TEXAS STATE UNIVERSITY
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PROJECT SUMMARY

Texas Department of Transportation

0-6729: Synthesis of Cost-Effectiveness of Extradosed Bridges

Background

An extradosed bridge is a bridge type that combines a prestressed girder bridge with cable-stayed bridge design concepts. Since the concept of the bridge is still relatively new, there is no clear definition and design document or guideline for extradosed bridges. Also, due to the unique characteristics of an extradosed bridge, it is likely to initially cost more than a conventional girder bridge but be less expensive than a cable-stayed bridge. A synthesis study examining general configurations and the overall cost-effectiveness of choosing an extradosed bridge is therefore needed. This study summarizes the advantages and disadvantages of using extradosed bridges, and methods for cost-effectiveness analysis and bridge selection procedures through a comprehensive literature review. The synthesis study also summarizes best practices and existing methodologies in determining how and when an extradosed bridge is cost-effective.

What the Researchers Did

This synthesis study identified and collected information on 120 extradosed bridges from Asia, Europe, North America, South America, and Africa through review of over 350 technical papers, reports, and websites. Cost information from 58 extradosed bridges and bridge selection reasons for 47 extradosed bridges were summarized. A statistical analysis of configuration, bridge selection, construction, and cost from the extradosed bridges was conducted. Over 100 individuals with experience in extradosed bridges were contacted, and telephone and email interviews of seven experts in extradosed bridges (three from Asia, two from Europe, and two from North America) were conducted. Information was used to better understand extradosed bridges and covered bridge construction, reasons for bridge selection, cost of construction, advantages and disadvantages, and maintenance and repair. Four case studies regarding extradosed bridge selection were also included in the report. This study summarized the advantages and disadvantages of using extradosed bridges, best practices, and existing methodologies; and proposed a bridge selection process and considerations in determining how and when an extradosed bridge is cost-effective and in the best interests of the public. A matrix and flow chart of the bridge selection process and considerations are recommended by the study.

What They Found

The study identified 120 extradosed bridges in use, under construction, or in the planning phase. While there is no widely accepted definition of extradosed bridges, according to statistics of extradosed bridge configurations from the literature review, it is recommended to use Ogawa and Kasuga's definition—defining an extradosed bridge by the stiffness ratio (load carried by stay cables divided by total vertical load). A bridge with a stiffness ratio less than 30 percent is defined as an extradosed bridge.

Most extradosed bridges documented used the free balanced cantilever construction method. The construction of the extradosed bridges occurred in different countries and at different times, and each bridge was constructed with different site conditions. Therefore, the construction costs collected from this study were highly variable. Cost information collected from selected companies with experience in girder bridges, extradosed bridges, and cable-stay bridges showed that while extradosed bridges are generally less expensive than cable-stayed bridges, due to less superstructure weight and hence the

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potential reduced cost of the substructure, the overall cost of extradosed bridge construction might not be necessarily higher than girder bridges and could be a more cost-effective alternative. Even though there are no specific data to support the maintenance cost and effort of extradosed bridges, there is no expected higher maintenance cost or effort compared to other common bridge types.

Bridge selection is a complicated process with many factors and considerations to be taken into account. The span range usually serves as the preliminary criteria to screen out bridge type alternatives. Besides initial construction costs, life-cycle cost analysis (LCCA), and value engineering (VE), and criteria-based bridge selection procedures are commonly used in the bridge selection process. There are a variety of advantages and disadvantages compared to girder bridges and cable-stayed bridges, with aesthetics (signature bridge and landmark structure), vertical clearance (navigation/vehicular) and height restriction, and construction and structure considerations identified as the top reasons for selecting extradosed bridges over other alternatives. The process of bridge selection related to extradosed bridges should be a consideration of the needs of the public, cost-effectiveness, job-site conditions, and restrictions. A recommended bridge type selection procedure was developed by the researchers, with engineering requirements, site conditions, structure considerations, aesthetic considerations, and other considerations to be used in screening bridge alternatives.

What This Means

The unique configuration of extradosed bridges provides an alternative for bridge selection in addition to commonly used cable-stayed bridges, girder bridges, arch bridges, and truss bridges. While extradosed bridges were generally found to be less expensive than cable-stayed bridges, the type of bridge could have an advantage over prestressed girder bridges in total material costs due to the reduced quantity of concrete due to the use of extradosed cables. In addition, due to the reduced superstructure weight, and hence the potential reduced costs of the substructure, the overall cost of extradosed bridge construction might not necessarily be higher than girder bridges and therefore could be a more cost-effective alternative.

An extradosed bridge is still a relatively new concept compared to cable-stay bridges and girder bridges. One of the major challenges of using this concept is the lack of specifications for bridge design. With the exception of Japan's codes, there are no widely accepted design rules in the codes that provide design standards for this bridge type. The Japanese design code (Specifications for Design and Construction of Cable-Stayed Bridges and Extradosed Bridges) is only available in the Japanese language, and the method does not define extradosed bridges. Rather, it provides a transition between an extradosed bridge cable and a stay cable. A bridge design specification or guideline is needed for engineers to better understand and use this new type of bridge.

While the process of bridge selection can be a consideration of the needs of the public, cost-effectiveness, job-site conditions, and restrictions, the recommended bridge type selection procedure developed by the researchers can only serve as a preliminary guideline for bridge selection with regard to extradosed bridges. A detailed and comprehensive bridge selection procedure with consideration of LCCA, VE, and criteria-based bridge selection procedures could be beneficial to the Texas Department of Transportation.

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