Investigation Report

Investigation on the Application of External Prestressing Technology in Bridge

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Abstract: To systematically evaluate the long-term performance of external prestressing technology and promote its engineering application, the international journal Prestress Technology of Tongji University recently organized a specialized symposium and conducted onsite follow-up visits and technical exchanges on two representative projects—the Xintan Qijiang Highway Bridge in Chongqing (completed in 2008) and the Qingquan Temple Jialing River Bridge in Nanchong, Sichuan (strengthened in 2014). The investigation revealed that, as China's first long-span continuous rigid-frame bridge employing a hybrid internal–external prestressing tendon system, the Xintan Qijiang Bridge has maintained good technical conditions in its right span with a hybrid tendon layout after 17 years of service, with no structural load-induced cracks, which fully verifies the long-term reliability and durability of the external prestressing system. Moreover, ten years after the implementation of comprehensive strengthening measures—including internal-box external prestressing—the Qingquan Temple Jialing River Bridge also remained structurally stable. On the basis of these findings, experts have recommended the development of dedicated inspection guidelines for external prestressing systems, with a focus on critical components such as anchorages and deviators, and the promotion of nondestructive testing and intelligent monitoring technologies. This investigation not only provides valuable empirical support for the application of external prestressing technology in both new and reinforced bridges but also emphasizes the importance of integrated collaboration among research, industry, management, and maintenance for the sustainable advancement of the technology.

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1 Introduction

External prestressing technology has seen increasingly widespread application in both new bridge construction and the strengthening of existing structures in recent years owing to its advantages such as ease of inspection and tendon replacement, as well as effective control over long-term structural deformation. However, as a relatively newer form of prestressing, its long-term performance under complex service conditions, durability assurance mechanisms, and operation and maintenance strategies still require systematic validation and summarization through a substantial number of real-world engineering cases. To gain an in-depth understanding of the technology's actual performance under real operating conditions and to promote its standardization and high-quality development, the editorial office of *Prestress Technology* (PT Journal), an international journal published by Tongji University, in collaboration with relevant organizations, recently organized a specialized field investigation. This investigation focused on two representative early adopter bridges of external prestressing technology in China—the Xintan Qijiang Highway Bridge in Chongqing and the Qingquan Temple Jialing River Bridge in Nanchong, Sichuan. Through onsite inspections, review of technical

documentation, and expert discussions, the team comprehensively assessed the current structural performance and conducted in-depth exchanges on inspection methodologies, key maintenance considerations, and future pathways for broader implementation. This article, based on the findings of the aforementioned field study, systematically presents the technical features, in-service performance, and practical insights from these two bridges, aiming to provide valuable reference for the engineering application of external prestressing technology.

2 Project Review

In 2005, Professor Xu Dong from the Department of Bridge Engineering at Tongji University, as the principal investigator (PI), jointly led a team comprising the Sichuan Highway Planning, Survey, Design and Research Institute Ltd. the Yunnan Institute of Transportation Planning and Design, Changsha University of Science and Technology, Liuzhou OVM Machinery Co., Ltd., Chongqing Expressway Group Co., Ltd., Liaoning Provincial Transportation Planning and Design Institute, and Yueyang Road & Bridge Construction Group Co., Ltd., to undertake the western China transportation research project titled "Research on Design and Construction Technologies for Externally Prestressed Bridges."

Based on the Chongqing Xintan Qijiang Highway Bridge, the project conducted research on the design theories and methods for externally prestressed bridges, key structural components, and reliable externally prestressed systems—particularly focusing on the cable arrangement methods and layout strategies for externally prestressed bridges. At the same time, the project carried out systematic studies on externally prestressed bridge anchorages, vibration reduction devices, anchoring systems, and construction techniques.

On the occasion of the 20th anniversary of the launch of this research project and the 17th anniversary of the completion and opening to traffic of the supporting project—the Chongqing Xintan Qijiang Highway Bridge—to better promote, report on, and popularize the technology of external prestressing, Tongji University's international journal "Prestress Technology" (hereinafter referred to as PT Journal) organized a special symposium on external prestressing technology. The symposium invited key participating institutions and technical personnel from that year's project to visit the bridge site for an onsite survey of its current condition and to engage in technical exchanges with the bridge's management and maintenance company.

3 Chongqing Xintan Qijiang Highway Bridge

The Chongqing Xintan Qijiang Highway Bridge (a continuous rigid-frame bridge with spans of 75+130+75 m) represents China's first practical application of a hybrid prestressing system—combining internal and external tendons—in a large-span bridge[1-5]. Specifically, the left span employs a conventional internal prestressing system, whereas the right span adopts a novel hybrid system and cancels the vertical prestressing of the web, thus providing a valuable comparative case study [6]. Construction of the bridge commenced in October 2005, and the entire bridge was joined in April 2008. The loading tests were completed in August 2009. The research findings from this project have been evaluated by experts and generally reached an internationally advanced level. Among these findings, the innovative approach to combining internal and external tendons—balancing the durability of external tendons with the crack resistance of the box-girder structure—has demonstrated originality and achieved an internationally leading standard.

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Figure 1 Current status of the Chongqing Xintan Qijiang Highway Bridge

The inspection report from December 2023 shows that the left span (with internal prestressing tendons) has a technical condition score of Dr = 87.04, whereas the right span (with a hybrid internal-external prestressing system) has a score of Dr = 92.33. Both spans are classified as Category 2 (Good), meaning that they exhibit only minor damage that does not affect their serviceability.

Figure 2 Hybrid prestressing tendon system

Figure 3 Experts discussions

Over the years of observation, the existing cracks have shown no further propagation. These cracks are caused primarily by early-stage curing practices and by concrete shrinkage and creep. No structural load-induced cracks have been identified. These results strongly confirm the long-term reliability and durability of the external prestressing system in large-span bridges.

During the survey, experts and maintenance companies focused their discussions on the inspection and maintenance of external tendons. They recommended strengthening attention to externally prestressing tendons during routine inspections, promoting nondestructive testing technologies such as magnetic flux testing, and regularly checking the protective conditions of critical components, including sheaths, vibration-damping connectors, anchorage points, and deviator blocks.

4 Inspection of the External Prestressing Technology Reinforcement Project

The Qingquan Temple Jialing River Bridge Project in Nanchong City, Sichuan Province, has a total length of 4.2 kilometers, including a bridge span of 1.6 kilometers and approach bridges totaling 2.6 kilometers. The bridge deck and approach bridges both have a uniform width of 24.5 m. The total investment for the project is 240 million yuan, and the construction period is 3 years.

Figure 4 Current status of the Qingquan Temple Jialing River Bridge

The Qingquan Temple Jialing River Bridge underwent a comprehensive renovation in 2014. The main components of the repair and reinforcement project included crack treatment, removal and renovation of the bridge deck system, greening of the central divider, replacement of crash barriers and streetlights as well as other ancillary structures, and replacement of bearings and expansion joints. The key focus of the renovation was bridge reinforcement, which involved techniques such as bonding carbon fiber fabric, tensioning carbon fiber plates, bonding steel plates, and applying external prestressing inside and outside the box girder.

This year marked the 10th anniversary of the bridge's completion of reinforcement and reopening to traffic. The expert panel conducted detailed inspections on the bridge deck, inside the box girders, and outside the box girders and held onsite discussions about the bridge's current condition. Afterwards, they visited Nanchong Highway Administration Bureau No. 2, the bridge maintenance and management company, to review relevant documentation. Through exchanges and communication with the management personnel, they gained a thorough understanding of the bridge's current condition and the ongoing inspection items.

Figure 5 Expert inspection of the Qingquan Temple Jialing River Bridge

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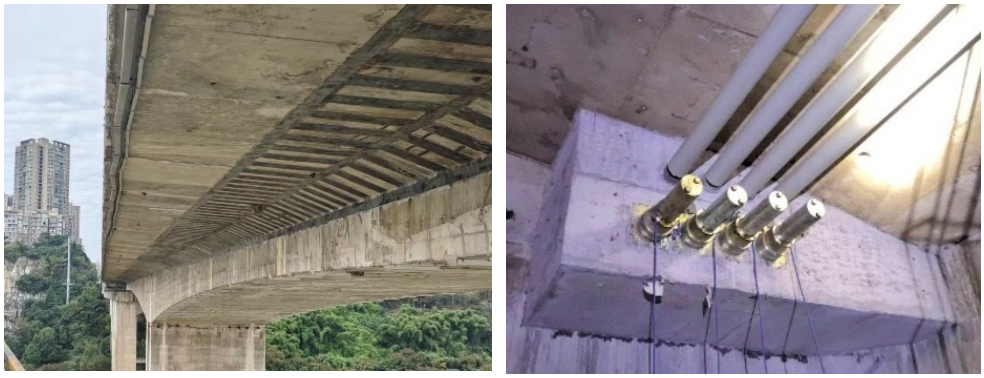
During bridge reinforcement, technologies such as carbon fiber plates, steel plate bonding, and external and internal prestressing within the box girder were comprehensively employed. More than ten years after reinforcement, the bridge continues to operate in excellent condition. The expert panel recommends making full use of the existing sensors on the bridge to conduct long-term monitoring of the prestress status, thereby providing data support for assessing the bridge's performance.



a) Carbon fiber plates applied to the outside of the box girder

b) Posttensioned prestressing tendons applied to the inside of the box girder

Figure 6 Application of the external prestressed reinforcement scheme in the Qingquan Temple Jialing River Bridge

5 Research Conclusions and Outlook

Through onsite follow-up visits and discussions, this symposium reached the following consensus:

(1) The Chongqing Xintan Qijiang Bridge has maintained excellent technical conditions over the past 17 years of operation, demonstrating that external prestressing technology has long-term safety and applicability in large-span bridges.

(2) A specialized inspection guideline for external prestressing systems should be established, with particular attention given to critical details such as anchorage and deviator devices, and intelligent monitoring methods should be introduced.

As an important academic platform in this field, the PT journal will continue to organize engineering follow-up visits, technical seminars, and special-issue publications, thereby fostering comprehensive collaboration among industry, academia, research, management, and maintenance. Moving forward, the PT journal plans to conduct a field study of an external prestressed box-girder bridge on a highway in Liaoning Province and will continuously monitor the performance of this technology under various environmental and structural conditions.

Figure 7 Expert symposium and exchange

Acknowledgments: This symposium lasted a total of 3 days and brought together over forty experts and staff members. We would like to extend our appreciation to Sichuan Highway Planning, Survey, Design and Research Institute Ltd., the coordinating and hosting organization for this symposium. We also wish to express our gratitude to the Zhongyu Operations Branch of Chongqing Expressway Group Co., Ltd. and the Nanchong Highway Administration Bureau No. 2, who provided valuable cooperation throughout the conference.

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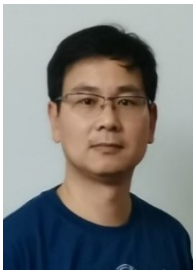
	**Zhichao Wang** M.E, Engineer. Tongji University Architectural Design (Group) Co., Ltd. Research Direction: Prestress Technology. Email: dutwzc@163.com		**Fangyuan Li** D.Eng, Professor, Department of Bridge Engineering, Tongji University. Research Direction: Bridge Engineering, 3D Print and New Material New Technology. Email: fyli@tongji.edu.cn