2019 9th International Conference on Education and Social Science (ICESS 2019)

Study on the Post-Tensioned Prestressed Concrete Bridge Construction Method

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Keywords: Post-tensioned prestressed concrete; Bridge construction; high-strength tendon; Normal stress; Resistance Moment

Abstract. To effectively promote the quality of concrete bridge, in this paper, we propose a post-tensioned prestressed concrete bridge construction method. Firstly, we introduce the background theory of post-tensioned prestressed concrete bridge construction, and illustrate the process flow chart of the post-tensioned prestressed technology. Secondly, we discuss how to utilize the prestressed principle in concrete bridge construction. Particularly, a hole are reserved below the eccentric distance in a concrete beam axis, and then high-strength steel can be installed and stretched. Moreover, normal stress of the concrete section is produced by the external load moment. Finally, we conduct a simulation to make performance evaluation by testing the vibration velocity under various truck speeds. Simulation results demonstrate that the post-tensioned prestressed technology is able to promote the safe level of the concrete bridge.

Introduction

In recent years, as the national economy developed rapidly, the requirements of high quality structure of the building have attracted more and more attention [1]. High quality construction project requires not only big span, high strength, but also good economic benefits [2]. However, the ordinary structure of armored concrete can't fully satisfy our requirements. The post-tensioned prestressed concrete is a new technology, which has been studied and developed for many years [3][4].

With the rapid development of modern bridge and highway construction, the post-tensioned concrete technology based construction methods have been widely exploited in many projects [5]. In pre-stressed concrete structure, pre-stressing tension of high-stress state is quite sensitive to corrosion [6]. When corrosion occurs, the speed will significantly accelerate compared with that of no stress state. It is possible to cause the section damage of pre-stressed reinforcement corrosion site, and then rapid failure of the pre-stressing force may happen [7][8]. Afterwards, there is a threat to the safety and durability of pre-stressed concrete structures and its related components.

Concrete refers to a composite material, which is made up of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes exploited are lime-based concretes such as Portland cement concrete [9][10]. Bridges are a common feature of the built environment and one of the key elements in modern civil engineering [11]. The basic rules of bridge design rely on the load-bearing structure. In particular, concrete bridge has attracted more and more attention [12][13].

Furthermore, prestressed concrete denotes a concrete construction material that is placed under compression prior to it supporting any applied loads [14][15]. This compression is generated by the tensioning of high-strength tendons located in or next to the concrete volume [16][17]. Tendons are composed of single wires, multi-wire strands or threaded bars, and they are generated from high-tensile steels, carbon fiber or aramid fiber [18].

After studying and analyzing the situation and development trend of post-tensioned pre-stressed concrete technology all over the world, in this paper, we propose a novel post-tensioned prestressed concrete bridge construction method. The rest of this paper is organized as follows: the next section describes the background theory of post-tensioned prestressed concrete bridge construction. Section 3

  DOI: 10.25236/icess.2019.040

provides the overview of the Prestress principle. In section 4, we propose a simulation to test the performance of the proposed method. Section 5 conclusions the whole paper.

Background Theory

In this section, we introduce the background theory of post-tensioned prestressed concrete bridge construction. Some reparatory works for post tensioned prestressing should be done in advance.

Component inspection and cleaning.

1) Concrete structures should be checked before putting the stress them to ensure that the appearance and size are consistent with the requirements of the quality standard. In addition, the strength of concrete tension member should not be less than the design requirements. If it is not specified in the design, it should not be less than 75% of the design strength grade.

2) We should check if the position of hot plate and the anchor hole are correct, and if grout hole and discharge port can meet the construction requirements.

Determination of the direction of tension

Generally, stress should be imposed from two ends. However, considering the site conditions and construction methods, the construction should implement according to the design drawing. Generally, the bridge and the plate are almost unilateral tension, in order to make the distribution of the stress evenly as possible, it is best to change the direction of each force.

There are many ways to apply prestress, such as symmetric tension, super tension, batch tension, segmented tension, and so on. Before implementing the prestress, we should make a good plan and careful preparation. Based on the above analysis, the process flow chart of the post-tensioned prestressed technology is given in Fig. 1.

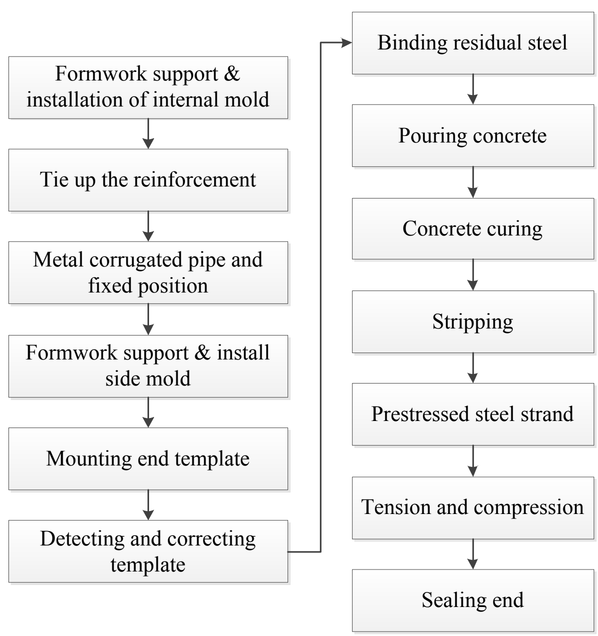

Fig. 1 Process flow chart of the post-tensioned prestressed technology.

Overview Of The Prestressed Principle

The prestressed concrete structure widely utilized the prestressed principle, and usually is reinforced with pre-tension elastic recoil force applied to a preset stress of concrete structure. Therefore, the prestressed principle can overcome the weakness of the concrete performance, give full play to the strength of the material, and achieve the light structure, large span, high strength, and durable purpose.

A hole should be reserved below the eccentric distance e in a concrete beam axis, and then high-strength steel is installed and stretched. Suppose that the strength imposed on the beam is N_p. Under the pre-applied force N_p, the normal stress of concrete section (stress is positive) is computed as follows.

$$\sigma_c = \frac{N_p}{A_c} + \frac{N_p e y}{I_c} \tag{1}$$

Normal stress of the concrete section generated by the external load moment M (including the weight of the beam) is computed as follows.

$$\sigma_c = -\frac{My}{I_c} \tag{2}$$

Normal stress of the concrete section can also be represented as follows.

$$\sigma_c = \frac{N_p}{A_c} + \frac{N_p e y}{I_c} - \frac{My}{I_c} \tag{3}$$

where A_c and I_c refer to concrete sectional area and anti-bending moment of inertia respectively, and y denotes the distance between the stress calculation point and the section centroidal axis.

In the limit condition, the ratio between the Resistance Moment provided by prestressing tendon and the Resistance Moment provided by non-prestressing tendon is defined as follows.

$$PPR = \frac{(M_u)_p}{(M_u)_{p+s}} \tag{4}$$

According to the design theory of flexural strength of concrete components, when the materials are fully utilized, Eq.4 can be modified as follows.

$$PPR = \frac{A_p f_{py}\left(h_p - \frac{x}{2}\right)}{A_p f_{py}\left(h_p - \frac{x}{2}\right) + A_n f_{ny}\left(h_n - \frac{x}{2}\right)} \tag{5}$$

where A_p and A_n refer to sectional areas of prestressing tendon and non-prestressing tendon respectively; f_{py} and f_{ny} denote the design value of tensile strength for prestressing tendon and non-prestressing tendon respectively; h_p and h_n refer to the distance between the outermost edge of the compression zone and centroids of sections of prestressing tendon and non-prestressing tendon respectively; x is the height of the compression zone

Simulation

To test the performance of the proposed method, in this section, we design a simulation to simulate working states of a post-tensioned prestressed concrete bridge. The speeds of trucks on the bridge are set to 10 km/h, 20 km/h, 30 km/h, and 40 km/h respectively. Moreover, measurements of dynamic interactions are considered when these trucks move across threshold of $0.03 \times 0.2m$ area. Next, we show the vibration velocity with different truck speeds, and experimental results are shown in Fig. 2 to Fig. 5.

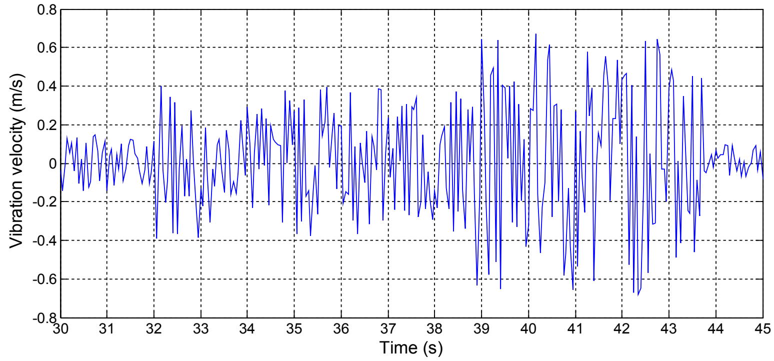

Fig. 2 Vibration velocity when the speed of truck is 10 km/h

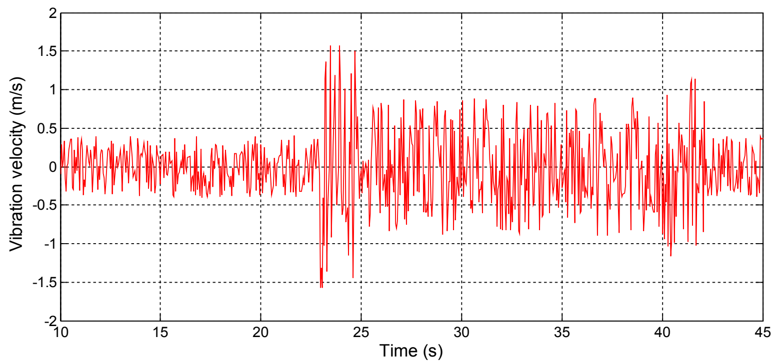

Fig. 3 Vibration velocity when the speed of truck is 20 km/h

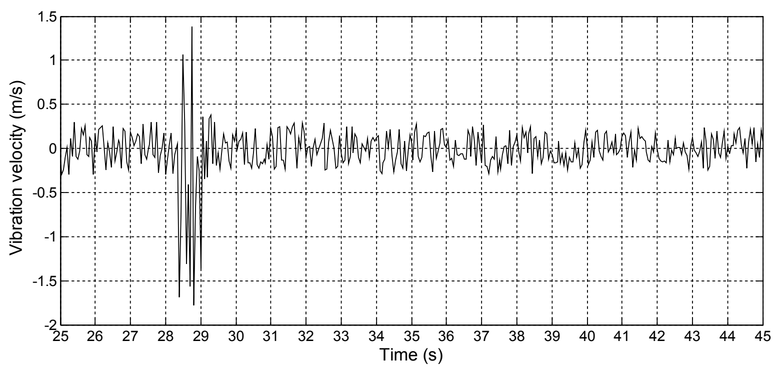

Fig. 4 Vibration velocity when the speed of truck is 30 km/h

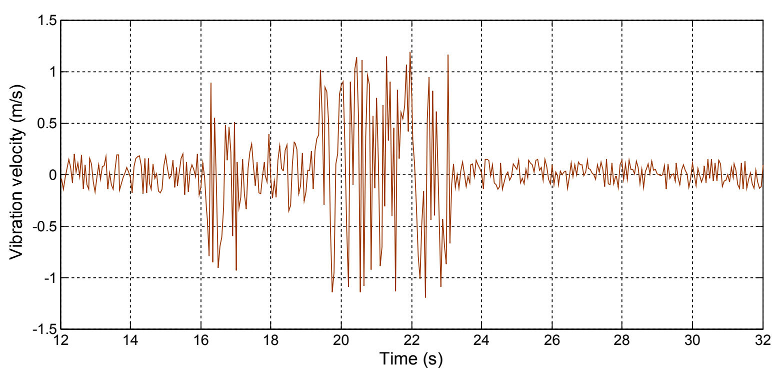

Fig. 5 Vibration velocity when the speed of truck is 40 km/h

Integrating all experimental results above, we can see that for different moving speeds of truck, vibration velocity is limited in a safe range, and the post-tensioned prestressed technology can ensure the concrete bridge to work safely.

Conclusion

This paper proposes a post-tensioned prestressed concrete bridge construction method. We discuss how to design the process flow chart of the post-tensioned prestressed technology in advance. Then, we discuss how to utilize the prestressed principle in concrete bridge construction. In the end, simulation results prove that the post-tensioned prestressed technology can effectively enhance the safe level of the concrete bridge.

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