SECTION II

FINITE ELEMENT MODELING OF STEEL-CONCRETE COMPOSITE BRIDGE

CHAPTER 5

INTRODUCTION

5.1 General

A traffic jam is a very serious problem in many major cities in Southeast Asia. Bangkok in Thailand is one of those cities that have suffered the problem for many years. To alleviate it, the Bangkok Metropolitan Administration conducted a project of constructing overpasses at busy junctions recently. Fast construction was an essential requirement since construction site was inevitably in the area of heavy traffic. The steel-concrete composite bridges are designed based on The American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, 1996. A variety of advantages of structural steel such as light weight, ductility, easily and short-time construction, and other miscellaneous are desirable properties in order to reduce the traffic problem.

The requirement to reduce cost and duration required for construction make composite solutions, adopting steel and concrete to the best used of these structural materials and extremely competitive in bridge construction. These two structural materials combine to act in such a way that the behavior of the individual elements is modified. Due to its greater stiffness and often higher load capacity, compared with its non-composite counterpart, composite construction is attractive the designers. Hence, the reduced height of the structure and further saving associated features can be worth while. The main disadvantage of composite construction is the requirement to provide connectors at the steel-concrete interface. There is also some increase in complexity of design, particularly for continuous structures.

In recent times, the composite steel-concrete girders with the concrete deck are introduced in the fly-over steel bridges in Bangkok. Those overpasses are steel-concrete composite bridges made of steel plate I-girders, concrete decks and steel bridge piers. The employment of the steel girders and the steel piers is to decrease the dead loads of the overpasses, helping reduce the size of foundation and shorten construction period. Upon completion, the performance of the overpasses was tested by measuring stresses under static truck loads. While the tests have confirmed the safety of the overpasses, it has been revealed that the design computation tends to overestimate the stress acting in the actual bridges.

5.2 Problem Statement

The finite element method (FEM) is a numerical technique that has become popular method in the past to analyze the bridge structural behavior. Two-dimensional (2D) and three-dimensional (3D) finite element analysis were very useful and effective to perform the bridge modeling by using beam and shell elements. However, under some circumstances supplementary information may be needed so as to understand the real behavior of the bridge with more detail. For example the interaction between the superstructure and the bridge piers, the design analysis of concrete barriers are usually treated as non-structural members. Many researches in the past by beam and shell element cannot yield this class of information adequately. Therefore, the finite element modeling of an entire steel-concrete composite bridge by more sophisticated 3D elements such as shell elements and solid element should be put on under the current stage of development of computer technology.

5.3 Objective and Scope of the study

This study aims to simulate the actual bridge behavior of steel-concrete composite bridge by using FEM. There are many researches related to finite element to bridge design, for example, bridge modal properties using simplified finite element analysis by Farrar and Duffey (1998), finite element analysis of steel-concrete composite girders by El-Lobody and Lam (2003), Chung and Sotelino (2006). In this research, three-dimensional finite element analysis of composite steel-concrete bridges is performed to simulate the actual bridge behavior. Not only the superstructure but the substructure is also considered. The accuracy of model is verified against the result acquired from a field test. Thai trucks are loaded at possible locations of the bridge in order to obtain the maximum stresses of the bridge.

The objective of this study can be summarily written as

1. To investigate the behavior of steel-concrete composite bridges named Rama III–Sathu Pradit Bridge such as stress and deflection from loading.
2. To improve the finite element model of steel-concrete bridge by using the solid element for concrete slab and shell element for steel girder and bridge pier.
3. Compare the results from three-dimensional finite element model with the loading test to improve the current design practice.
4. To study the influence of concrete barriers of the steel-concrete composite bridge.
5. To study the interaction between superstructure and bridge pier.
6. To study the influence of Young's modulus of concrete of the steel-concrete composite bridge.
7. To study the reactions at the bearings on the bridge piers

In the present study, the discrepancy between the design values and the test results is looked into by conducting the finite element analysis, based on which the factors responsible for the structural behavior of the steel-concrete composite bridge are discussed. A finite element program, MARC (1994) is used in this study to determine stress and deflection of the composite steel-concrete girder bridge. In particular, Rama III–Sathu Pradit Bridge is picked up, since it is typical of the overpasses and the in-situ measurements under the known loads are available.