Design and Construction of Arch Bridge with Variable Steel-Concrete Composite Section Based on Vertical Erection-Rotation Method

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Summary

This paper describes an innovative use of a variable steel-concrete composite section for the main arch ribs to take combined advantages of steel and concrete strength. And vertical erection method that can significantly simplify and accelerate arch bridge construction with better structure integrity and higher stability during construction is proposed. Since steel construction is relatively simple because of its advantages of high strength to weight ratio, offsite prefabrication and quick on-the-spot assembly, the use of steel box as the stiffening core of arch rib section becomes an ideal choice for the initial arch framing using the developed erection method. The prefabricated steel box can be erected vertically on temporarily restrained horizontal hinge device at the spring line with minimal hoisting equipments. The completed two half-leaf can then rotate down on its own weight to meet at the mid-span for closure in a few hours. The completed steel arch frame can serve as formwork and supporting system to provide a sufficient and safe platform for the placement of concrete that forms a variable composite rib section, and for erection of spandrel columns and deck system. This construction technique and structure optimization can significantly simplify and speed up arch bridge construction with added work zone safety and better constructability, thus provides a viable solution for arch bridge construction having difficult site condition. Pilot projects including a 75-meter highway bridge are presented to demonstrate the basic concept, design features, construction procedures and erection control.

Keywords: arch bridge; conceptual design, performance-based design; vertical erection-rotation method; steel-concrete composite section

1. Introduction

Reinforcement concrete arch bridges have advantages of aesthetic appeal, durability and economy over other bridge types in area with deep ravine. Conventional construction methods for the reinforced concrete arch bridges uses scaffolding or centering system can be expansive, unsafe and impractical for arch bridges with long span, because the erection and removal of centering system becomes more difficult and costly as span increases. For long span arch bridge, a system with high line crane and stay-cables is often utilized to erect bridge ribs in a cantilever form, segment by segment. The cantilever launching method saves material and related cost, but the construction procedure is complex and time-consuming. During construction, the loading conditions change when new precast members are assembled or cast-in-place concrete elements of various ages are combined, which leads to a time-dependent stress accumulation. Meanwhile, the boundary conditions change when supporting elements are adds or removed, which leads to closely structural loading-carrying system transfers. Since the incomplete bridge can experience a wide range of stress variation during the construction, bridge components have to be designed for different loading conditions at different construction stages which imply additional cost for construction. Therefore, sophisticated methods are needed to carry out the structural analysis and structure

https://doi.org/10.2749/222137810796063355
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