Florida Department of Transportation
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NEW ACCESS HATCHES IN EXISTING CURVED BOX GIRDER BRIDGES

PROBLEM STATEMENT

Steel box girders are inspected periodically by maintenance crews who walk or crawl through the inside of the girders searching for signs of corrosion or damage. The interior of the box, which can be dangerous because of unusual temperatures and poor ventilation, is reached through access hatches that are usually provided in the bottom flange immediately before or after an expansion joint. These locations are chosen because (1) bending moments are small close to the expansion joint, and (2) the pier over which the expansion joint is located facilitates access--inspection crews need only a ladder to reach the access hole. Nevertheless, the spans covered by box girders are often long, and the girders are constructed as continuous segments over three or more supports. Hence, the distance between access hatches frequently exceeds the limit that rescue crews can reach in the event of an emergency. This situation has concerned safety officials and has prompted the Florida Department of Transportation (FDOT) Safety Office to request the construction of additional access holes in all existing box girder bridges.

OBJECTIVES

This study is designed to find locations where additional holes can be placed in order to decrease the distance between access hatches in existing bridges. Since new access holes should not adversely affect the structural behavior of the bridge, local strengthening may be necessary. With the strengthening option available, designers may freely choose the location of the access holes, generally to satisfy other criteria, such as practicality and accessibility. However, strengthening may be costly if the access hole is placed at a heavily stressed location. To eliminate or reduce the amount of strengthening work needed for adding a new access hole, minimally stressed locations are suggested.

FINDINGS

Minimally stressed regions are identified through detailed elastic and inelastic finite element analyses of 19 box girder bridges from the State of Florida inventory that are being considered for rehabilitation. Many of the bridges under consideration are horizontally curved and are comprised of steel U-shapes acting compositely with a reinforced concrete deck. The bridge data are summarized in the following table:

Bridge	Spans	Lanes	Span lengths		Radius of Curvature		Element length (inches)	Number of elements
			Min (feet)	**Max** (feet)	**Min** (feet)	**Max** (feet)		
390	5	1	180	233.5	620	620	6	1923
521	3	1	76	120	5770.6	5770.6	4	816
525	2	1	136.3	162.7	Straight	Straight	4	897
598	4	1	145.5	171.5	392.9	694.5	6	1895
601	4	1	133	238	304.5	Straight	6	1382
606	3	2	184	263.7	1439.9	2772.3	4	1310
607	3	2	154	219.3	2857.3	Straight	4	1582
528	5	2	158	192	5729.3	5729.3	6	1658
537	5	2	100	213	716.2	716.2	6	1390
538a	5	2	122.5	172	1432.4	9951.3	6	1585
538b	5	2	145.5	211	1432.4	2864.8	6	1762
538c	4	2	167	210	2864.8	2864.8	6	1508
538d	7	2	121	210	1432.4	2864.8	6	2486
539	5	2	130	183.5	717.2	717.2	6	1539
540	6	2	78	178	953.9	953.9	6	1661
541a	5	2	125.5	207	821.5	1415.7	6	1686
541b	5	2	105.5	201	821.5	2117.8	6	1604
542a	6	2	144	204	1146.9	1146.9	6	2096
542b	6	2	114	194	1146.9	28649	6	1834

CONCLUSIONS

Finding appropriate locations for the placement of access hatches in such bridges is complicated by the horizontal curvature and requires a thorough understanding of both elastic and inelastic behavior of the structural system. A detailed finite element model is created from four node shell elements and is used in a case study of one of the existing bridges. Material and geometric nonlinearities are included in the analyses that focus on the behavior and strength (both static and fatigue) of the bridge. A smaller but more detailed shell element model is also used to investigate flexural strength of a segment of the same bridge. In addition to the shell models, a beam-column finite element model that accounts for warping is created. This model is computationally more efficient than the shell models and is used in case studies of all nineteen existing bridges. The force and moment envelopes due to dead and live load combinations following AASHTO's Load and Resistance Factor Design (LRFD) specifications are calculated and are presented.

Based on the results of the finite element analyses, five different schemes are devised for locating regions where additional access holes could be added without strengthening. The construction sequence is considered in the analyses by adopting quasi-open section properties for dead loads and closed section properties for live loads. The five schemes incorporate different levels of interaction between normal and shear stresses and account for fatigue considerations. Analysis shows that fatigue is an important factor in determining these locations and should carefully be considered in any evaluation, especially if welding in the vicinity of the holes will be used. Based on the proposed schemes, suitable regions where access holes can be placed without additional strengthening are identified for each bridge. In addition to bottom flange access holes, tentative locations are also identified for placing openings in the webs. Strengthening should be considered for access holes located outside the proposed regions.

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