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Developments in International Bridge Engineering

Selected Papers from Istanbul Bridge Conference 2014

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Preface

The movement of people, goods, and services between urban settlements and production facilities is the essential circulation that keeps regional and national economies running. Bridges are the vital connectors that ensure that transportation systems function safely and economically as intended by those who have planned and conceptualized them. Bridge engineering is a special discipline within structural engineering that focuses on the design, construction, erection, assessment, and maintenance of these connectors for the benefit of society. Bridges are often durable symbols of technical prowess, economic power, and esthetic refinement. Just as many ancient bridges that have become landmarks evoke in us a sense of amazement at the creative skills of the old masters who built them, so do their younger counterparts that display the flair of more recent builders who have combined advanced analysis techniques with modern, high-performance materials to craft structures that defy the heretofore unchallenged limits in terms of span, height, or frugal use of material resources. Its many counterexamples notwithstanding, bridge engineering is indeed a uniquely singular parade arena to display technical experience and artistic maturity. It is sometimes a shared responsibility among engineers and the special breed of architects who have the craftsmanship to improve the technical attributes of the finished product. We hope that this book will serve to give its readers an overview of the many problems that must be resolved to produce bridge structures that will meet the challenges they will face during their service lifetime.

The Turkish Group of the International Association for Bridge and Structural Engineering (IABSE), in collaboration with Middle East Technical University (METU), the Turkish General Directorate for State Highways (KGM), the General Directorate for State Railways (TCDD), the Turkish Contractors Association, the Turkish Association for Structural Steel (TUCSA), the Turkish National Committee for Roads (YTMK), the Turkish Association for Seismic Isolation, the International Association for Earthquake Engineering (IAEE), the Transportation Research Board (TRB), American Concrete Institute (ACI), the Bridge Engineering Association, and SIBERC served as host for the Istanbul Bridge Conference during August 11–13, 2014. The conference was generously supported by many sponsors, AGM, Arsan

Kaucuk, Aydiner Inc. Company (Aybet), BERD, Besmak, Cengiz Nurol, Chodai Co., Computers and Structures, Inc. (CSI), DOKA, DUYGU Engineering, EMAY International Engineering and Consultancy Inc, EM-KE, Endem Construction, EPO Construction Chemicals, FIP Industriale, FREYSAŞ, IC İçtaş Construction Co, Ilgaz İnşaat, INPRO, JOTUN, KMG Project, KOBA Engineering and Consulting Co. Ltd, LARSA, MAGEBA, Mapa İnşaat ve Ticaret A.Ş., Maurer Söhne GmbH & Co., MEGA Engineering Consulting Co., Mistras Group, MOOG Gmbh, Otoyol Yatırım ve İşletme A.Ş., Ozdekan Rubber Company, PERİ, Pitchmastic Pmb Ltd, Sismolab, Strainstall, TEMELSU International Engineering Services, TESTART, TNO Diana, TTS International Engineering and Architecture, WireCo Structures, Wowjoint, Wuhan HIRUN Engineering Equipment Co., YAPIFEN Engineering, and Yüksel Proje.

iBridge was attended by **250** participants representing **30** different countries. The conference program included **96** papers. It was complemented by a visit to the construction site for the third Istanbul Strait crossing, a major project that will place the bridge among the top five long-span bridges in the world in several categories when it has been completed.

The 19 papers selected for this book represent a cross section of the breadth of the topics that were taken up in the conference. The selection has been made on the basis of scientific and technical relevance, timeliness, and expected added value for practitioners. A few authors who were invited to finalize their papers for inclusion in the book failed to do so on time, and a few others were eliminated because they had been submitted elsewhere for publication. The papers represent current concerns in bridge engineering as they exist in many countries and the solutions for those issues that have been arrived at under codified constraints that have echoes in other locations. Theory, experiment, and practice are presented in balanced proportions in the texts that follow.

We have grouped them under four broadly defined thematic areas as follows:

- "Modeling and Analysis" (7 papers)
- "Construction and Erection Techniques" (3 papers)
- "Design for Extreme Events" (4 papers)
- "Condition Assessment and Structural Health Monitoring" (5 papers)

The book has been divided into four principal sections along these themes.

The editors would like to acknowledge the excellent cooperation that they have received from the authors in revising their papers according to reviewer comments and the tens of reviewers, from the Scientific Committee as well as externally named experts (many in multiple assignments), who willingly gave much of their time in examining the papers for their content to ensure that this would be a printed source with a positive impact, and provide guidance for their colleagues in the broader engineering community. The editorial staff at Springer Publishers has been unfailingly helpful in guiding us toward producing a book in their style.

We have received invaluable support from the staff at INTERCON that served as the Conference Secretariat and doubled as providers for the initial screening process of the written contributions.

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Contents

Part I
Modeling and Analysis

Optimal Design of Pile Foundation in Fully Integral Abutment Bridge

Jun Qing Xue, Bruno Briseghella, Bao Chun Chen, Pei Quan Zhang and Tobia Zordan

Abstract In order to resolve the durability problem of expansion joints and bearings, the integral abutment bridge (IAB) has become more and more popular. For integral abutment bridge, choosing a suitable pile foundation type is a challenging problem, because the substructure is fixed with superstructure to bear the load together. In this paper, the design of the pile foundation in a fully integral abutment bridge (FIAB) in China was analyzed. A finite element model was built by the commercial software MIDAS considering soil-structure interaction and construction stage simulation. A sensitive analysis was carried out to investigate the influence of different pile foundation types on the mechanic performance of the IAB. The results show that when the circular pile is used, the stress of pile, negative moment and tensile stress of girder are smaller than those when the rectangular pile is used. With the increase of pile diameter, the stress and displacement of pile decrease, while the bending moment of pile and the negative moment and tensile stress of girder increase. For rectangular piles, with the increase of cross-sectional length-width ratio, the bending moment of pile, negative moment and tensile stress of girder decrease; while the stress and displacement of pile increase.

1 Introduction

At present, many jointed bridges have been constructed all over the world, in which expansion joints and bearings are installed in order to absorb cyclic thermal expansion and contraction, creep and shrinkage, and differential settlement. The expansion joints and bearing of bridges are easily damaged during service life of

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many jointed bridges due to the influence of increasing age, climate, environment and some unpredictable destructive effects of nature [1]. Furthermore, the damaged expansion joints and bearings will produce a series of secondary diseases. Moreover, the maintenance cost and vehicle restrictions caused by frequent repair or the serious social impact are remarkable [2, 3]. In order to resolve the durability problem of expansion joints and bearings, many engineers proposed the concept of "No expansion joint is the best joint". In this case, the integral abutment bridge (IAB), which can eliminate expansion joints and bearings, becomes a challenging solution [4, 5]. Different with jointed bridges, the abutments of integral abutment bridges are fixed to the girders. The superstructure, abutments and pile foundations, backfill and soil around pile foundations work as a frame. Therefore, the type of pile foundation has a great impact on the mechanical performance of integral abutment bridges, which can be considered as one of the key problems in the design of IAB.

2 Case Study

In this paper, a fully integral abutment bridge (FIAB) in China was chosen as case study. The bridge is located in Shi-An expressway. The bridge is a two-span prestressed concrete fully integral abutment bridge. The main features are listed in Table 1. The elevation layout and typical cross section are shown in Figs. 1 and 2, respectively. The details of fully integral abutment and approach slab are illustrated in Fig. 3.

Table 1 Main features of bridge

Total length	41.8 m	
Number of spans	2	
Girder information	Number per span	4
	Height	1.2 m
	Type	Box-girder
Deck information	One carriageway	12.5 m × 0.22 m
Pier height (cap + column)	1.4 + 5.0 m	
Abutment height (backwall + stem)	1.3 + 1.4 m	
Pile	Number per each abutment	7
	Cross-sectional shape	Circular
	Diameter	0.7 m
	Length	34 m
	Number per each pier	1
	Cross-sectional shape	Circular
	Diameter	1.5 m
	Length	45 m

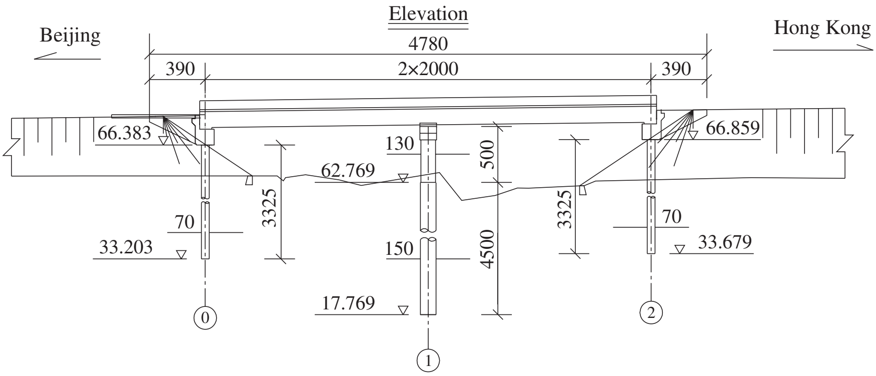

Fig. 1 Elevation layout (cm)

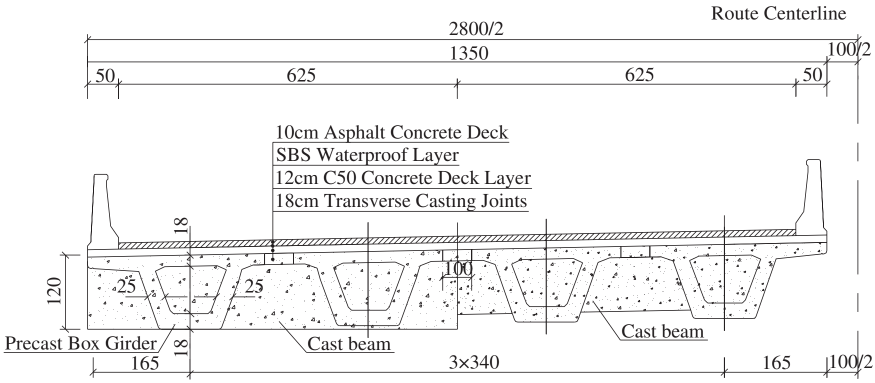

Fig. 2 Typical cross section of precast box girder (cm)

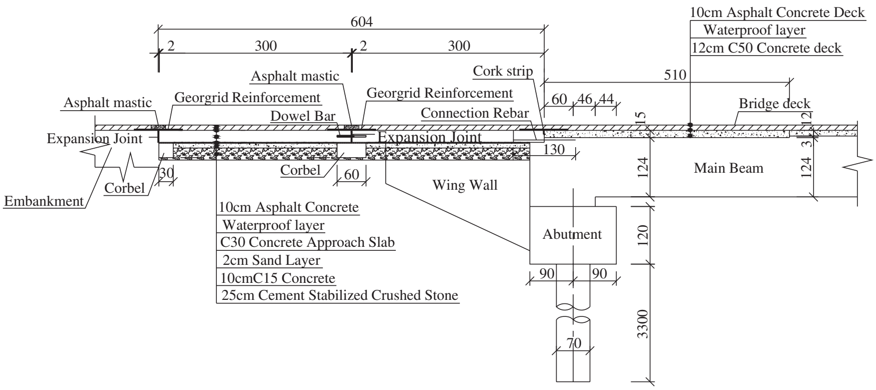

Fig. 3 Details of fully integral abutment and approach slab (cm)