Geotechnical and Structural Instrumentation for Road Tunnels

Course Number: GE-02-502

PDH: 4

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Module 15: Geotechnical and Structural Instrumentation

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary instruments used to monitor ground movement, structural deformation, and groundwater behavior during tunnel construction.
- **Select** appropriate instrumentation based on specific geotechnical questions and project-specific risk management goals.
- **Evaluate** the benefits of automated versus manual monitoring systems to ensure data continuity and safety.

Executive Summary: Geotechnical and structural instrumentation is a critical component of risk management in underground construction, primarily serving to monitor performance and mitigate problems. Modern programs leverage electronic and computer-coupled systems to provide real-time data on ground movement, structural integrity, and groundwater pressure, ensuring that construction procedures can be modified before minor movements escalate into significant failures or legal liabilities.

Introduction

The primary purpose of geotechnical and structural instrumentation is to **monitor the performance** of underground construction to avoid or mitigate problems. While monitoring can provide a scientific bonus or advance design procedures, its implementation is driven by operational safety and stability.

Historically, monitoring was a manual, labor-intensive process involving "number crunching" and hand-plotted graphs. In the early 21st century, advanced instrumentation and remote monitoring allow for real-time reporting and automatic alerts if movements or stresses reach pre-set **trigger levels**.

Key measurement categories include:

- **Quasi-static position changes**: Ground movement, building movement, and tunnel movement.
- **Long-term effects**: Groundwater movement and pressure.
- **Dynamic response**: Ground movement from vibrations caused by drill and blast operations.

Ground Movements – Vertical & Lateral Deformations

Purpose of Monitoring

Monitoring detects movements while they are small, allowing for modification of construction procedures. This serves as the first line of defense to protect surface facilities (roads, buildings) and subsurface utilities. Data is also used to verify design assumptions and evaluate contractor claims.

Equipment, Applications, Limitations

Ground movement is monitored using a variety of point-based and borehole instruments:

- **Deep Benchmarks**: Steel pipes drilled into stable strata (preferably bedrock) outside the zone of influence. They provide the absolute stable reference for all other survey points.

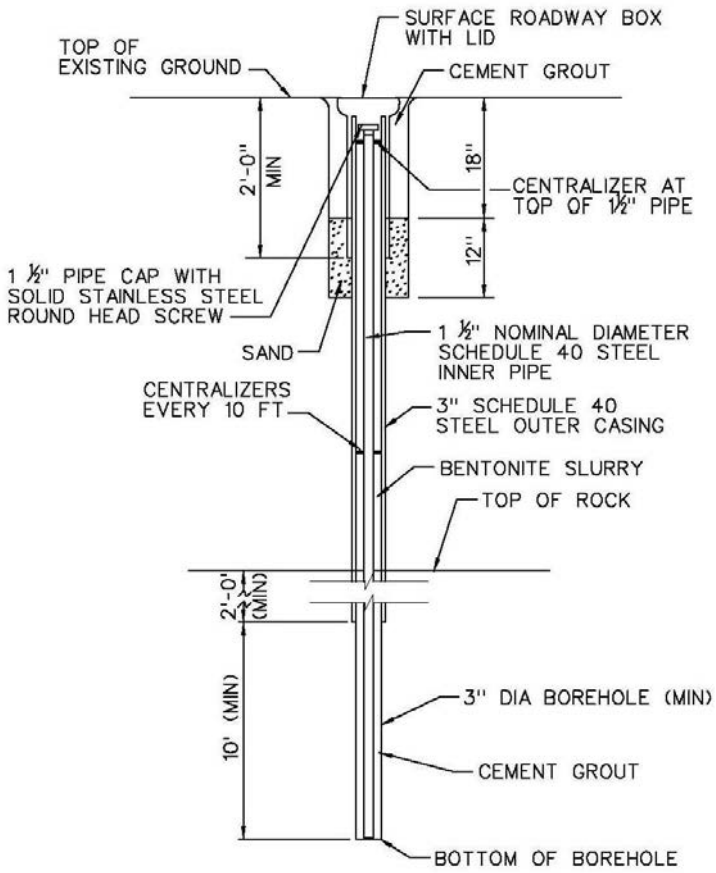

Figure 15-1: Deep Benchmark

- **Survey Points**: Detect surface or near-surface movements. They range from simple wooden stakes to steel rods with rounded heads for surveyor continuity.

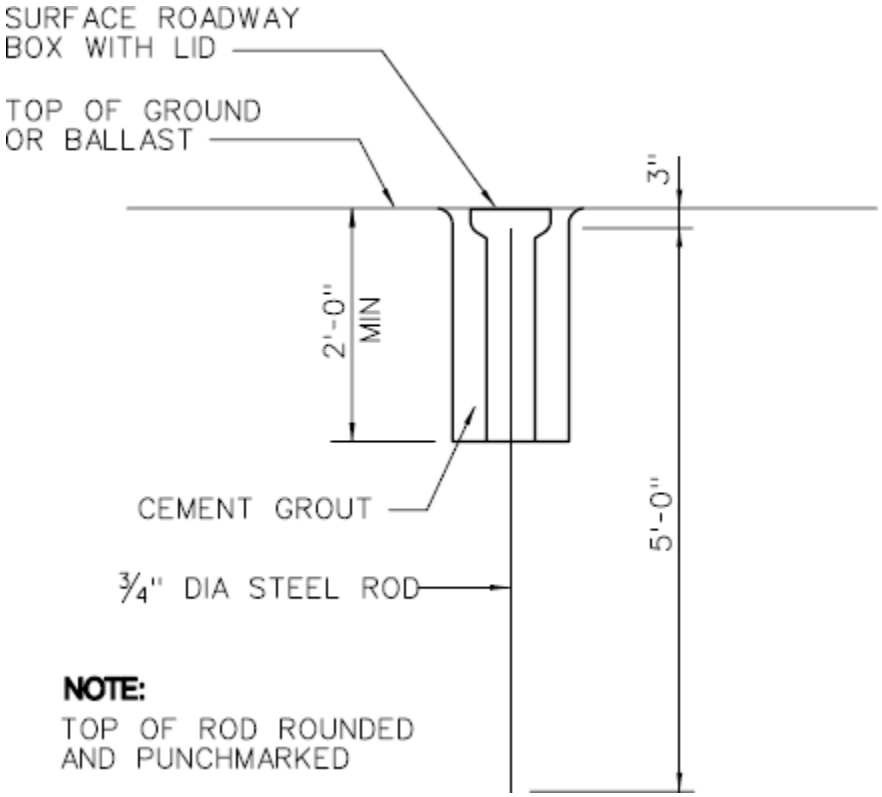

Figure 15-2: Survey Point

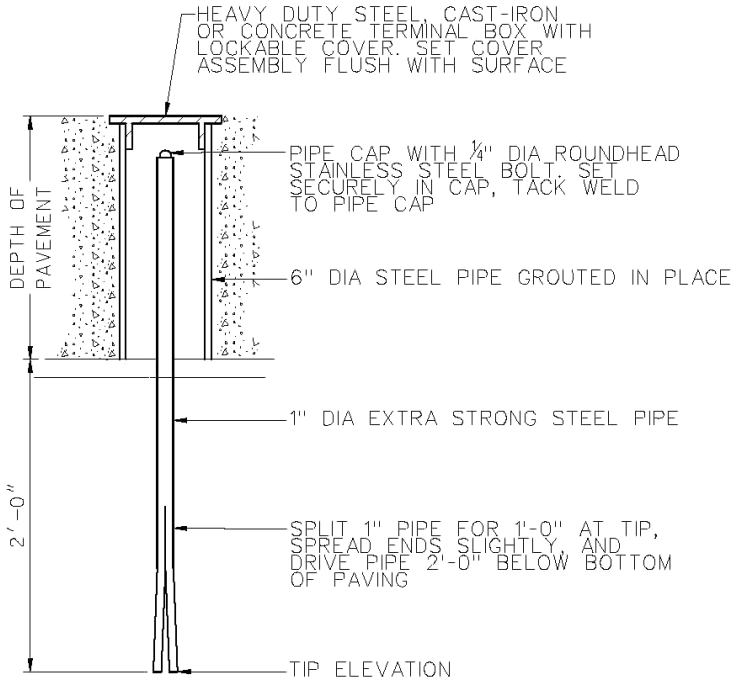

Figure 15-3: Survey Point in Rigid Pavement Surface

- **Borros Points**: Anchors at the lower end of a driven pipe used to determine settlement at a precise depth.

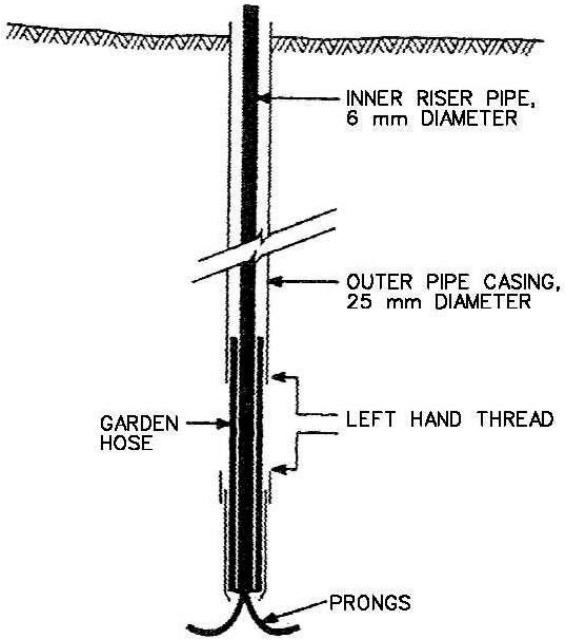

Figure 15-4: Schematic of Borros Point (After Dunnicliff, 1988, 1993)

- **Probe Extensometers**: Measure distance changes between multiple points in a borehole using a portable electrical transducer probe.

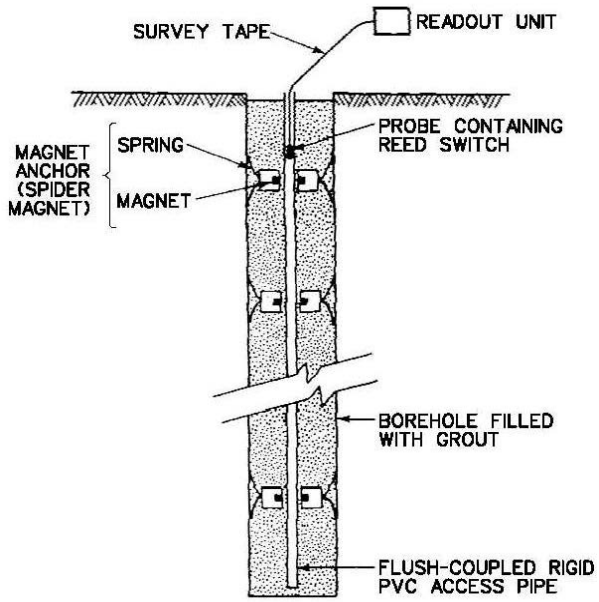

Figure 15-5: Schematic of Probe Extensometer with Magnet/Reed Switch Tansducer, Installed in a Borehole (After Dunnicliff, 1988, 1993)

- **Fixed Borehole Extensometers**: Grouted anchors (SPBX or MPBX) connected to surface reference heads by rods. These can be installed from the surface or horizontally from advancing excavations.

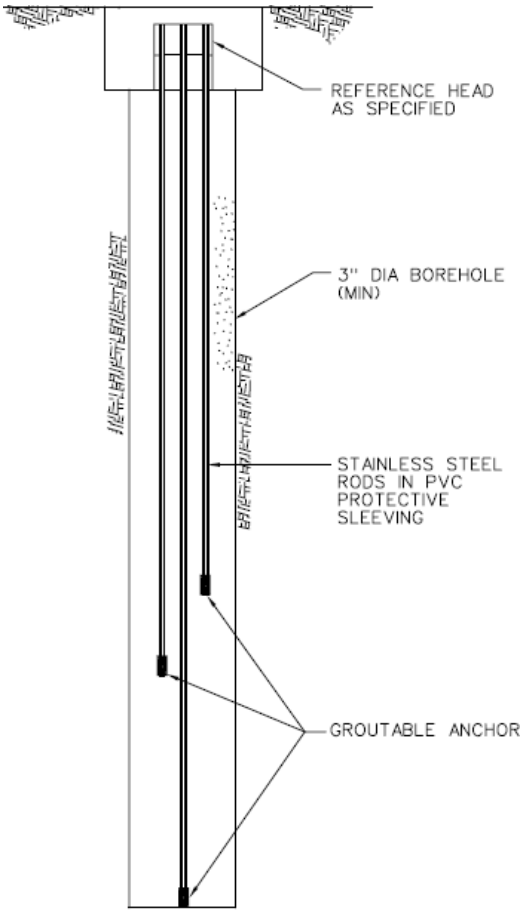

Figure 15-6: Multiple Position Borehole Extensometer Installed from Ground Surface

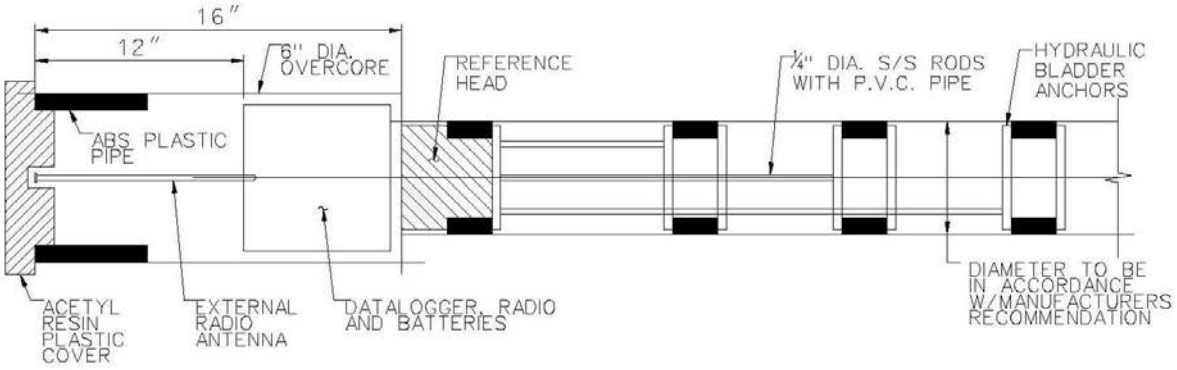

Figure 15-7: Horizontal Borehole Extensometer Installed from Advancing Excavation

Purchase this course to see the remainder of the technical materials.