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Influence of Adjacent Deep Foundation Pit Construction on Main Beams of PC Continuous Box Girder Bridge

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Abstract: *In order to study the influence of the construction of deep foundation pit close to the main girder of PC continuous box girder bridge on the mechanical performance of the main girder, this paper finds that the construction of deep foundation pit will have a certain impact on the mechanical performance of the main girder of the bridge through the analysis of test data, which is mainly reflected in the deformation and stress of the main girder. This paper also studies the relationship between temperature changes and stress changes. The research results have certain theoretical and practical significance for deep foundation pit construction and bridge design.*

Keywords: *Deep foundation pit, PC continuous box girder, Construction technique*

1. Introduction

The large-span prestressed concrete (PC) continuous beam Bridges often encounter issues such as mid-span downwarping and beam body cracking, which result from factors like concrete shrinkage, creep, prestressed concrete loss, construction quality, and overload. These problems significantly reduce the bridge's bearing capacity and adversely affect its normal operation, necessitating prompt bridge reinforcement and rehabilitation [1]. Temperature effects have always been a crucial consideration in bridge design and operation, and ailments caused by temperature loads are not uncommon during construction and operation [2].

The G106 Beijing-Guangzhou Dongming Yellow River Highway Bridge, also known as "the first bridge in Qilu," is situated in the northwest of Heze City, Shandong Province [3]. It serves as a connection between Shandong Rizhao and Dongming Expressway in the east and Henan Jiyuan Changyuan Expressway in the west [4]. The upper structure is a composite system of cast-in-place prestressed concrete steel structure and continuous beam. The lower consolidated pier of the main bridge adopts double thin-walled rectangular piers, the non-consolidated pier adopts rectangular hollow piers, the transition pier adopts separated bearing platforms, and the non-transition pier adopts left and right integrated large volume bearing platforms [5]. The main bridge is a prestressed concrete beam bridge with nine holes, featuring a combination of a 75m+7×120m+75m rigid frame and a continuous combined structure system, totaling 990m. The approach bridge consists of a 40m and 50m prestressed simply supported bridge floor continuous T beam, resulting in a total length of 4142.14m [6]. After years of operation, the bridge experienced beam cracking and mid span deflection. In order to solve these problems, reinforcement construction was carried out on the bridge. However, the construction process for cable-stayed system reinforcement is intricate, and the tension construction can lead to local stress concentration in the main beam, potentially causing sudden failure during the tensioning stage. To ensure the structure's safety during construction, a comprehensive tracking and monitoring system was implemented, meticulously observing each working condition [7].

Excavating in close proximity to a foundation pit not only displaces the enclosing structure but also affects the adjacent foundation pit's enclosure structure [8]. Reducing and controlling the influence of irregular deep foundation pits on adjacent public buildings poses a challenge [9]. It is difficult to manage the deformation of supporting structures and soil mass during foundation pit excavation. Effectively controlling the deformation of deep foundation pits and adjacent important structures is crucial for the smooth progress of such projects [10]. Figure 1 illustrates a comparison of the main bridge before and after cable-stayed reinforcement.

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Figure 1: Schematic diagram of the reinforced cable-stayed system and deep foundation pit of the main bridge of Dongming Huanghe River Bridge.

2. Main Beam Stress Monitoring

A total of 47 test sections are distributed throughout the entire bridge. The stress section measurement points for main beams 63# to 65# are arranged according to the layout depicted in Figure 2.

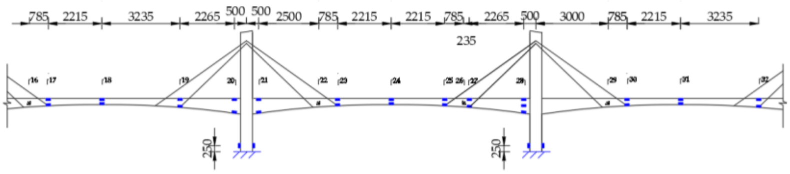

Figure 2: Layout charts of stress test of main girder section (Unit:cm).

3. Main Beam Alignment Monitoring

The linear monitoring points for the main bridge are positioned on the top plate of the main beam. In each monitoring cross-section, two measuring points are symmetrically arranged along the center line of the main beam. Additionally, along the longitudinal axis of the bridge, measuring lines are established at the pier top section, 1/8 section, long and short cable anchoring area, and mid-span section. On each measuring line, 67 measuring points are distributed, resulting in a total of 134 measuring points.

4. Strain and Deformation Monitoring Results of Main Beam

4.1. Strain Monitoring Results of Main Beam

As depicted in Figure 3, a comparison between October 19, 2022, and February 19, 2023, reveals that the average strain difference on the middle floor of the inner span of the box girder of the main bridge is -97.61με. This difference indicates a generally compressive stress condition. It is noteworthy that all strain measurement points within the box girder of the main girder remain within the specified limit value without any sudden increases.

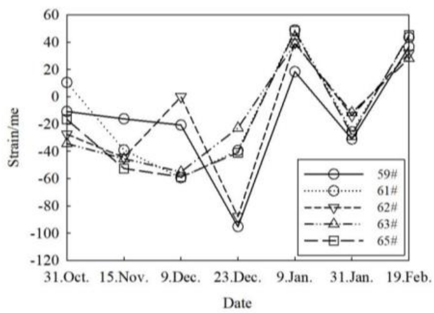

Figure 3: Partial span strain and time relationship diagram.

4.2. Deformation Monitoring Results of Main Beam

As illustrated in Figure 4, when comparing the data from August 2022 to May 2023, the average deformation difference observed on the middle floor of the inner span of the box girder of the main bridge is -10.87mm. This indicates an overall downward deflection. It is worth noting that all deformation measurement points within the box girder of the main girder remain within the specified limit value, and there are no sudden increases. Additionally, on February 19, 2023, the average temperature was found to be 10.78℃ lower than that recorded on October 19, 2022.

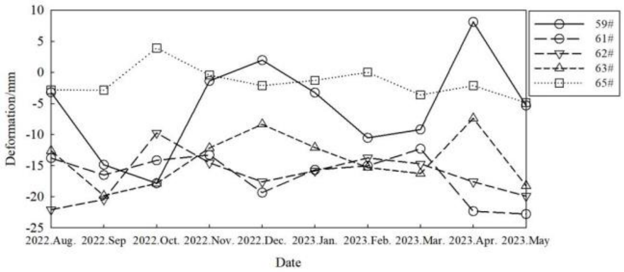

Figure 4: Partial span deformation and time relationship diagram.

5. Conclusions

The change in strain is primarily proportional to the temperature variation, where a larger temperature difference corresponds to a greater strain difference. As the temperature increases, the strain difference measured on February 19, 2023 has significantly reduced. The analysis suggests that temperature changes lead to the contraction of the main beam and relaxation of cable forces, ultimately resulting in a decrease or increase in compressive stress on the bridge tower. Comparing the data from October 19, 2022, to February 19, 2023, the average strain difference on the middle floor of the inner span of the box girder of the main bridge is -97.61με, indicating an overall compressive stress condition. Furthermore, the average temperature has decreased by 10.78℃. Considering the previous data, the overall difference between temperature and stress has diminished, primarily due to temperature effects. All strain measuring points in the main bridge tower and main beam boxes remained within the specified limit values, and no sudden increases were observed.

Acknowledgements

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