CHAPTER 1 - INTRODUCTION

1.1. Integral Bridge Concept

A bridge should be designed such that it is safe, aesthetically pleasing, and economical. Prior to the 1960s, almost every bridge in the U.S. was built with expansion joints. These expansion joints often did not perform as well as intended. They required considerable maintenance, which undermined the economical operation of the bridges. Accident and vehicle damage caused by defective expansion joints raised safety concerns. Starting in the early 1960s, the use of jointless bridges for new bridge construction attracted widespread interest.

Jointless bridges can be classified into four groups (Wolde-Tinsea and Klinger, 1987):

- flexible arch bridges,
- slip joint bridges,
- abutmentless bridges, and
- integral bridges

In the U.S., the term integral bridge usually refers to bridges with short stub-type abutments connected rigidly to the bridge deck without joints. This rigid connection allows the abutment and the superstructure to act as a single structural unit (Figure 1.1). Typically, single rows of piles provide foundation support for the abutments.
1.2. Objectives and Scope of Research

As temperatures change daily and seasonally, the lengths of integral bridges increase and decrease, pushing the abutment against the approach fill and pulling it away. As a result the bridge superstructure, the abutment, the approach fill, the foundation piles and the foundation soil are all subjected to cyclic loading, and understanding their interactions is important for effective design and satisfactory performance of integral bridges.

The ability of piles to accommodate lateral displacements is a significant factor in determining the maximum possible length of integral bridges. In order to build longer integral bridges, pile stresses should be kept low. Thus, the primary objectives of this research are:

1. Conduct a literature review to establish the current state of knowledge with regard to cyclic loading damage to piles of integral bridges,
2. Investigate the rotational behavior of a VDOT semi-integral abutment through large scale laboratory experiments,
3. Investigate the ability of a VDOT semi-integral abutment to withstand cyclic loading induced by temperature variations through large scale laboratory experiments,
4. Investigate the ability of three pile types (H-pile, pipe pile, and prestressed reinforced concrete pile) to withstand cyclic lateral displacements induced by temperature variations,
5. Investigate the significance of the interactions among the abutment, the approach fill, the foundation soil, and the piles through finite element analyses, and
6. Investigate the possibility of using simple procedures for design of piles supporting integral bridges.
1.3. Contents of Dissertation

A literature review concerning the cyclic loading damage to piles of integral bridges is presented in Chapter 2. A summary of the formulation and the available solution methods for the laterally loaded pile problem is also included in this chapter.

Chapter 3 discusses the effects of temperature variation on integral abutment bridges. A procedure to consider both daily and seasonal temperature cycles in experimental testing is proposed. This procedure was used for the abutment and the pile experiments described in Chapters 4 and 5.

Chapter 4 presents the design, the construction, the test setup, and the findings of the experimental program on VDOT semi-integral abutments that were subjected to static and cyclic load tests in the laboratory. Discussions, conclusions, and recommendations about the research program are also provided.

Chapter 5 presents the design, the construction, the test setup, and the findings of the experimental program on three piles types (H-pile, pipe pile, and prestressed reinforced concrete pile). All piles were subjected to cyclic load tests in the laboratory.

Chapter 6 presents the findings of series of finite element analyses that were performed to investigate the significance of interactions among the abutment, the approach fill, the foundation soil, and the piles. The possibility of using simple procedures for design of the piles was also investigated and the findings of the investigations are presented. Discussions of the results of the analyses and recommendations for future research are presented at the end of this chapter.

Chapter 7 contains the conclusions and recommendations drawn from the research. Recommendations for future studies and research are given at the end of this chapter.

Appendix A contains a research report presented to the Virginia Transportation Research Council (VTRC) in 1999 by the author, Prof. J. M. Duncan, and Prof. R. M. Barker. This report discusses the behavior of integral abutment bridges based on a literature review, a field trip and a finite element analysis.
Figure 1.1. Simplified geometry of an integral abutment bridge