Preliminary Investigation

Caltrans Division of Research, Innovation, and System Information

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Post-Tensioned Box Girder Deck Replacement Methodology

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Executive Summary

A significant portion of state owned bridges in California has post-tensioned box girders. The majority of these bridges were built in the 1970's. As these bridges age, it is essential to preserve and replace their decks. Caltrans currently has two methods for the deck replacement of these bridges: falsework shoring, and sectional replacement. These methods are costly and impractical. As a result, research is needed to establish a new method for the deck replacement of post-tensioned box-girder bridges without any reliance on falsework shoring and with minimum traffic disruptions. The new method is deemed to be a staged replacement method [Castrodale & White, 2004]. Regardless, the new method should be investigated for its short-term and long-term effects on the properties of girders, post-tensioning cables, and other bridge components.

1. Background

A significant portion of state owned bridges in California has post-tensioned box girders. The construction of these nearly 7000 bridges rapidly expanded in the mid to late 1970's and continues. As these bridges age, it is essential to preserve and replace their decks before any issue arises in their girders. Caltrans does not currently have a feasible method for the deck replacement of post-tensioned box-girder bridges without any reliance on falsework shoring and with minimum traffic disruptions. It is essential to establish a new method and investigate its short-term and long-term effects on the structural integrity of all bridge components.

2. Summary of Findings

Caltrans currently has two methods, according to the contacts in Section 5, for the deck replacement of post-tensioned box-girder bridges. These methods and their disadvantages are as follows.

2.1. Falsework Shoring

The parabolic path of post-tensioning cables, as shown in Figure 1, tends to create negative moments, thus, a negative curvature and an upward deflection at the mid-span of the girder. This effect cancels out in the presence of dead loads. If the deck is completely removed in a deck replacement project, provisions should be made to substitute the dead loads from the weight of the deck. One method which Caltrans currently uses is falsework shoring to block any upward deflection when the deck is completely removed.

Disadvantage: Falsework shoring is costly. At times, falsework shoring is not even practical because of the presence of a river or a busy urban area under the bridge. As a result, research is needed to establish a new method for the deck replacement of post-tensioned box-girder bridges without any reliance on falsework shoring.

2.2. Sectional Replacement

As it was mentioned in Section 2.1, a complete removal of the deck creates an upward deflection at the mid-span of the girder. One method which Caltrans currently uses to avoid a complete loss of the dead loads from the weight of the deck is sectional replacement, as shown in Figure 2.

Disadvantage: It is practically hard to perform a sectional replacement; therefore, it is unappealing to contractors. In addition, it is not clear what lap length of transverse reinforcement is adequate at the borders of each section. As a result, research is needed to minimize the number of sections, to optimize the configuration of the sectional replacement, and to specify the adequate lap length of transverse reinforcement.

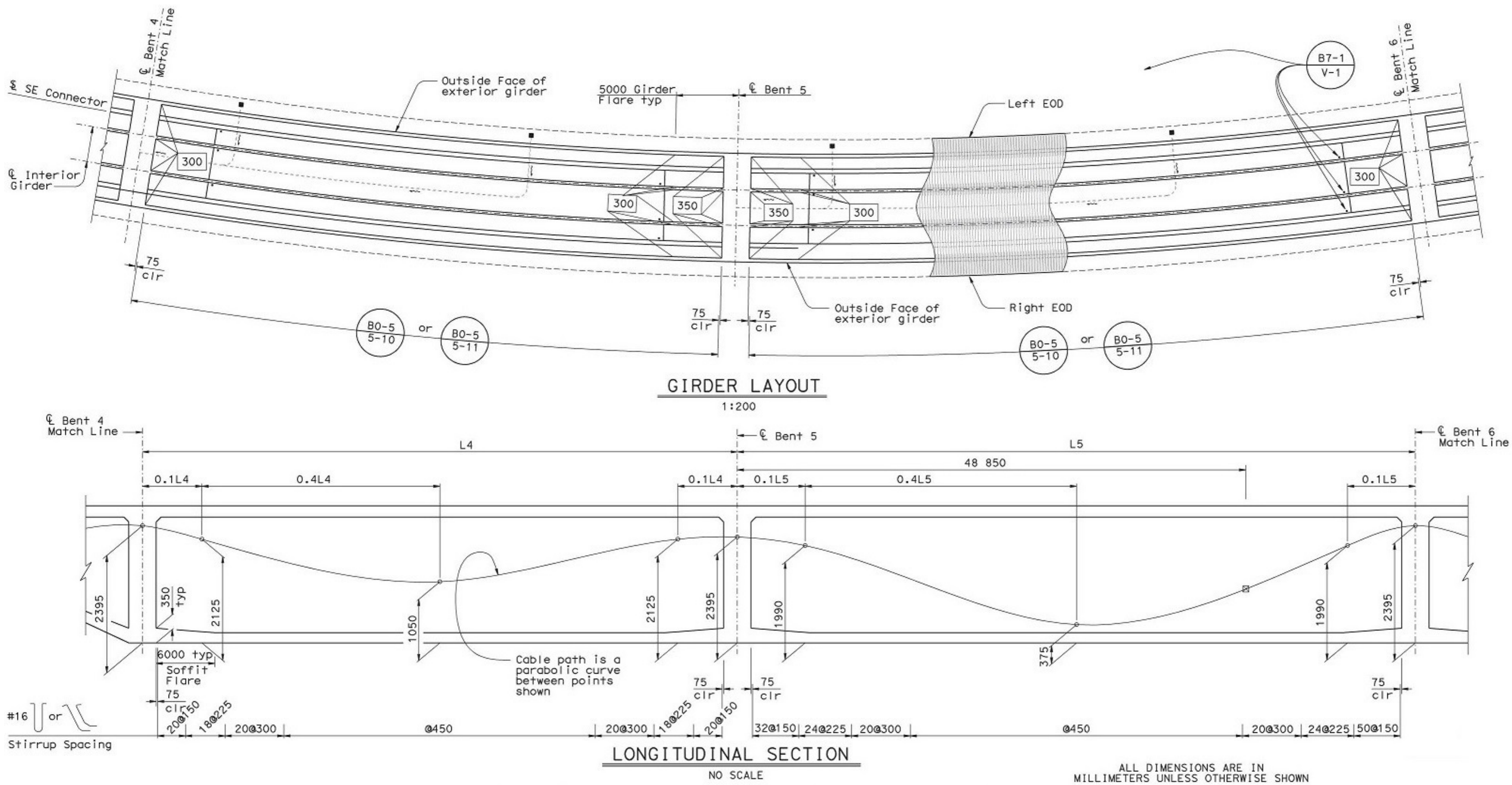

Figure 1. Sample post-tensioned box girders (from Bridge 56-0802F)

3. Gaps in Findings

It is necessary to establish a new method for the deck replacement of post-tensioned box-girder bridges without any reliance on falsework shoring. An alternative to the falsework shoring method is the traditional sectional replacement method, but it is impractical. As a result, research is needed to establish a new method for the deck replacement of post-tensioned box-girder bridges. Two possibilities for the new method are

- an optimized sectional replacement method with minimum number and optimum configuration of sections,
- a staged removal and replacement from the depth of the deck.

Except for these methods, other possibilities which do not currently exist in the literature should be also explored.

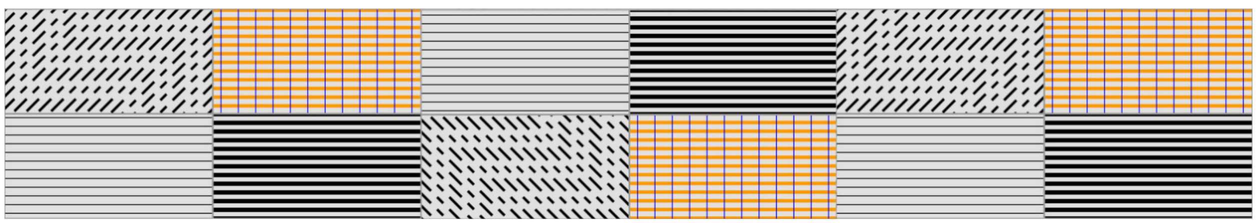

Figure 2. Schematic sectional replacement of a 2-lane deck

4. Next Steps

Research is needed to establish a new method for the deck replacement of post-tensioned box-girder bridges without any reliance on falsework shoring. The new method should be practical and should impose minimum traffic disruptions. A potential solution is to optimize the traditional sectional replacement method. Another potential solution is to perform a staged removal and replacement from the depth of the deck, as shown in Figures 3 and 4.

Regardless of what the new method will be, the following steps are deemed to be necessary:

1. A comprehensive finite element model for both single-span and multi-span configurations with significant details in the deck, girders, and post-tensioning cables should be implemented. Time dependent phenomena, such as shrinkage and creep, should be also considered in this finite element model.
2. Various scenarios in which one section or multiple sections are completely removed from the deck should be laid out. Under each scenario, the model of Step 1 should be used to investigate the nature and the magnitude of newly developed strains and stresses. As a result, concerns about short-term and long-term property changes or potential damages should be addressed.

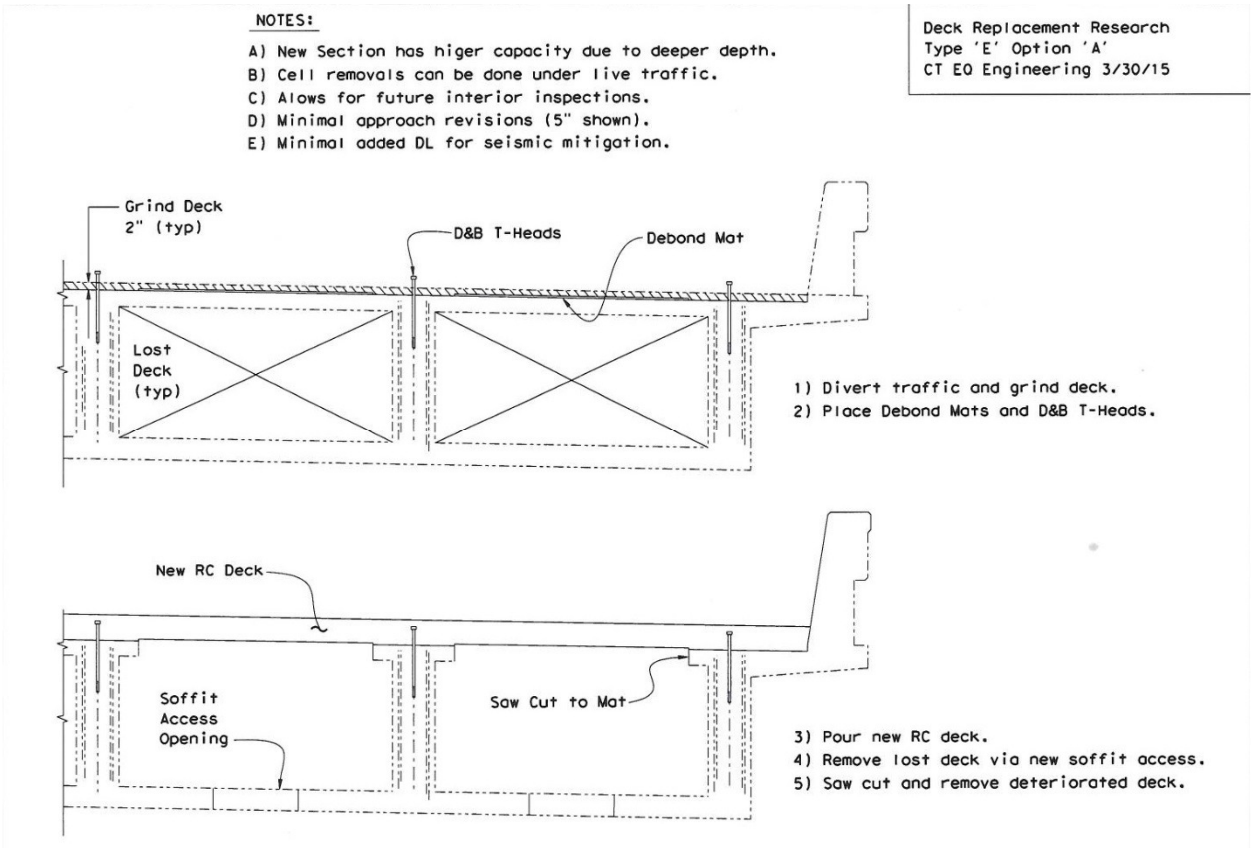

Figure 3. Staged depth removal and replacement method, Option A

3. The Step 2 results should be used to determine how large of a section or sections can be completely removed from the deck without inadmissible short-term and long-term property changes and damages. As a result, an optimum configuration for the sectional replacement method, with the fewest number of sections, should be proposed.
4. Various scenarios in which a partial depth removal from the deck is performed should be laid out. Under each scenario, the model of Step 1 should be used to investigate the nature and the magnitude of newly developed strains and stresses. As a result, concerns about short-term and long-term property changes or potential damages should be addressed.
5. The Step 3 and Step 4 results should be used to propose the most feasible deck replacement method. This method should be compared with Caltrans' current approaches to the deck replacement of post-tensioned box-girder bridges.
6. Concerns about the adequate amount of lap splices and the adequate stress transfer between new and old sections should be addressed for any deck replacement method.
7. If other methods are proposed through this research study, the proposed methods should be compared with the Step 5 results.

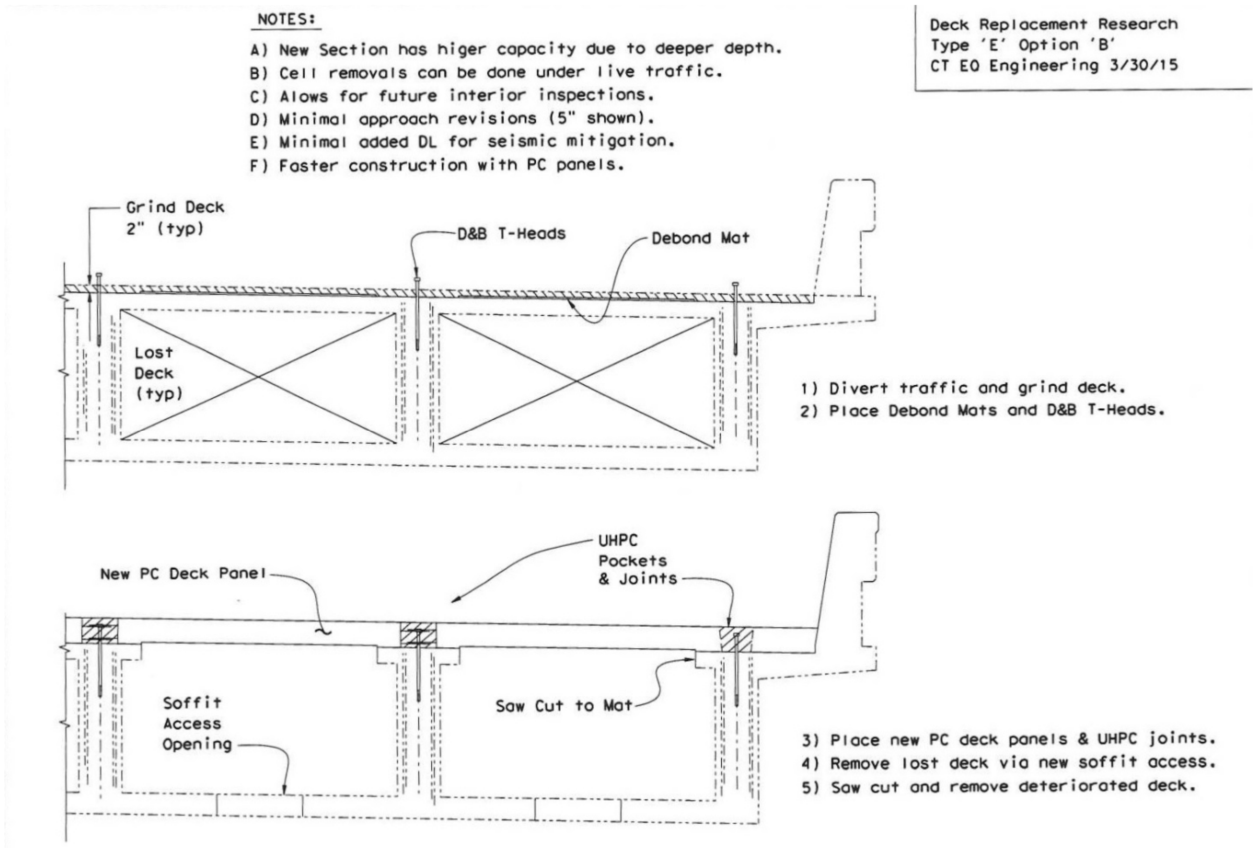

Figure 4. Staged depth removal and replacement method, Option B

5. Contacts

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6. References

Castrodale RW, White CD (2004) Extending span ranges of precast prestressed concrete girders. National Cooperative Highway Research Program Report 517.