

# TECHBRIEF



The Structures research and technology program aims to foster increased durability of new bridges and observable increases in the service life of existing structures, placing an emphasis on increasing highway safety while preserving the environment. The program focuses on researching nondestructive evaluation technologies to identify structural deficiencies and support bridge management systems. It also uses high-performance materials to repair and rehabilitate the existing inventory of deficient bridges. This find it and fix it program is supplemented by research which examines all aspects of bridges and foundations, including planning, design, construction, management, maintenance, inspection, and demolition.

Specific expertise areas include bridge coatings, bridge infrastructure, bridge management, nondestructive evaluation, corrosion protection, foundations, scour, geotechnical research, high-performance materials, aerodynamics, seismic research, and structures instrumentation.



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Turner-Fairbank Highway  
Research Center  
6300 Georgetown Pike  
McLean, VA 22101-2296

## Permanent Ground Anchor Walls

Summary Report of Research on Permanent Ground Anchor Walls, Volumes I Through IV (PUBLICATION NOS. FHWA-RD-98-065, -066, -067, and -068)

Design Manual for Permanent Ground Anchor Walls (Publication No. FHWA-RD-97-130)

TB Wall—Anchored Wall Design and Analysis Program for Personal Computers

FHWA Contact: Al DiMillio, HNR-10, (703) 285-2436

### Introduction

The reports produced and the product of work done on the subject of Permanent Ground Anchor Walls include: (1) a report with four volumes—*Summary Report of Research on Permanent Ground Anchor Walls, Volume I: Current Practices and Limiting Equilibrium Analyses, Volume II: Full-Scale Wall Tests and a Soil Structure Interaction Model, Volume III: Model-Scale Wall Tests and Ground Anchor Tests, and Volume IV: Conclusions and Recommendations*; (2) *Design Manual for Permanent Ground Anchor Walls*; and (3) TB Wall—Anchored Wall Design and Analysis Program for Personal Computers, a microcomputer program for the analysis/design of anchored walls.

Research aimed at improving the design and construction of permanent ground anchor walls is presented. The research focused on tied-back soldier beam walls for highway applications. These walls are generally less than 7.6 m (25 ft) high, and they are supported by one or two rows of permanent ground anchors.

### Summary Report of Research on Permanent Ground Anchor Walls

#### *Volume I: Current Practices and Limiting Equilibrium Analyses*

This volume presents apparent earth pressure methods for determining the lateral earth load. This volume discusses the differences between anchored and braced walls; reviews the limiting equilibrium bases for the apparent earth pressure diagrams; and reviews current force equilibrium methods (simple limiting equilibrium methods) for evaluating the external stability of an anchored wall. A force equilibrium method was developed and used to illustrate how anchor position, soil strength, and location of the failure surface affect anchor load and internal and external stability of a wall. The factor of safety, inherent in the apparent earth pressure diagrams, is determined. Recommendations for using general-purpose slope stability computer programs for determining lateral load, and evaluating internal and external stability of an anchored wall, are made.

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### *Volume II: Full-Scale Wall Tests and a Soil Structure Interaction Model*

This volume presents the research results of building a 7.6-m- (25-ft-) high wall in medium-dense sand and of developing a numerical model to be implemented in a computer program for the design of soldier beams. Apparent earth pressure diagrams for one-tier and multi-tier walls were developed. Measured bending moments are compared with moments predicted by different design methods. The volume describes axial load behavior of the soldier beams; compares the behavior of drilled-in and driven soldier beams; and includes axial loads, bending moments, wall and ground movements, and anchor loads for each stage of construction. A numerical model combines apparent earth pressure diagrams to describe the pressure on the wall and soil spring in order to model the lateral resistance below the bottom of the excavation.

### *Volume III: Model-Scale Wall Tests and Ground Anchor Tests*

This volume presents the research

results of testing four model-scale soldier beam and lagging walls constructed in medium-dense sand; 10 hollow-stem-augered ground anchors; wall and ground movements for modal walls with different soldier beam stiffnesses; and one or two levels of anchors. Results for load tests and long-term monitoring for ground anchors are also included.

The volume also presents measured strains in the ground anchor tendons and anchor grout for six anchors. Recommendations regarding apparent earth pressures, control of ground movement, ground anchor design and installation, and ground anchor testing are made.

### *Volume IV: Conclusions and Recommendations*

This volume presents conclusions, research needs, and recommendations for implementing the research results. Recommendations are made for: (1) determining the shape and magnitude of apparent earth pressure diagrams for granular soils and stiff clays, (2) using limiting equilibrium analyses to determine the total

lateral earth load and wall stability, (3) estimating axial and lateral load applied to the toe, (4) computing the axial and lateral load-carrying capacity of the toe, (5) selecting the corrosion protection for the anchor tendons and the soldier beams, and (6) constructing and testing large-diameter ground anchors in fine-grained soils.

### **Design Manual for Permanent Ground Anchor Walls**

The manual is comprised of existing information, as well as the results of experiments on full-scale wall tests, soil-structure interaction considerations, model-scale wall tests, and measurements on large-diameter ground anchors.

### **TB Wall—Anchored Wall Design and Analysis Program for Personal Computers**

TB Wall is a microcomputer program for designing and analyzing anchored walls. The program uses the numerical model presented in Volume II and implements apparent earth pressure diagrams and soil spring in order to model the lateral resistance below the bottom of the excavation.

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**Key Words:** Ground anchor walls, tie backs, ground anchors, anchors, retaining walls, apparent earth pressures, earth pressures, wall deformations, ground movements, model tests, limiting equilibrium, internal and external stability, specification, contracting procedures.

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