INDEPENDENT STRUCTURAL ANALYSIS FOR THE CORPUS CHRISTI NEW HARBOR BRIDGE PROJECT

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TECHNICAL MEMORANDUM

EXPANSION JOINT PIER SEGMENTS - UPLIFT

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Revision History

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Table of Contents

1. Introduction

This technical memorandum discusses a previously-reported finding of the Independent Structural Analysis (ISA) concerning uplift at the disc bearings supporting the expansion joint pier segments at piers 2N and 2S of the Corpus Christi New Harbor Bridge, cable-stay main bridge. The current design does not meet the project requirements.

2. References

The following documents are referenced in this memorandum.

1. Texas Department of Transportation (TxDOT), "Technical Provisions for US 181 Harbor Bridge Project: Comprehensive Development Agreement." ["TP"]
2. American Association of State Highway and Transportation Officials (AASHTO), "LRFD Bridge Design Specifications," 7th Edition, 2014 with 2015 Interim Revisions. ["AASHTO LRFD"]
3. "277609-NHB-PLN-MSUPER_B-01" Sheet Nos. NHB 177-184C for Expansion Joint Pier Segment Details, "277609-NHB-PLN-MSUB_B-00" Sheet Nos. 33 & 34C for Vertical Stay Details, and "277609-NHB-PLN-M13B+C-01" Sheet Nos. NHB 121-124A for Bearing Details ["Design Drawings" or "Current Design"]
4. "277609-NHB-REP-MWER-02: US181 Harbor Bridge Replacement Project: Wind Engineering Report," Revision 2, May 4, 2021 (First received by ISA Team June 7, 2022) ["Wind Report"]
5. Flatiron Dragados LLC, "FDLLC-RFI-000111: Back Span Pier Vertical Tendon," dated June 26, 2017. ["RFI 111"]
6. Independent Structural Analysis for the Corpus Christi New Harbor Bridge Project, Document Number: 1010 dated January 8, 2021 ["ISA Phase 1 Report"]
7. Independent Structural Analysis for the Corpus Christi New Harbor Bridge Project, Document Number: 2010 dated April 23, 2022 ["ISA Phase 2 Part 1 Report"]
8. Meeting Notes of 26 May 2022 meeting in Austin, TX between TxDOT, FDLLC, HNTB, ARUP-CFC, and IBT ["May 2022 Meeting"].
9. Meeting Notes and Presentations of 10 June 2022 meeting in Austin, TX between TxDOT, FDLLC, HNTB, ARUP-CFC, and IBT ["June 2022 Meeting"]
10. Meeting Notes and Presentations of 29 July 2022 meeting in Austin, TX between TxDOT, FDLLC, HNTB, ARUP-CFC, and IBT ["July 2022 Meeting"]

3. Background

TP §13.2.1.1 requires that the "Developer shall proportion bridge spans to avoid uplift at supports. Permanent tie-downs are prohibited." RFI 111 seeks relief from TP §13.2.1.1 by requesting acceptance of tie-downs at the backspan piers, which include transition piers 2N and 2S, using vertical tendons. This RFI assured that "The vertical tendon will connect the pier and superstructure in order to preclude any actual uplift under these conservative Factored Load conditions. The prestressing force in these vertical tendons will preload the bearings in compression to alleviate any resultant uplift."

4. Summary of Finding

In the May 2022 Meeting, the ISA Team confirmed a previously-reported finding (identified in the ISA Phase 1 Report and subsequently in the ISA Phase 2 Part 1 Report) that bearing uplift under both Service and Strength loadings occurs in the current design. In this meeting, the Developer's Lead Engineer (DLE) acknowledged that uplift occurs under Strength loadings.

With the current design, uplifted bearing(s) at piers 2N and 2S would not be able to transmit lateral loads once uplift occurs. In the May 2022 meeting, the DLE indicated that they were working with a bearing supplier to develop details that would ensure that the bearings would retain their lateral capacity given uplifted deck displacements. Additionally, the DLE has indicated that they do not intend to design the bearings to resist uplift. The DLE's actions indicate that bearing uplift will be allowed to occur, which does not meet the project requirements. Also, the ISA Team does not agree with the validity of such an approach, as briefly explained in the following paragraphs.

Following the instructions of RFI 111, it was assumed that there would be no bearing uplift. However, the ISA analysis results reveal that uplift does occur. Since the bearings as currently designed do not have uplift restraint capacity, tension reactions would shift to the tendons and non-linear behavior would result. This is inconsistent with the ISA and the analyses of others – namely the frequency domain dynamic analyses documented in the Wind Report which assumes linear superposition.

If uplift were allowed to occur at piers 2N or 2S, the box girder would lift off from at least one of its bearings, resulting in an elongation of vertical tie-down stays and a redistribution of the loads between the compressed bearing(s)/tie-down stay(s) system and the superstructure through additional axial load, shear, flexure, and torsion. Bearing uplift introduces non-linear behavior that would result in a reduction of the vertical, lateral, and torsional stiffness of the superstructure connection at piers 2N and 2S, which is not considered in the analyses. It would be inconsistent with a fundamental assumption in the Wind Report and in other analysis models that presume the structure remains within the linear domain under the design wind loadings. Appendix E of the Wind Report explicitly states, "The equivalent static wind load analysis is based on the assumption of linear elastic behaviour and results in different load cases which can be analysed to develop an envelope of stress conditions in the structure. These loads are suitable for a linear structure for both positive and negative loads."

In addition, unseating of bearings would likely lead to unacceptable bearing performance and maintenance issues.

5. Conclusion

The ISA has identified bearing uplift at both the NB and SB box girders at piers 2N and 2S, and this does not meet the project requirements, specifically TP §13.2.1.1 / RFI 111. The DLE has also acknowledged that uplift occurs under AASHTO Strength load combinations. Since bearing uplift under any limit state is not allowed, and since uplift is incompatible with the Wind Report and other structural models, calculations attempting to model and compute post-uplift non-linear behavior are not justified.