Road and Structure Protection Through Weight Control

Why a Bridge Design Code?

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TABLE OF CONTENTS

1/ INTRODUCTION

No structure can be designed without a set of design criteria. On the one end of the scale, these design criteria may simply consist of complying with the intuitive "feel" for the structure or of some requirements tentatively established by the designer himself/herself on a structure-by-structure basis. On the other end of the scale, a number of experts may set up the rules for design by studying the pros, cons, and implications of the various requirements. Such a set of design criteria is often referred to as the design code.

It is sometimes argued that design codes tend to restrict the creative ability of the designer, and therefore, the ideal requirement should merely be that the structure remains safe while fulfilling its intended functions. Examples of the world's most spectacular bridges, i.e., bridges with long spans for which there exists no code of practice, are given in defence of having no code at all.

In this essay it is proposed that in spite of some spectacular results, the practice of not having a properly drawn up code of practice is not a desirable one. Advantages and disadvantages of codes of varying degrees of complexity are also discussed with particular reference to bridges, together with the mechanics of writing a code.

2/ THE CASE OF A BRIEF CODE OR NO CODE AT ALL

The absence of a design code makes a designer think about the structure and all the loads that the structure may have to sustain during its lifetime. Ideally, this situation should encourage innovation. In practice, however, because of limited available time, the designers are forced to take short cuts. They make simplistic assumptions, which lead to conservative designs, and tend to follow previous practice where available. For the same type of structure, different firms of consulting engineers are likely to use different sets of design criteria. This can be conveniently illustrated with the help of Table 1, which lists the various load combinations which were considered in the design of some of the most famous suspended bridges of the world.

In Table 1, D, W, L, and T refer to dead loads, wind loads, live loads, and temperature effects, respectively. A load combination (D, L, T, W/2) having a value of 1.25, for example, means that the total stress allowed for the combination of nominal dead load, live load, temperature, and half the design wind load is 1.25 times the normal unit stress.

It is suprising to note that significantly different sets of load combinations were used for these embodiments of engineering excellence! Clearly, only one set of loading combinations can be the optimum or ideal one. This means that the designs of most of these bridges are not quite ideal. The fact that various firms tended to use the same factors for bridges built years apart in different geographic locations indicates a lack of extensive research in establishing the design criteria and, also, a lack of interaction between designers of different firms.

The discrepancy in the design criteria is not limited to the load combination factors. In the absence of a design code, the designers are left to decide upon the design live loads and wind loads, etc. The controversy in the U.K. regarding the adequacy of design live loads for the Severn suspension bridge underlines the need for a design code even for suspension bridges. Incidentally, the only exhaustive study to establish design live loads for long-span bridges has been conducted in Canada in connection with the rehabilitation of the Lions' Gate Bridge in British Columbia.

A consulting firm faced with the task of even a major bridge cannot be realistically expected to invest a substantial amount of time in the research for establishing the optimum design criteria. The amount of time available to the designers of short- and medium-span bridges is even smaller. Therefore, the need for a design code for these structures is even stronger.

3/ THE CASE OF ADOPTING CODES OF OTHER COUNTRIES

Although a bridge is mainly designed for live loads, the periodical damage that it receives is mainly caused by environmental effects. A

Table 1/ Load Combinations for Allowable Stress Factors for the Design of Suspension Bridge Towers

		Same Firm		Same Firm		Same Firm			
	Bridge	Isle of Orleans	Lion's Gate	Ogdensburg	AMM Halifax	Forth	Bosphorus	Delaware	Verrazano Narrows
	Year Built	1935	1938	1960	1970	1964	1973	1951	1964
	Main Span, m	322	472	351	427	1006	1074	655	1298
LOAD COMBINATIONS	D, W		1.0						
	D, L				1.0	1.0	1.0		
	D, L, T	1.0	1.0	1.0	1.1	1.1		1.0	
	D, L, T/2								1.1
	D, L/2, T								1.1
	D, L, T, W	1.15	1.15						
	D, L, T, W/2			1.25	1.25	1.25	1.25		
	D, T, W			1.25	1.25			1.25	1.25
	D, L/2, T/2, W/2								1.25
	D, L/2, T, W					1.25	1.25		

bridge should, therefore, be designed with its environment in mind so that the long- and short-term maintenance needs are minimized. A designer not familiar with the environment of the bridge cannot be expected to design an efficient structure without a code which provides for the bridge environment. Similarities in heavy vehicle weights or military hardware are not reasons enough to adopt bridge design codes of other countries.

Bridges designed by codes of other countries in which the environment is substantially different may be able to sustain loads quite satisfactorily. However, such bridges would either be unnecessarily expensive or are likely to have substantial maintenance problems. Adopting from codes of other countries is possible and, indeed, wise, but it should be done systematically and selectively. The Ontario Highway Bridge Design Code, for example, is developed for the environment of Ontario. Its indiscriminate use in Pakistan or Saudi Arabia would lead to epoxy-coated bars with excessive depths of cover in the concrete deck slabs, which is quite unnecessary and wasteful in environments where de-icing salts are not sprayed on bridge decks.

The task of developing a set of design criteria or a design code for bridges should be in the hands of the authority having jurisdiction. The investment in the writing of a bridge design code is extremely small as compared to the savings which are affected by a thoughtfully developed code. The resulting bridges are economical in both short and long runs.

4/ THE ONTARIO HIGHWAY BRIDGE DESIGN CODE

Bridges in Ontario, like the rest of North America, used to be designed by the American Association of State Highway and Transportation Officials (AASHTO) code. Realizing that it was nearly impossible to readily incorporate even very significant results of extensive research into the AASHTO code, Ontario decided to write its own bridge design code. Its design load was based on actual heavy vehicle data in the province, and the various code provisions were developed with the specific environment of Ontario in mind. The Ontario code was perhaps the first limit state bridge design code in the world. It is noted that the probabilisticbased limit state approach results in bridges which are uniformly safe in all components.

The code is specific and not just a set of recommendations. It is expected that in the next short while it will be legally required to design all bridges in Ontario by the Ontario code. The document is divided into two parts. The first part is the code, which is so written that it can be legally enforced. The second part is the commentary to the code, which provides the explanation of certain code requirements and gives the background information for nearly all requirements.

4.1/ Mechanics of Code Writing

Normally, codes are written by voluntary labour. It takes about 10 to 15 years to develop a bridge design code from scratch. The disadvantage of a code written over a long period of time is that it does not keep up with the latest developments.

The first edition of the Ontario code was written by a team of about 80 engineers in a relatively short time of about three years. Part of the reason for this success was that the consultants on the task force were paid for their services. Soon after the preliminary first edition of the code was published in 1979, work was started on the revision of the code. This work led to the second edition, which was published in late 1983.

The code writing was undertaken by 17 technical subcommittees, each consisting of from three to six members, under a steering control of an 11 member Code Development Committee. The membership for the code task committee was drawn up from established experts from Ontario, the rest of Canada, and the U.S.A. It was ensured that the code provisions were not affected by lobbies from the various industries.

The Ontario code is seen by many countries as a model on which to base their own code.

5/ CONCLUSIONS

It is suggested that the design of bridges should not be left in the hands of even the most knowledgeable and well-intentioned designers without a design code. The design code of other countries should not be indiscriminately adopted. Instead, design codes specific to the traffic and environment of the bridge location should be written with both the long- and short-term maintenance of the bridge in mind. For best results the code should be written as a concensus document by a team of experts drawn from government, universities, and the industry.