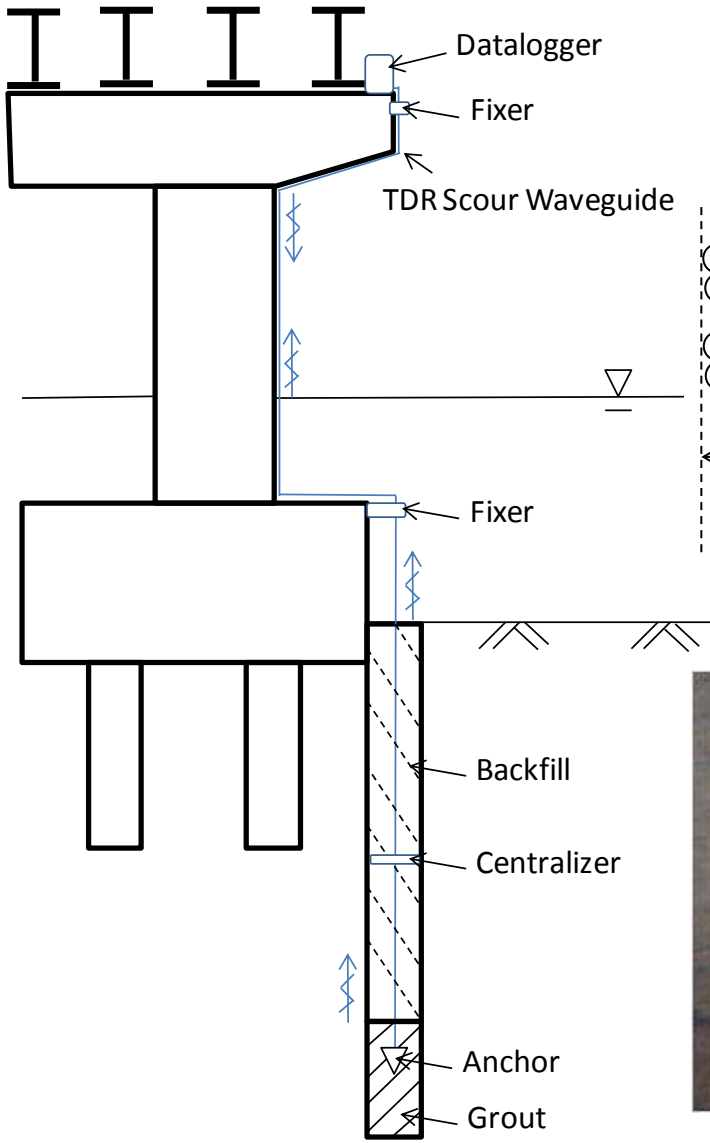
Attenuation & Hard installation

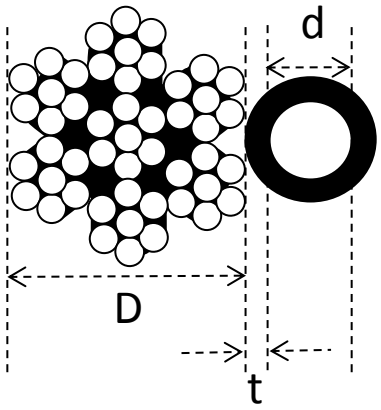


Yu & Yu (2011)

Practical probe design

Development of TDR scour sensing waveguide



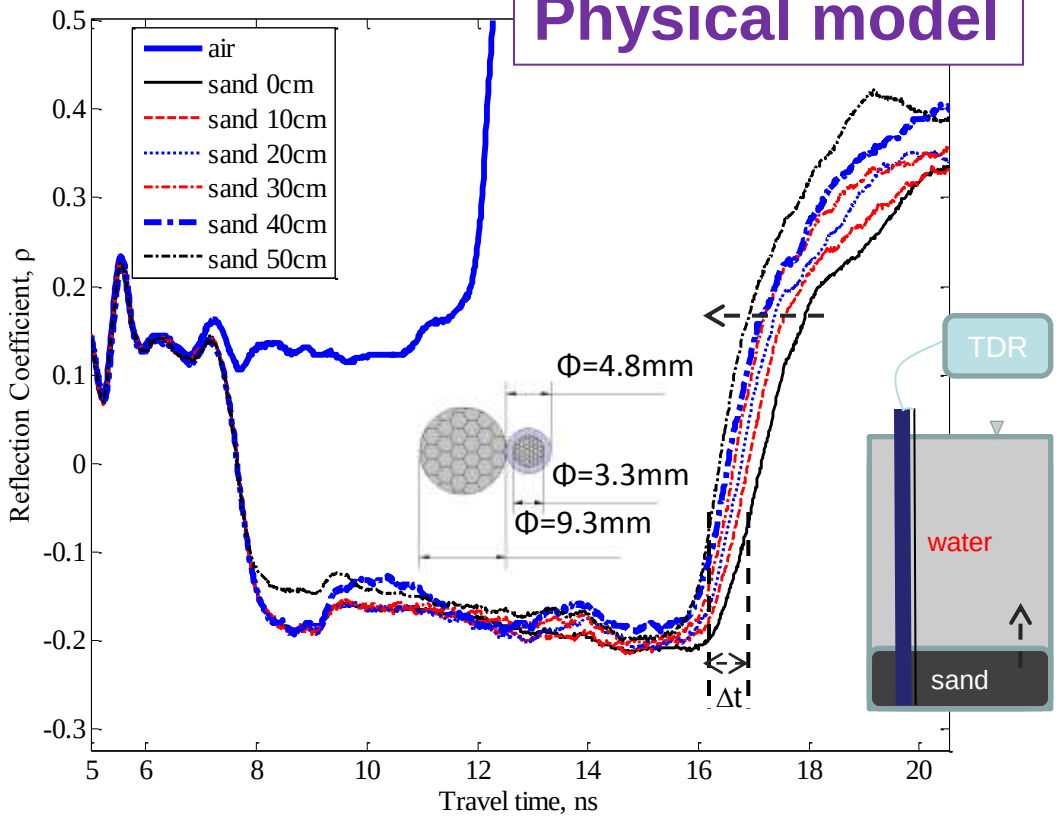


Main steel strand + insulated wire

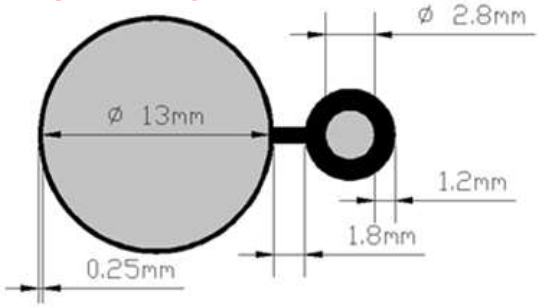
1. Reduce signal attenuation
2. Increase durability
3. Easy installation

Development of TDR scour sensing waveguide

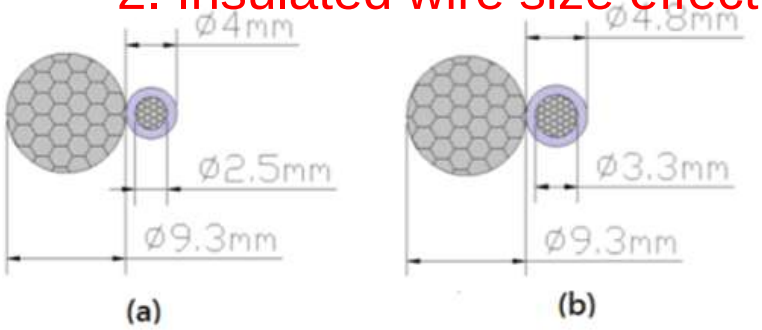
Physical model



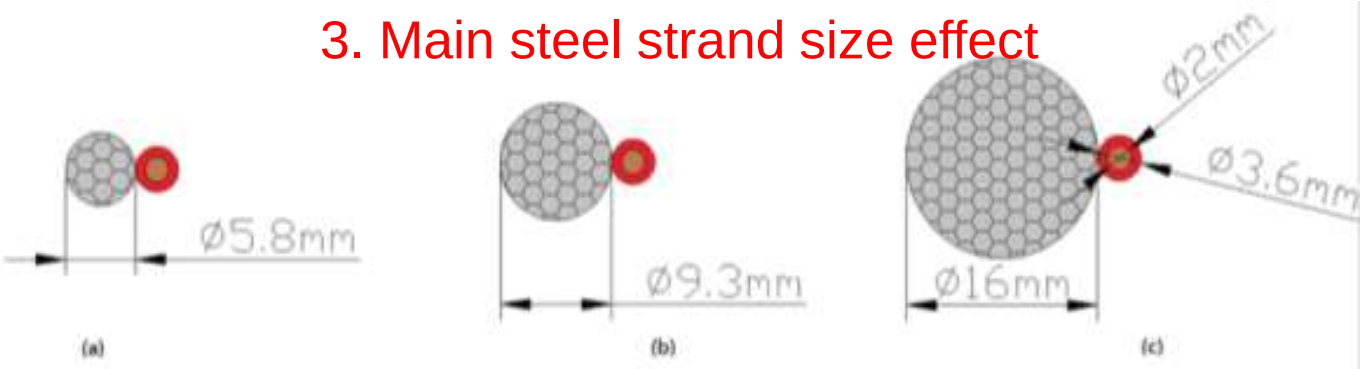
1. Spacing effect



2. Insulated wire size effect



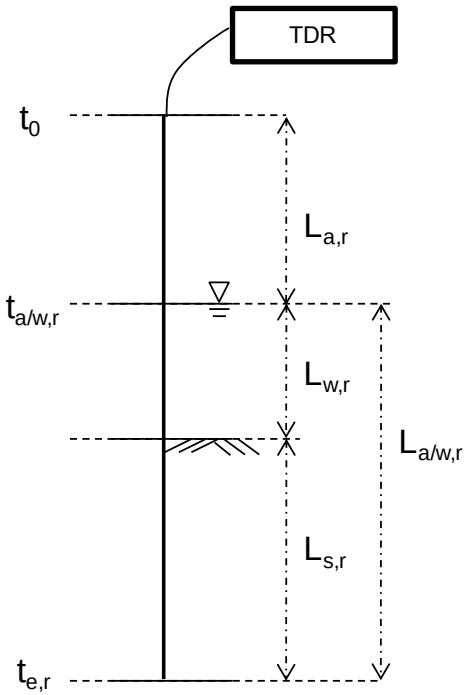
3. Main steel strand size effect



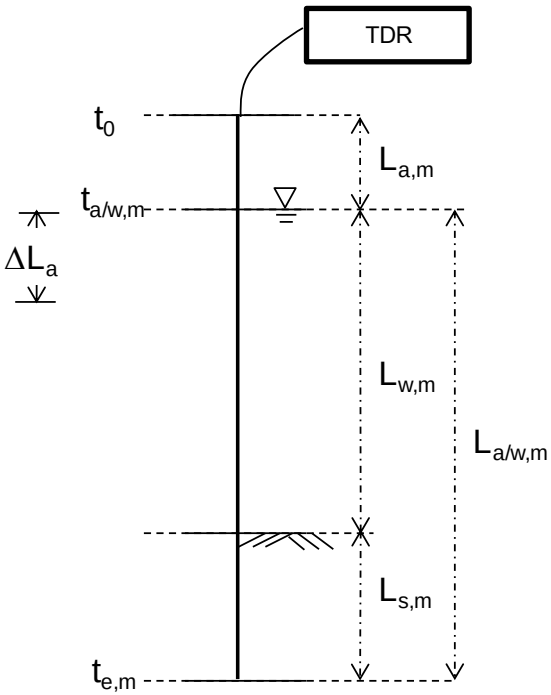
Data Reduction: Calibration and Measurement

Modified total travel time analysis

⇨ **Improve measurement accuracy & stability**



Reference



Subsequent measurement

Step 1 : V_a calibration

$$(t_{a/w,m} - t_0) - (t_{a/w,r} - t_0) = \frac{2\Delta L_a}{V_a}$$

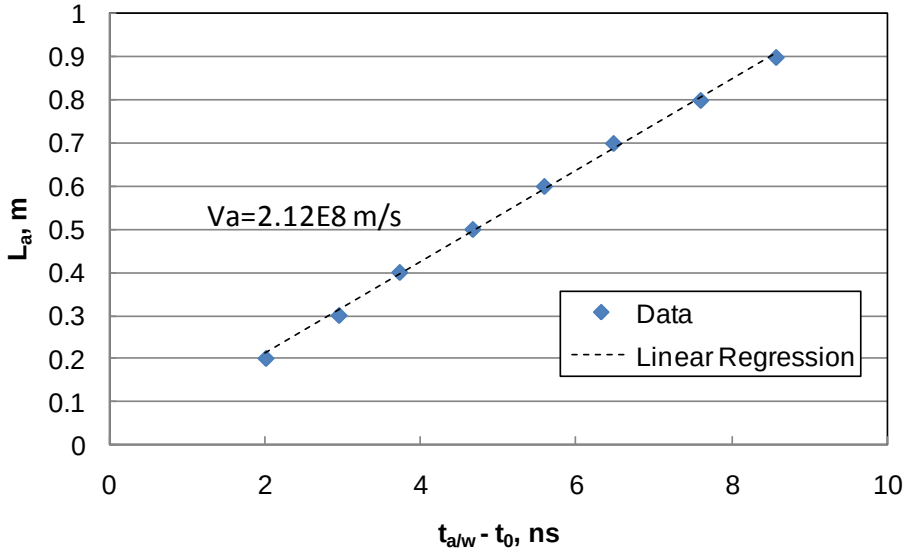
Step 2 : V_w & V_s calibration

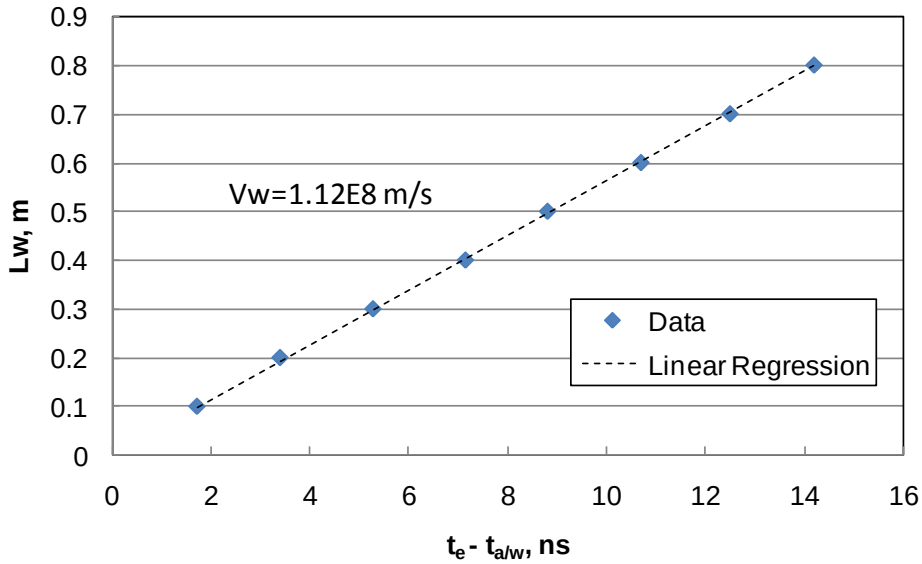
$$\begin{cases} (t_{e,r} - t_{a/w,r}) = \dfrac{2L_{w,r}}{V_w} + \dfrac{2L_{s,r}}{V_s} \\ (t_{e,m} - t_{a/w,m}) = \dfrac{2L_{w,m}}{V_w} + \dfrac{2L_{s,m}}{V_s} \end{cases}$$

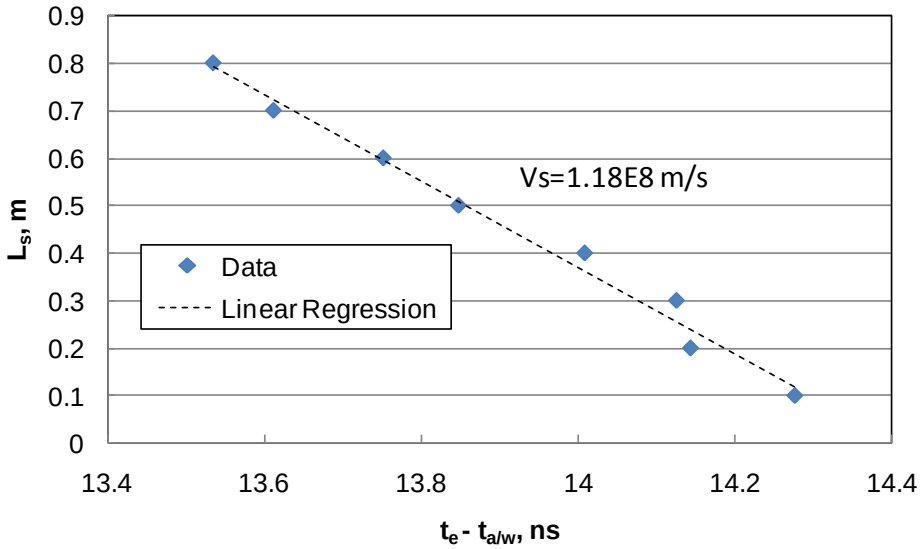
Step 3 : Real measurement

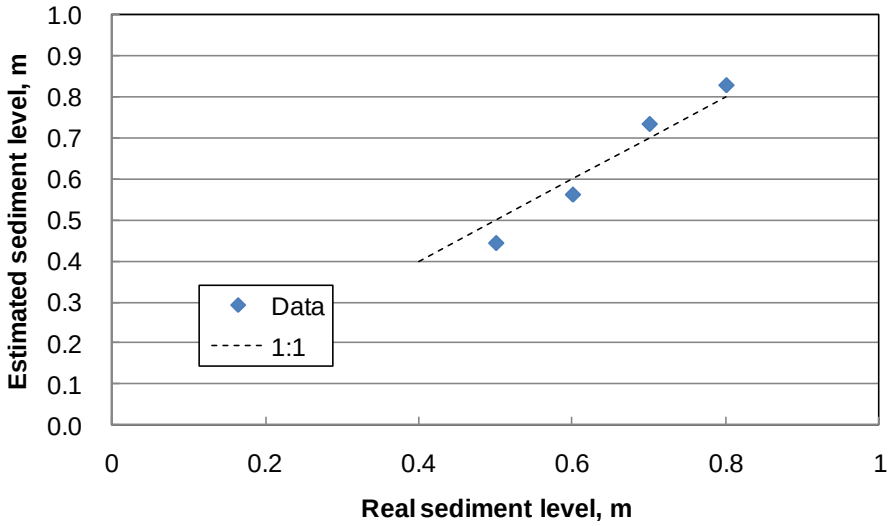
$$(t_{e,m} - t_{a/w,m}) = \frac{2\left(L_{a/w,m} - L_{s,m}\right)}{V_w} + \frac{2L_{s,m}}{V_s}$$

Data Reduction: Calibration and Measurement

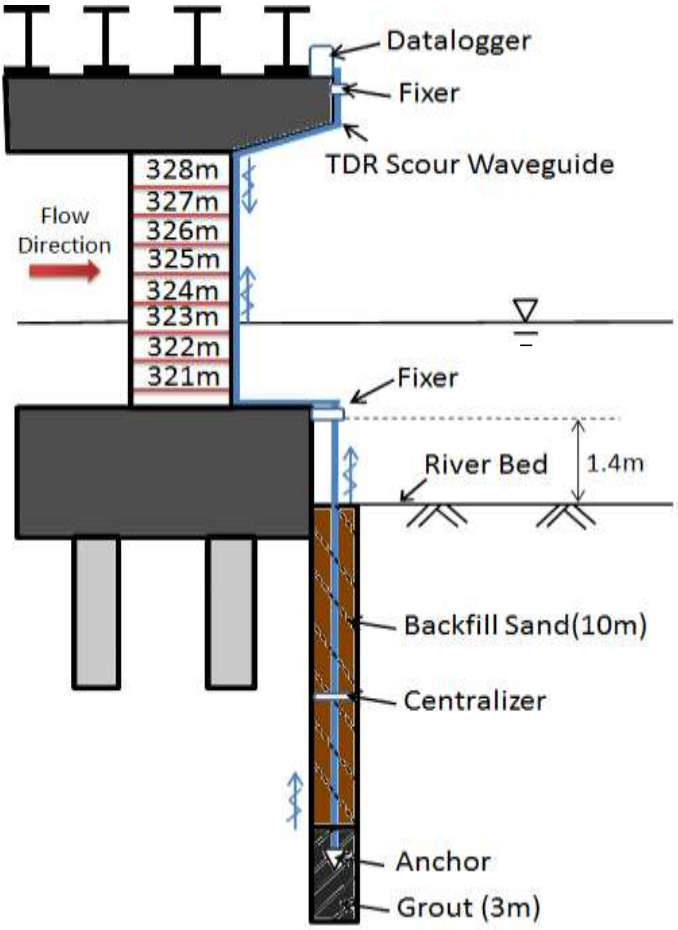


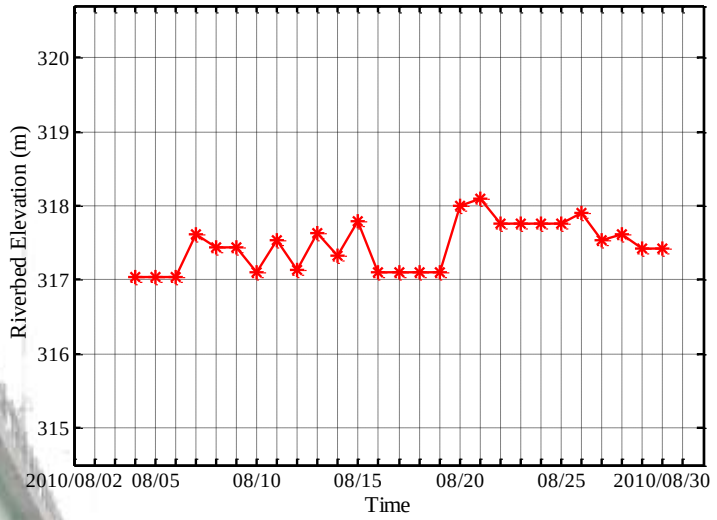






Pilot Field Installation and Evaluation

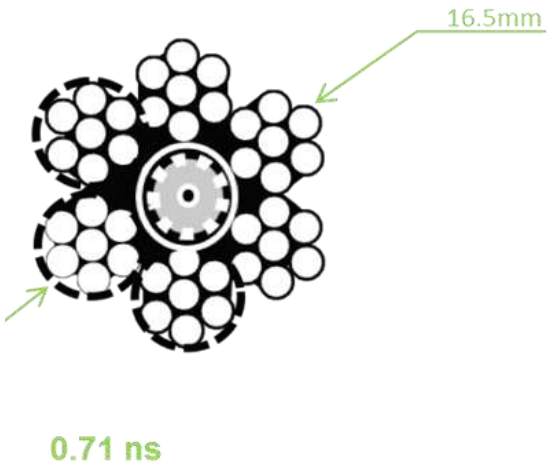




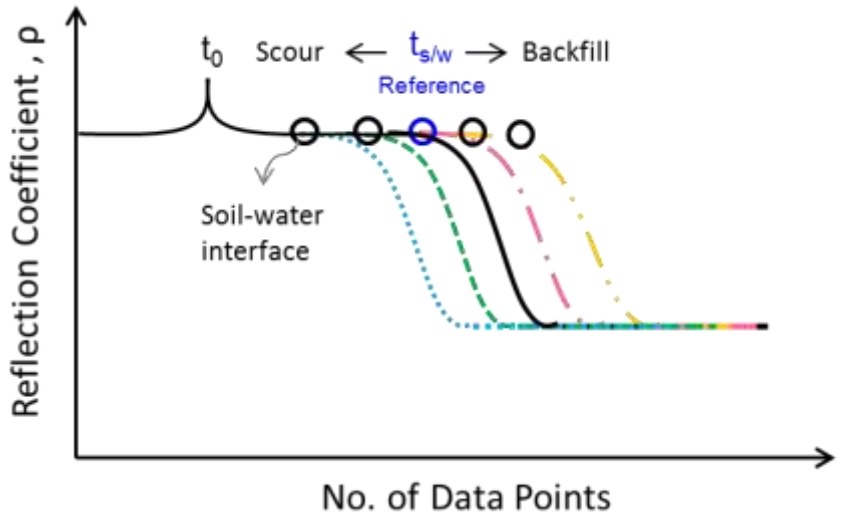
Future Study

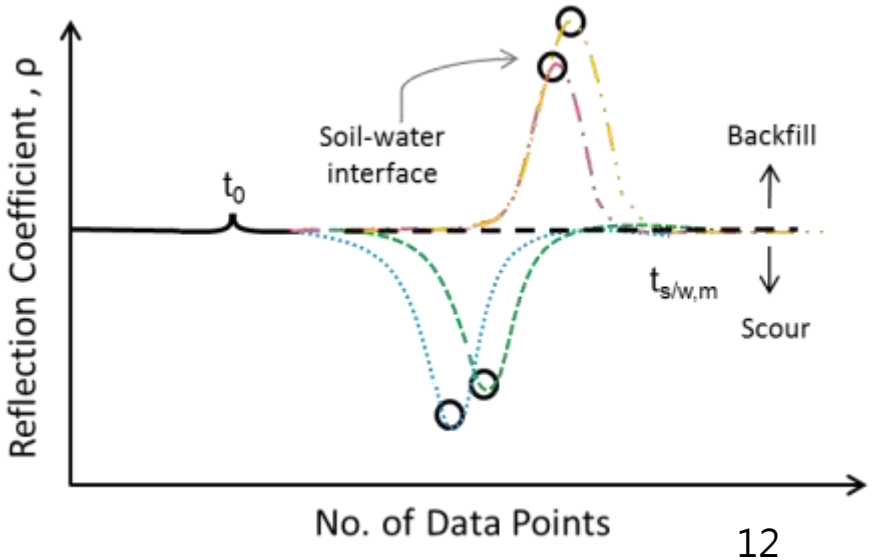
Bottom-up measurement

- **Reduce the rainfall influence at air section**



Bottom-up type wire
1. Single wire
2. Coaxial embedded





Thank you for your attention

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