

AMERICAN UNIVERSITY OF BEIRUT

INFLUENCE OF RAILINGS ON
WHEEL LOAD DISTRIBUTION IN SKEWED
CONCRETE SLAB BRIDGES

by
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for the degree of Master of Engineering
to the Department of Civil and Environmental Engineering
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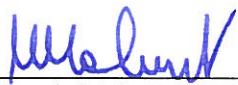
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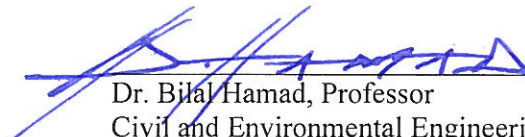
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AN ABSTRACT OF THE THESIS

Ghassan Mohammad Fawaz for Master of Engineering
Major: Civil Engineering

Title: Influence of Railings on Wheel Load Distribution in Skewed Concrete Slab Bridges

The presence of railings or parapets acting integrally with the bridge deck have the effect of stiffening and attracting load to the slab edge and therefore altering the lateral wheel load distribution on highway bridges. This may also result in increasing the load-carrying capacity of bridges. The current research presents a parametric study to investigate the influence of typical integral railings on wheel load distribution as well as on the load-carrying capacity of skewed concrete slab bridges. Typical one-span, simply supported, multi-lane (one to four lanes), skewed reinforced concrete slab bridges are considered. The finite-element method is used to investigate the effect of span length, slab width, skew angle and to calculate the wheel load distribution on the bridge slab at the critical section. AASHTO design trucks loads are placed transversally and longitudinally to produce maximum moments at the critical section of the slabs. Various configurations of railings on either or both edges of the slab are considered for straight and skewed bridges. Straight bridges with no railings will serve as reference cases. The wheel load distribution on the bridge slab at the critical section for the reference cases and for cases with railing and/or skewness are calculated and compared. The results are also assessed and evaluated with AASHTO procedures, and recommendations are made to assess the influence of railings on skewed bridges. This research will assist structural engineers in better designing new straight and skewed concrete slab bridges, or evaluating more precisely the load-carrying capacity of existing bridges in the presence of railings. In addition, the approach adopted in this research can also be considered as an adequate and practical method for strengthening and rehabilitating skewed concrete slab bridges.

CONTENTS

| | |
|--|----------|
| ACKNOWLEDGEMENTS | v |
| ABSTRACT | vi |
| LIST OF ILLUSTRATIONS | xi |
| LIST OF TABLES | xiii |
| Chapter | |
| 1.INTRODUCTION..... | 1 |
| 1.1 Background | 1 |
| 1.2 Design Procedures | 2 |
| 1.3 Research Objectives | 2 |
| 1.4 Scope and Methodology of Proposed Research | 3 |
| 1.5 Thesis Organization..... | 4 |
| 2.BACKGROUND AND AASHTO DESIGN PROCEDURES | 5 |
| 2.1 Introduction | 5 |
| 2.2 Skewed Concrete Bridges | 5 |
| 2.3 Background Studies..... | 8 |
| 2.4 AASHTO Standard Specifications for Highway Bridge..... | 11 |
| 2.4.1 Slab Design | 11 |
| 2.4.2 Edge Beam | 13 |
| 2.4.3 Live Load Deflection | 13 |
| 2.5 AASHTO Load Resistance Factor Design (LRFD)..... | 13 |
| 2.5.1 Slab Design | 13 |

| | | |
|--|--|-----------|
| 2.5.2 | Edge Beam | 15 |
| 2.5.3 | Live Load Deflection | 15 |
| | | |
| 3.BRIDGE CASES DESCRIPTION, MODELING AND ANALYSIS.. | | 16 |
| | | |
| 3.1 | Introduction | 16 |
| 3.2 | Bridge Cases Description | 16 |
| 3.2.1 | Geometry and Dimensions..... | 16 |
| 3.2.2 | Physical Properties..... | 19 |
| 3.2.3 | AASHTO Design Truck | 19 |
| 3.2.4 | Longitudinal Loading Position of Design Trucks..... | 20 |
| 3.2.5 | Transverse Loading Position of Design Trucks..... | 20 |
| 3.2.6 | Railings Implementation Methodology | 30 |
| 3.3 | Finite Element Modeling and Analysis | 39 |
| 3.4 | Summary | 44 |
| | | |
| 4.ANALYSIS RESULTS AND DISCUSSION..... | | 49 |
| | | |
| 4.1 | Introduction | 49 |
| 4.2 | Presentation of Results | 49 |
| 4.2.1 | Maximum Longitudinal Bending Moment | 50 |
| 4.2.2 | Edge Beam Moment | 50 |
| 4.2.3 | Maximum Transverse Moment..... | 51 |
| 4.2.4 | Maximum Live Load Deflection..... | 51 |
| 4.3 | Finite Element Analysis (FEA) Results and Discussion | 60 |
| 4.3.1 | Skewed Bridges with No Railings “Case 1” | 60 |
| 4.3.1.1 | FEA Results versus AASHTO | 60 |
| 4.3.1.1.1 | Maximum Longitudinal Bending Moment and Edge Beam Moment..... | 60 |
| 4.3.1.1.2 | Maximum Transverse Moment | 62 |

| | | |
|-----------|--|-----|
| 4.3.1.1.3 | Maximum Live Load Deflection | 63 |
| 4.3.1.2 | FEA Results of Skewed Versus Straight Bridge | 71 |
| 4.3.1.2.1 | Maximum longitudinal Bending Moment and Edge Beam Moment..... | 71 |
| 4.3.1.2.2 | Maximum Transverse Moment | 71 |
| 4.3.1.2.3 | Maximum Live Load Deflection | 72 |
| 4.3.1.3 | Summary..... | 81 |
| 4.3.2 | Skewed Bridges with One Railing “Case 2”..... | 81 |
| 4.3.2.1 | FEA Results versus AASHTO | 81 |
| 4.3.2.1.1 | Maximum Longitudinal Bending Moment and Edge Beam Moment..... | 81 |
| 4.3.2.1.2 | Maximum Transverse Moment | 84 |
| 4.3.2.1.3 | Maximum Live Load Deflection | 85 |
| 4.3.2.2 | FEA Results of Skewed Versus Straight Bridges..... | 92 |
| 4.3.2.2.1 | Maximum Longitudinal Bending Moment and Edge Beam Moment..... | 92 |
| 4.3.2.2.2 | Maximum Transverse Moment | 92 |
| 4.3.2.2.3 | Maximum Live Load Deflection | 93 |
| 4.3.2.3 | Summary..... | 102 |
| 4.3.3 | Skewed Bridges with Two Railings “Case 3” | 102 |
| 4.3.3.1 | FEA Results versus AASHTO | 102 |
| 4.3.3.1.1 | Maximum Longitudinal Bending Moment..... | 102 |
| 4.3.3.1.2 | Maximum Transverse Moment | 104 |
| 4.3.3.1.3 | Maximum Live Load Deflection | 105 |
| 4.3.3.2 | FEA Results of Skewed versus Straight Bridges..... | 112 |
| 4.3.3.2.1 | Maximum Longitudinal Bending Moment..... | 112 |
| 4.3.3.2.2 | Maximum Transverse Moment | 112 |
| 4.3.3.2.3 | Maximum Live Load Deflection | 113 |
| 4.3.3.3 | Summary..... | 122 |
| 4.4 | Summary Results of Maximum Longitudinal Bending Moment for all Skewed Bridges with/without Railings | 123 |
| | | |
| 5. | SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.... | 127 |
| | | |
| 5.1 | Summary | 127 |

| | | |
|---------------------------|--|------------|
| 5.2 | Conclusions | 128 |
| 5.2.1 | Longitudinal Bending Moments | 129 |
| 5.2.2 | Edge Beam Moments | 130 |
| 5.2.3 | Maximum Transverse Moment | 131 |
| 5.2.4 | Maximum Deflections | 131 |
| 5.3 | Recommendations | 132 |
| BIBLIOGRAPHY | | 133 |
| Appendix | | |
| 1. | LONGITUDINAL BENDING MOMENT TABLES | 134 |
| 2. | LONGITUDINAL BENDING MOMENT PLOTS | 199 |

ILLUSTRATIONS

| Figure | Page |
|---|------|
| 2.1. Straight versus Skewed Bridge layout | 6 |
| 2.2. Description of Skewed Bridge | 7 |
| 3.1. Typical Cross Sections for One-lane, Two-Lane, Three-Lane and Four-Lane Bridge Cases with/without Railings | 18 |
| 3.2. AASHTO HS-20 Design Truck (Source: AASHTO Standard Specifications for Highway Bridges, 2002). | 22 |
| 3.3(a). Longitudinal Truck Position in a Typical 36 ft One-Span Bridge for Maximum Positive Bending Moment. | 23 |
| 3.3(b). Assumed Longitudinal Truck Position in a Typical 36 ft One-Span Bridge for Maximum Positive Bending Moment in the Current Study. | 23 |
| 3.4. Typical Cross-Section and Plan of Two-Lane 36ft Span Bridge under Center-Lane Loading Condition..... | 25 |
| 3.5. Typical Cross-Section and Plan of Two-Lane 36ft Span Bridge under Center-Center Loading Condition. | 26 |
| 3.6. Typical Cross-Section and Plan of Two-Lane 36ft Span Bridge under Edge Loading Condition..... | 27 |
| 3.7(a). Edge Truck Centered Longitudinally with Adjacent Truck Placed Side-By-Side..... | 28 |
| 3.7(b). Edge Truck Centered Longitudinally Each in Its Lane. | 29 |
| 3.8. Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with No Railings under Edge Loading E1..... | 31 |
| 3.9. Typical Cross-Section and Plan of a Two-Lane 36 ft Skewed Bridge (30 degrees) with No Railings under Edge Loading E1. | 32 |
| 3.10. Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with One Railing under Edge Loading E1. | 33 |
| 3.11. Typical Cross-Section and Plan of a Two-Lane 36 ft Span Skewed Bridge (30 degrees) with One Railing under Edge Loading E1..... | 34 |

| | | |
|----------|---|----|
| 3.12. | Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with One Railing under Edge Loading | 35 |
| 3.13. | Typical Cross-Section and Plan of a Two-Lane 36 ft Skewed Bridge (30 degrees) with One Railing under Edge Loading E2..... | 36 |
| 3.14. | Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with Two Railings under Edge Loading E1 | 37 |
| 3.15. | Typical Cross-Section and Plan of a Two-Lane 36 ft Span Skewed Bridge (30 degrees) with Two Railings under Edge Loading E1..... | 38 |
| 3.16(a). | Finite Element Model for aTwo-Lane, 36ft Span Bridge, Angle of Skewness =30 degrees, Two Railings - Geometry and Loading. | 41 |
| 3.16(b). | Finite Element Model for aTwo-Lane, 36ft Span Bridge, Angle of Skewness =30 degrees, Two Railings - Deformed Shape. | 42 |
| 3.16(c). | Finite Element Model for aTwo-Lane, 36ft Span Bridge, Angle of Skewness =30 degrees, Two Railings - Longitudinal Bending Moment Contour Plots..... | 43 |
| 4.1. | Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, No Railings with Edge Loading E1. | 56 |
| 4.2. | Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E1 | 57 |
| 4.3. | Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E2 | 58 |
| 4.4. | Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1 | 59 |
| 4.5. | FEA Maximum Longitudinal Bending Moment – Ratio $M0/\alpha\alpha / M0/00$.. | 77 |
| 4.6. | FEA Edge Beam Moment – Ratio $M0/\alpha\alpha / M0/00$ | 78 |
| 4.7. | FEA Maximum Transverse Moment – Ratio $M0/\alpha\alpha / M0/00$ | 79 |
| 4.8. | FEA Maximum Live Load Deflection – Ratio $\Delta0/\alpha\alpha / \Delta0/00$ | 80 |
| 4.9. | FEA Maximum Longitudinal Bending Moment – Ratio $M1/\alpha\alpha / M1/00$.. | 98 |
| 4.10. | FEA Edge Beam Moment – Ratio $M1/\alpha\alpha / M1/00$ | 99 |

| | | |
|-------|--|-----|
| 4.11. | FEA Maximum Transverse Moment – Ratio $M1/\alpha\alpha / M1/00$ | 100 |
| 4.12. | FEA Maximum Live Load Deflection – Ratio $\Delta1/\alpha\alpha / \Delta1/00$ | 101 |
| 4.13. | FEA Maximum Longitudinal Bending Moment –Ratio $M2/\alpha\alpha / M2/00$. | 118 |
| 4.14. | FEA Edge Beam Moment – Ratio $M2/\alpha\alpha / M2/00$ | 119 |
| 4.15. | FEA Maximum Transverse Moment – Ratio $M2/\alpha\alpha / M2/00$ | 120 |
| 4.16. | FEA Maximum Live Load Deflection – Ratio $\Delta2/\alpha\alpha / \Delta2/00$ | 121 |

TABLES

| Table | Page |
|---|------|
| 3.1. Geometrical Characteristics and Dimensions of Modeled Bridges | 19 |
| 3.2. Longitudinal Truck Position in One-Span Bridges for Maximum Positive Moment at Centerline..... | 24 |
| 3.3. SAP2000 Files Organization and Labeling for all Bridges with No Railings and with E1 Transverse Loading Condition (SET 1)..... | 45 |
| 3.4. SAP2000 Files Organization and Labelling for all Bridges with One Railing and with E1 Transverse Loading Condition (SET 2)..... | 46 |
| 3.5. SAP2000 Files Organization and Labelling for all Bridges with One Railing and with E2 Transverse Loading Condition (SET 3)..... | 47 |
| 3.6. SAP2000 Files Organization and Labelling for all Bridges with Two Railings and with E1 Transverse Loading Condition (SET 4)..... | 48 |
| 4.1. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge Deck Span = 36 ft, Deck Width = 24 ft, No Railings with Edge Loading E1 | 52 |
| 4.2. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E1 | 53 |
| 4.3. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E2 | 54 |
| 4.4. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1 | 55 |
| 4.5. Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment | 65 |
| 4.6. Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment | 66 |
| 4.7. Comparison of FEA Edge Beam Moment with AASHTO Moment | 67 |
| 4.8. Comparison of FEA Edge Beam Moment with LRFD Moment | 68 |

| | | |
|-------|---|-----|
| 4.9. | Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment..... | 69 |
| 4.10. | Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion70 | |
| 4.11. | FEA Maximum Longitudinal Bending Moment – Ratio $M0/\alpha\alpha / M0/00$ | 73 |
| 4.12. | FEA Edge Beam Moment – Ratio $M0/\alpha\alpha / M0/00$ | 74 |
| 4.13. | FEA Maximum Transverse Moment – Ratio $M0/\alpha\alpha / M0/00$ | 75 |
| 4.14. | FEA Maximum Live Load Deflection – Ratio $\Delta0/\alpha\alpha / \Delta0/00$ | 76 |
| 4.15. | Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment | 86 |
| 4.16. | Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment | 87 |
| 4.17. | Comparison of FEA Edge Beam Moment with AASHTO Moment | 88 |
| 4.18. | Comparison of FEA Edge Beam Moment with LRFD Moment | 89 |
| 4.19. | Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment..... | 90 |
| 4.20. | Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion91 | |
| 4.21. | FEA Maximum Longitudinal Bending Moment – Ratio $M1/\alpha\alpha / M1/00$ | 94 |
| 4.22. | FEA Edge Beam Moment – Ratio $M1/\alpha\alpha / M1/00$ | 95 |
| 4.23. | FEA Maximum Transverse Moment – Ratio $M1/\alpha\alpha / M1/00$ | 96 |
| 4.24. | FEA Maximum Live Load Deflection – Ratio $\Delta1/\alpha\alpha / \Delta1/00$ | 97 |
| 4.25. | Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment | 106 |
| 4.26. | Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment | 107 |
| 4.27. | Comparison of FEA Edge Beam Moment with AASHTO Moment | 108 |
| 4.28. | Comparison of FEA Edge Beam Moment with LRFD Moment | 109 |

| | | |
|-------|---|-----|
| 4.29. | Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment..... | 110 |
| 4.30. | Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion | 111 |
| 4.31. | FEA Maximum Longitudinal Bending Moment – Ratio $M2/\alpha\alpha / M2/00...$ | 114 |
| 4.32. | FEA Edge Beam Moment – Ratio $M2/\alpha\alpha / M2/00$ | 115 |
| 4.33. | FEA Maximum Transverse Moment – Ratio $M2/\alpha\alpha / M2/00$ | 116 |
| 4.34. | FEA Maximum Live Load Deflection – Ratio $\Delta2/\alpha\alpha / \Delta2/00$ | 117 |
| 4.35. | FEA Maximum Longitudinal Bending Moment..... | 125 |
| 4.36. | FEA Maximum Longitudinal Bending Moment – Ratio $Mi/\alpha\alpha / M0/00...$ | 126 |

CHAPTER 1

INTRODUCTION

1.1 Background

Since the early 1900s, bridges have been undergoing a steady evolution in design and construction. Bridge engineers have continuously attempted to improve and expand their methods of analysis, design, and construction, as new types of bridges were conceived. Often this was the result of new analysis or construction techniques. Many types of bridges are in use today, ranging from short-span slab bridges to suspension structures. The most common component of all bridges is the bridge superstructure or bridge deck.

Reinforced concrete slab bridges offer economic alternatives for short-span bridges. The main advantage of cast-in-place concrete slab bridges is the ability to provide a smooth finishing surface by field adjustment of the roadway profile during construction. Typically, the design of highway bridges must conform to specifications such as in the American Association of State Highway and Transportation Officials (AASHTO). These include the AASHTO Standard Specifications for Highway Bridges (AASHTO Specs 2002) and the AASHTO Load Resistance Factor Design (AASHTO LRFD 2010). These specifications are based on a thorough understanding of the lateral wheel load distribution on the bridge slab, which is required to develop a realistic design for these highway bridges.

1.2 Design Procedures

The AASHTO design procedures were originally developed in the 1940s, based on the research work of Westergaard (1926, 1930), Newmark (1938), and Jensen (1938, 1939) on moments and stress distribution in reinforced concrete slabs. The analysis, which was based on the classic plate theory, assumed the slabs to be homogeneous and perfectly elastic material. Results for various loading and edge conditions were summarized in tables and charts, developing calculations of various coefficients.

1.3 Research Objectives

Skewed bridges are often encountered in highway design when the geometry of an overpass cannot accommodate straight bridges that are perpendicular to the highway they cross. Skewed bridges, therefore, form an angle (non-perpendicular) to the axis of the highway while their supporting piers are still aligned with it. Railings acting integrally with the bridge deck have the effect of stiffening and attracting load to the slab edge and therefore altering the lateral wheel load distribution on highway bridges.

In this research, the finite-element method is used to investigate the influence of integral railings on wheel load distribution as well as on the load-carrying capacity of skewed concrete slab bridges. Typical one-span, simply supported, multilane (one to four lanes), skewed reinforced concrete slab bridges are considered. A parametric study will be conducted with a variation of span lengths, slab widths and slab depths. Various skew angles and different configurations of railings on either or both edges of the slab are considered. The case of straight bridges with no railings will serve as reference bridges. AASHTO design trucks (HS20) are assumed, longitudinally and transversally, in order to produce maximum bending moments.

The wheel load distribution on the bridge slab at the critical section for the reference and railing cases are calculated and compared. The results are also assessed with the AASHTO standard specifications (2002) and AASHTO LRFD design specifications (2010) procedures. Recommendations related to the interpretation of the effect of railings on skewed bridges will be proposed to bridge engineers.

1.4 Scope and Methodology of Proposed Research

The current research will present the finite element results of a parametric study to accurately evaluate the effect of railings on wheel load distribution in skewed concrete slab highway bridges.

In the finite element method, the bridge is discretized into a convenient number of elements, which are assumed to be interconnected at nodal points; each element has the properties corresponding to the original structure. In the present research, the finite element modeling consists of shells for concrete slab, frames for railings and simple supports for the piers. The finite element program SAP2000 (2012) is selected for the analysis.

The finite element method is used to investigate the effect of span length and slab width on simply supported, one-span, one- to four-lane skewed concrete slab bridges. Four typical span lengths are investigated: 24, 36, 46, and 54 ft. (7.2, 10.8, 13.8, and 16.2 m). Given that the typical lane width is 12 ft. (3.6 m) and that the case of one-lane bridges have an additional 1 ft width of slab on each side, the overall slab widths for bridges are: 14 ft (4.2 m) for one lane, and 24 ft (7.2 m) for two lanes, 36 ft (10.8 m) for three lanes, and 48 ft (14.4 m) for four lanes. Six angles of skewness are considered including 0, 10, 20, 30, 40 and 50 degrees with the zero angle corresponding to the non-skewed or straight bridge.

Design trucks are assumed to be traveling in the same direction. Various positions of the design trucks are assumed, longitudinally and transversally, in order to produce maximum bending moments. The cases of straight bridges without railings are first analyzed and considered as the reference cases. Railings are then placed integrally at either or both of the slab edges for various skewness angles considered. The wheel load distribution on the bridge slab at the critical section for the reference cases and for skewed bridges with railings are calculated and compared. The results are also assessed with the AASHTO standard specifications (2002) and AASHTO LRFD design specifications (2010) procedures.

1.5 Thesis Organization

The thesis is divided into six chapters including this introduction. Chapter 2 is a general description of the research work including a description of skewed reinforced concrete slab bridges, AASHTO Standard Specifications and LRFD design procedures. Chapter 3 includes a description of the bridge cases considered and the finite element models used in the analyses. Chapter 4 discusses the effect of railings on the different bridge models considered with tables showing the different results and assessment with AASHTO design standards. Conclusions and recommendations are presented in Chapter 5.

CHAPTER 2

BACKGROUND AND AASHTO DESIGN PROCEDURES

2.1 Introduction

In this chapter, a definition of skewed concrete bridges and a background section are presented, and, for later comparison between FEA results and conventional methods of bridge design, a summary of AASHTO Standard Specifications (2002) and AASHTO LRFD (2010) design procedures are provided.

2.2 Skewed Concrete Bridges

Skewed bridges are often encountered in highway design when the geometry of the overpass cannot accommodate straight bridges perpendicular to the axis of the highway they cross, as shown in Figure 2.1.

Therefore, skewed bridges by definition form an angle (non-perpendicular) with the axis of the highway they cross. Their piers, on the other hand, are aligned with the axis of the highway. The skew angle in this case denotes the angle between the axis of support (pier) relative to a line normal to the longitudinal axis of the bridge, i.e., a zero degree skew angle denotes a rectangular or straight bridge, as described Figure 2.2.

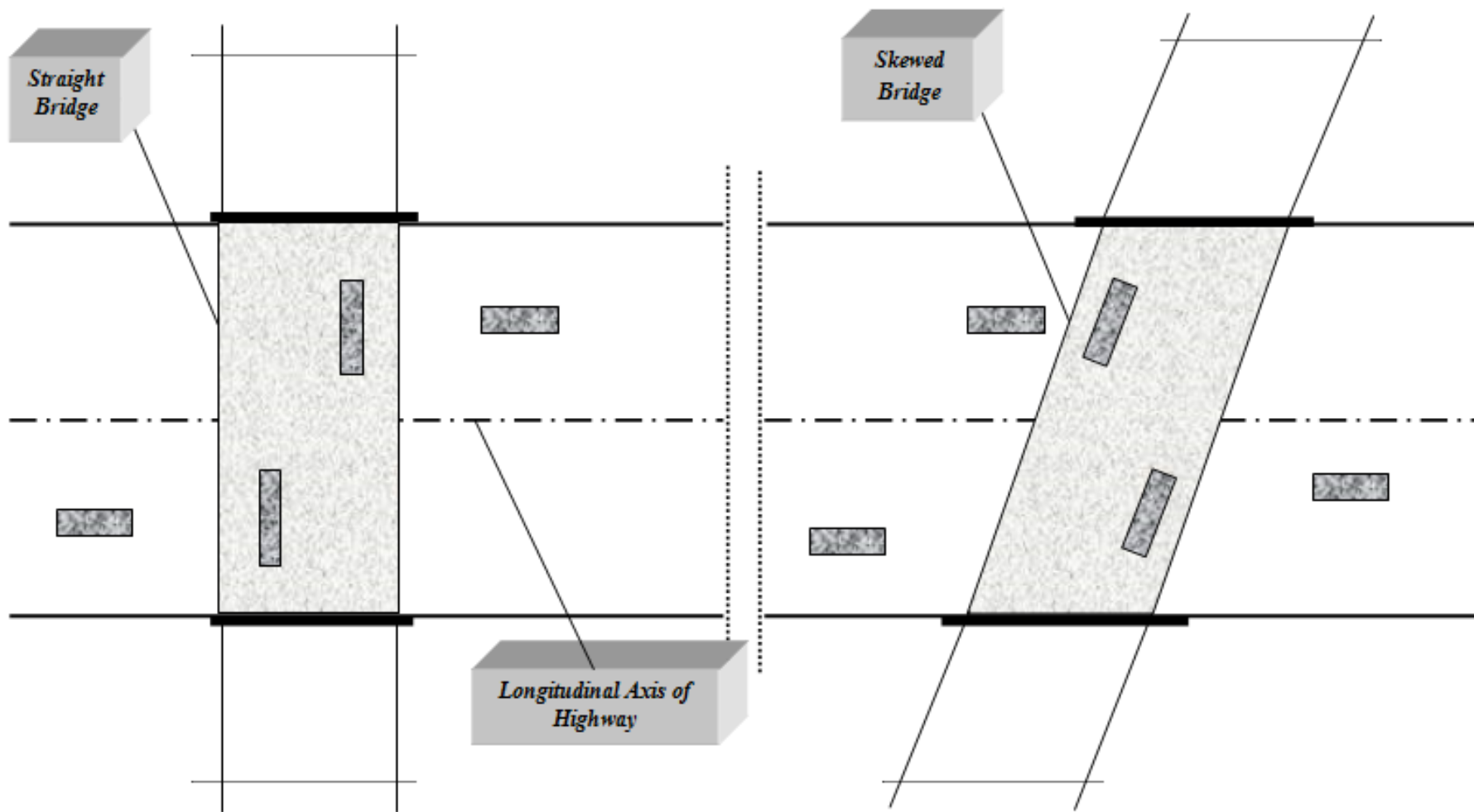


Figure 2.1: Straight versus Skewed Bridge layout

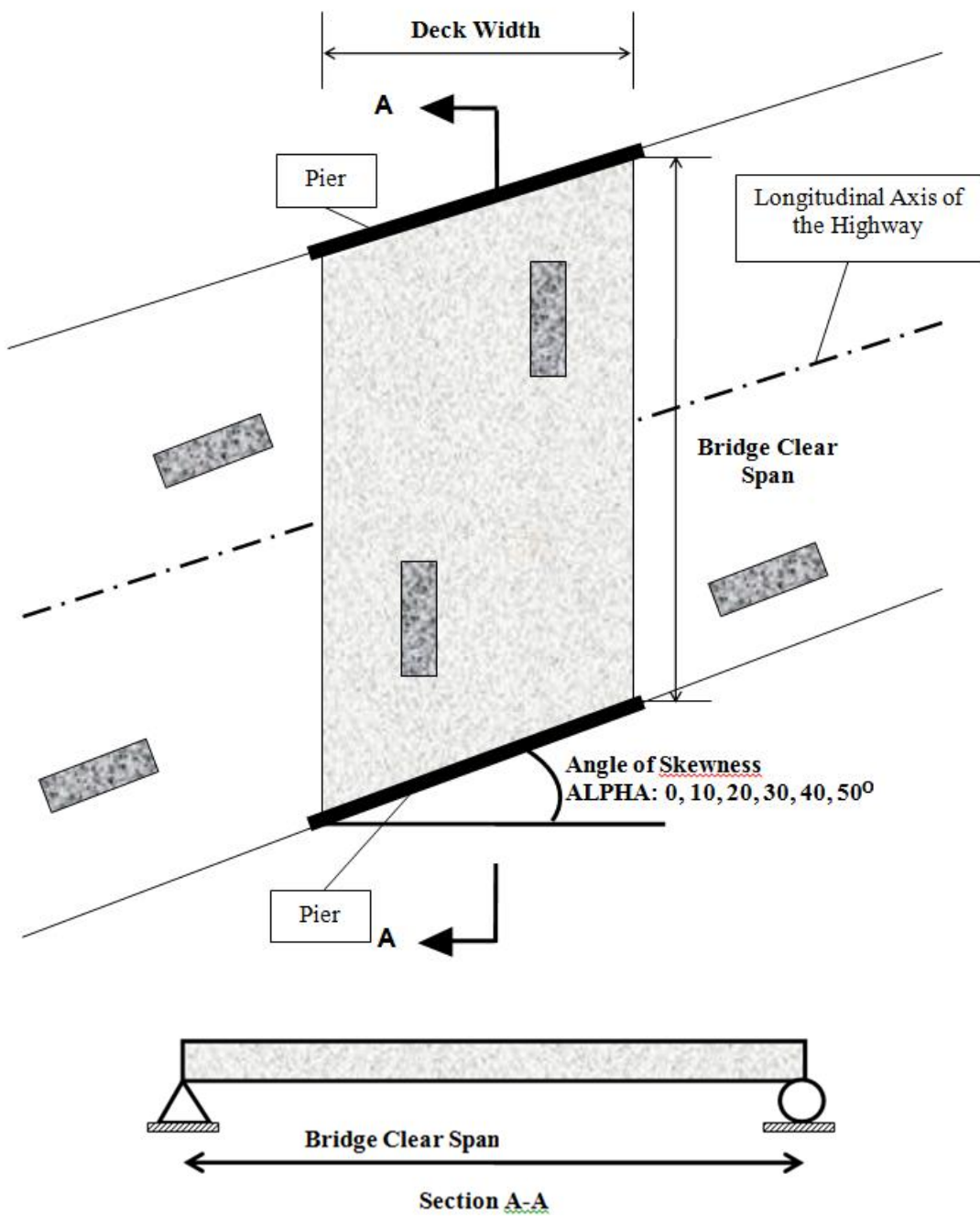


Figure 2.2: Description of Skewed Bridge

2.3 Background Studies

A concrete slab bridge is designed according to the provisions for main reinforcement parallel to traffic. The AASHTO design procedures was originally developed in the 1940s, based on the research work of Westergaard (1926, 1930) and Jensen (1938, 1939) and is presented in AASHTO Standard Specifications for Highway Bridges (2002) (section 3.24 “ Distribution of Loads and Design of Concrete Slabs”).

Shekar et al. (1993) performed extensive experimental and analytical investigation to evaluate the load-carrying capacity of existing reinforced concrete slab bridges. The experimental phase of the investigation consisted of field testing of six slab bridges. Test results were used to develop 3D FEA models to be applied by practicing engineers. The test data compared favorably with FEA results and verified that concrete slab bridges have the strength necessary to resist highway loading. Significant differences between maximum bending moments were also obtained for 2D and 3D analyses because of the participation of nonstructural members such as curbs. Therefore, 3D FEA was recommended in analyzing slab bridges.

Frederick (1997) presented the results of an experimental and finite-element analysis investigation of load distribution in a concrete slab bridge. A typical one-span, simply supported slab bridge with a three-lane width was considered. The design live load bending moments were calculated using AASHTO standard specifications (2003) provisions. The FEA was performed using rectangular plate bending element. A one fifteenth size scale concrete model was constructed and tested in the laboratory. The FEA results correlated well with the test data and were less than AASHTO empirical equation. The results for multiple-lane loading indicated that the slab behaved

essentially as a wide beam with minor variations in the longitudinal bending moment across the width.

Mabsout et al. (2004) presented the results of an extensive investigation of reinforced concrete slab highway bridges using finite-element analysis. Simply supported one-span bridges were considered with various span lengths, numbers of lanes, and loading conditions (Edge and Centered loading) for cases with and without shoulders. A total of 112 case study bridges were analyzed. The maximum longitudinal bending moments, edge beam moments, and maximum deflections were compared with AASHTO design procedures and conclusions were made regarding the results. The effect of applying the AASHTO reduction factors for the FEA moments with three (10%) and four lanes (25%) was investigated.

Menassa et al. (2007) presented a study to investigate the influence of skew angle on reinforced concrete slab bridges. Typical one-span, simply supported, multi-lane (one to four lanes), and reinforced concrete slab bridges were modeled and analyzed using the finite element method and various angles of skewness were considered. The case of straight bridges served as reference bridges. A total of 96 case study bridges were analyzed and subjected to AASHTO HS-20 design trucks positioned close to one edge on each bridge to produce maximum bending in the slab. The finite element analysis (FEA) results for skewed bridges were compared to the reference straight bridges as well as the American Association for state Highway and Transportation Officials (AASHTO) standard specifications and LRFD procedures. The ratio between the FEA longitudinal moments for skewed and straight bridges was almost one for bridges with skew angle less than 20° . This ratio decreased to 0.75 for bridges with skew angles between 30° and 40° , and further decreased to 0.5 skew angle

of the bridge increased to 50°. AASHTO Standard Specifications gave similar results to the FEA maximum longitudinal bending moment when the skew angle is less than or equal to 20°. As the skew angle increases, AASHTO Standard Specifications procedure overestimated the maximum moment by about 20% for 30°, 50% for 40° and 100% for 50° skew angle. The AASHTO LRFD Design Specifications procedure overestimated the maximum longitudinal bending by up to 40% for skew angles less than 30° and reaching 50% for 50° skew angle. This research supported the AASHTO Standard Specifications as well as the LRFD procedure in recommending that bridges with skew angles less than or equal to 20° to be designed as straight (non-skewed) bridges.

A previous study by Mabsout et al. (1997) was conducted to investigate the influence of sidewalks and railings on wheel load distribution in steel girder highway bridges. A typical one-span, two-lane, simply supported, composite steel girder bridges were selected in order to investigate the influence of various parameters such as: span length, girder spacing, sidewalks, and railings. A total of 120 bridges were analyzed using three-dimensional finite-element analysis. AASHTO HS20 design trucks were positioned in both lanes to produce maximum moments. The finite-element analysis results were used in calculating the maximum wheel-load distribution factors (DF), which were compared with the simple AASHTO standard specifications (2003) formula, $DF=S/5.5$, and the formula developed as part of NCHRP project 12-26 (1988), included in AASHTO LRFD (2010). The analysis of the steel girder bridges indicated that the AASHTO LRFD wheel load distribution formula correlated conservatively with the finite-element results and were all less than the typical empirical formula ($S/5.5$). The presence of sidewalks and railings were shown to increase the load-carrying

capacity by as much as 30% if they were included in the strength and evaluation of highway bridges.

A recent and extensive study by Waked et al. (2010) was conducted to investigate the influence of sidewalks and railings on wheel load distribution in one-span concrete slab highway bridges. Typical one-span, simply supported, multi-lane (one to four lanes), reinforced concrete slab bridges were modeled and analyzed using the finite element method and various configurations of sidewalks and/or railings on either or both edges of the slab were considered. The case of one-span bridges with no sidewalks and railings served as reference bridges. AASHTO design trucks (HS20) are assumed, longitudinally and transversally, in order to produce maximum bending moments. The wheel load distribution on the bridge slab at the critical section for the reference and continuous sidewalk/railing cases were calculated and compared. The results were also assessed with the AASHTO Standard Specifications and AASHTO LRFD Design Specifications procedures. The presence of railings was shown to decrease the longitudinal bending moments by about 15 to 25%.

The studies above by Menassa et al. (2007) and Waked et al. (2010) form the basis for the current research which will address the influence of railings on skewed reinforced concrete highway bridges.

2.4 AASHTO Standard Specifications for Highway Bridge

2.4.1 Slab Design

A concrete slab bridge is designed with the provisions for main reinforcement parallel to traffic. AASHTO specifies a distribution width for highway loading or an empirical formula to reduce the two-way bending problem into a beam (one-way) bending problem. Therefore, reinforced concrete slab bridges are typically designed as a

series of beam strips. AASHTO Standard Specifications (2002) suggest three approaches to determine the live load bending moment for HS20 loading. One approach, which will be adopted for the assessment in this study, is described below.

Section 3.24.3.2 of AASHTO (2002) provides empirical equations for the longitudinal bending moment M per foot width, for the case of main reinforcement parallel to traffic and is applicable only to simple spans.

$$- M_{\text{AASHTO}} (\text{Kip-ft/ft}) = 0.9S \quad \text{for } S < 50 \text{ ft} \quad (1a)$$

or

$$- M_{\text{AASHTO}} (\text{Kip-ft/ft}) = (1.30S - 20) \quad \text{for } 50 \text{ ft} < S < 100 \text{ ft} \quad (1b)$$

where S =span length in feet.

The above AASHTO specifications suggest that slab bridges with skew angle less than 30 degrees be designed as a typical slab at right angles with no further modifications to the effect of skewness. However, if the skew angle exceeds 30 degrees, AASHTO suggest the use of an alternate superstructure configuration such as a rigorous finite element analysis. The analysis of bridges according to the AASHTO must consider both truck and lane loading, with the design being based on the governing of the two load cases. However for short-span structures, the truck loading governs the design.

Also, AASHTO gives special provisions for transverse reinforcement placed perpendicular to the main steel reinforcement in bridge slabs. The amount of distribution reinforcement is given as a percentage of the main reinforcement equal to $100/(S)^{1/2}$, where S is in feet, and shall not exceed 50%.

2.4.2 *Edge Beam*

According to section 3.24.8, a longitudinal AASHTO edge beam moment of a simple span is provided for slabs having main reinforcement parallel to traffic as:

$$- M_{\text{edge_AASHTO}} \text{ (Kip-ft/ft)} = 0.1 \times P \times S \quad (2)$$

where:

P=16 Kips for the AASHTO HS20 design truck;

S = the span length in feet.

AASHTO does not specify a width for the edge beam. However, some departments of transportation use an edge beam width of 1.5 ft, which leads to:

$$- M_{\text{edge_AASHTO}} \text{ (kip-ft/ft)} = 0.1 \times P \times S / 1.5 \quad (3)$$

2.4.3 *Live Load Deflection*

AASHTO maximum live load deflection D for simple or continuous spans (section 8.9.3.1) shall not exceed:

$$- D \text{ (in)} = \frac{S}{800} \quad \text{where S is the span length of the bridge in inches} \quad (4)$$

2.5 **AASHTO Load Resistance Factor Design (LRFD)**

2.5.1 *Slab Design*

According to AASHTO LRFD (2010) section 3.6.1.2.1, the vehicular live loading on the roadways of bridges shall consist of a combination of design truck HS20 (section 3.6.1.2.2) or tandem (section 3.6.1.2.3) with design lane load (section 3.6.1.2.4) similar to the AASHTO Standard Specifications lane load (AASHTO Specs fig 3.7.6B) and consists of a uniformly distributed load in the longitudinal direction of 0.64 Kip/ft and occupying 10 ft transversally.

AASHTO LRFD section 4.6.2.3 provides an equivalent strip width to design slab bridges similar to the previous bridge specifications. This simplistic approach is to divide the total static moment M_0 by the bridge equivalent width E to achieve a moment per unit width for design. The equivalent width E of longitudinal strips per lane for both shear and moment is determined using the following formulas:

The width for one lane (two lines of wheels) loaded is:

$$- \quad E = 10 + 5(L_1 \times W_1)^{1/2} \text{ in inches} \quad (\text{LRFD Equation 4.6.2.3-1}) \quad (5a)$$

The width for multilane loaded is:

$$- \quad E = 84 + 1.44(L_1 \times W_1)^{1/2} \leq \frac{W}{N_L} \text{ in inches} \quad (\text{LRFD Equation 4.6.2.3-2}) \quad (5b)$$

where:

E = equivalent width in inches;

L_1 = span length in feet taken equal to the lesser of the actual span or (60 ft);

W_1 = modified edge-to-edge width of bridge taken to be equal to the lesser of the actual width or (60 ft) for multi-lane loading, or (30 ft) for single-lane loading;

W = physical edge-to-edge width of bridge;

N_L = number of design lanes.

The live load longitudinal bending moment M is therefore obtained as:

$$- \quad M_{LRFD} \text{ (Kip-ft/ft)} = \frac{M_0}{E}$$

For skewed bridges, AASHTO LRFD 4.6.2.3-3 reduces the longitudinal force effects by a factor r which is a function of the skew angle

$$- \quad r = 1.05 - 0.25 \tan \theta \quad (6)$$

where θ is the skew angle in degrees.

2.5.2 Edge Beam

AASHTO LRFD edge beam moment (article 4.6.2.1.4b) shall be assumed to support one line of wheel load and a tributary portion of the design lane load. Where the effective width is the sum of the distance between the edge of the deck and the inside face of the barrier (assumed equal to 1 ft), plus 1 ft, plus one quarter of the strip width specified above, but shall not exceed either one-half the full strip width or 6 ft.

2.5.3 Live Load Deflection

AASHTO LRFD maximum deflection D for simple or continuous spans (article 2.5.2.6.2) shall not exceed:

- D (in) = $\frac{S}{800}$ where S is the span length of the bridge in inches (7)

CHAPTER 3

BRIDGE CASES DESCRIPTION, MODELING AND ANALYSIS

3.1 Introduction

This chapter presents the parametric study carried out on the analysis of reinforced concrete slab bridges. The various geometric and physical characteristics of the bridges as well as the different railings configurations and loading patterns are presented. The chapter also outlines the three-dimensional (3D) finite element modeling technique adopted and summarizes all the bridge cases considered.

3.2 Bridge Cases Description

3.2.1 *Geometry and Dimensions*

A total number of three hundred eighty four geometrically distinct simply supported one-span reinforced concrete slab bridges cases are considered in the study, whereby the following geometrical properties are varied:

- Span length
- Number of lanes
- Angle of skewness
- Transverse truck loading
- Presence of railings

The four span lengths considered, with the corresponding slab thicknesses chosen to control deflection, are as follows:

- Span length of 24 ft with slab thickness of 18 inches

- Span length of 36 ft with slab thickness of 21 inches
- Span length of 46 ft with slab thickness of 24 inches
- Span length of 54 ft with slab thickness of 27 inches

A typical lane is considered to have a fixed width of 12 ft. Cases of one-lane bridges have an additional 1 ft width of slab on each side. For the number of lanes considered, from one to four, the corresponding slab widths are as follows:

- 14 ft for one-lane bridges ($1+1 \times 12+1= 14$ ft)
- 24 ft for two-lane bridges ($2 \times 12 = 24$ ft)
- 36 ft for three-lane bridges ($3 \times 12 = 36$ ft)
- 48 ft for four-lane bridges ($4 \times 12 = 48$ ft)

Another parameter of this study is the angle of skewness, which was defined in Chapter 2 as the angle between the axis of the support (pier) and a line normal to the longitudinal axis of the bridge (Figure 2.2). Six angles of skewness are considered including 0, 10, 20, 30, 40, and 50 degrees with the zero angle corresponding to the non-skewed or straight reference bridge.

When present, railings are 8in wide and 30 in deep above slab. These railings may be on either or both edges of the bridge.

Figure 3.1 illustrates typical cross-sections for one-lane, two-lane, three-lane and four-lane bridge cases with/without railings.

Table 3.1 summarizes the geometrical characteristics and dimensions of all the bridge cases analyzed.

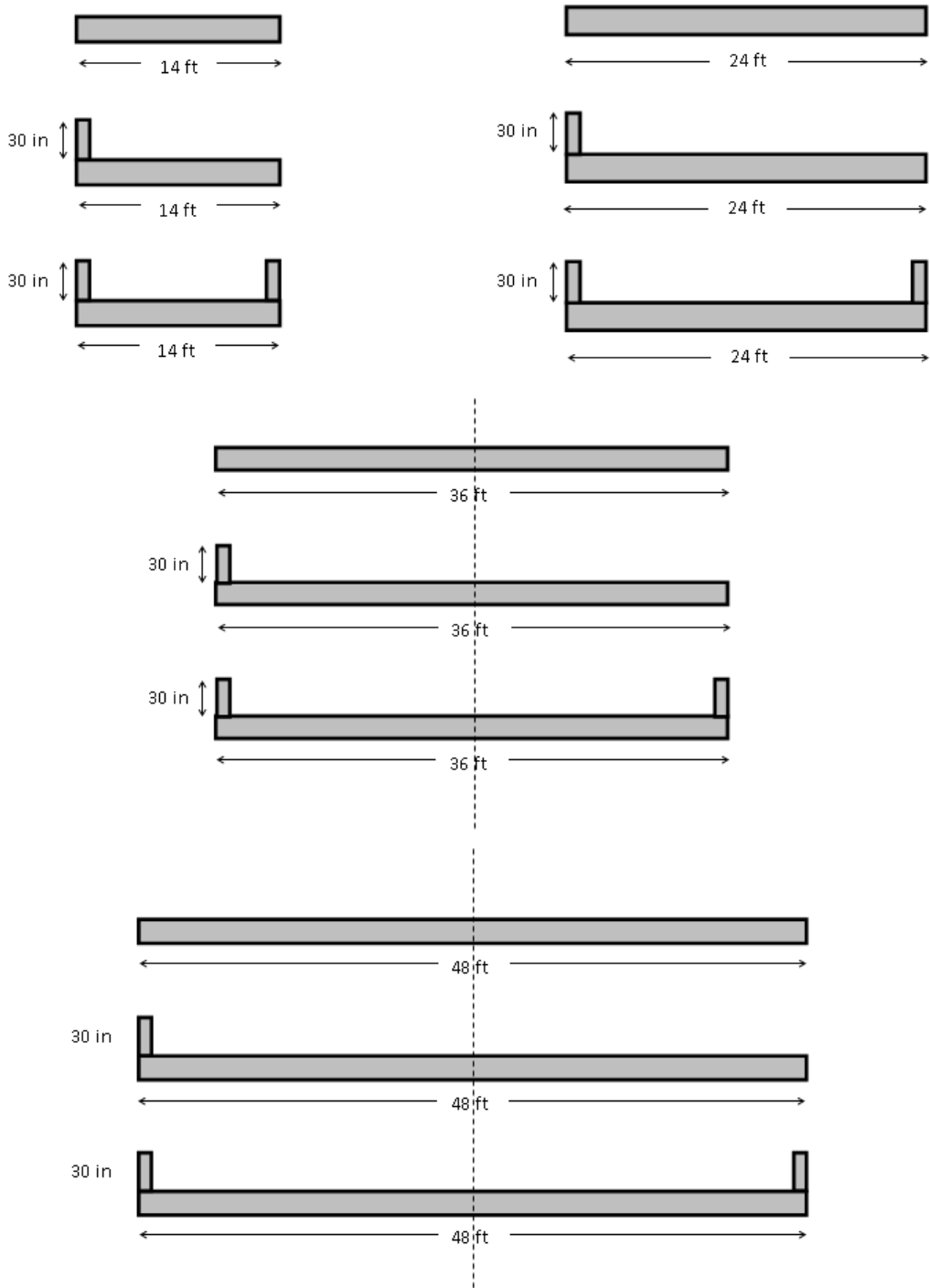


Figure 3.1: Typical Cross Sections for One-lane, Two-lane, Three-lane and Four-lane Bridge Cases with/without Railings

Table 3.1: Geometrical Characteristics and Dimensions of Modeled Bridges

| No. of Lanes n | Span Length S (ft) | Slab Thickness t (in) | Slab Width B (ft) | Angle of Skewness |
|---------------------|----------------------------|-------------------------------|---------------------------|------------------------------|
| 1 | 24 | 18 | 14 | 0, 10, 30, 40 and 50 degrees |
| | 36 | 21 | | |
| | 46 | 24 | | |
| | 54 | 27 | | |
| 2 | 24 | 18 | 24 | 0, 10, 30, 40 and 50 degrees |
| | 36 | 21 | | |
| | 46 | 24 | | |
| | 54 | 27 | | |
| 3 | 24 | 18 | 36 | 0, 10, 30, 40 and 50 degrees |
| | 36 | 21 | | |
| | 46 | 24 | | |
| | 54 | 27 | | |
| 4 | 24 | 18 | 48 | 0, 10, 30, 40 and 50 degrees |
| | 36 | 21 | | |
| | 46 | 24 | | |
| | 54 | 27 | | |

3.2.2 *Physical Properties*

The material properties of the normal-strength concrete adopted in the study are as follows:

- Compressive Strength: f'_c (28 days) = 4,000 psi
- Modulus of Elasticity: $E_c = 3.60 \times 10^6$ psi
- Poisson's Ratio: $\nu = 0.2$

3.2.3 *AASHTO Design Truck*

The analysis and design of any highway bridge must consider truck and lane loading. However, truck-loading provisions govern for short-span structures when considering AASHTO Standard Specifications (2002). Therefore, the bridges in this study are analyzed for HS20-44 Truck load as given in AASHTO (Figure 3.2). The

maximum weight of this truck is 72 Kips distributed over two rear axles and one front axle as follows:

- 32 Kips for each of the rear axles
- 8 Kips for the front axle

The three axles are equally spaced at 14 ft.

3.2.4 Longitudinal Loading Position of Design Trucks

For the non-skewed bridges, the maximum moment is determined when the midpoint between the center of gravity of the HS-20 truck and the center load (at the middle axle) coincides with the mid-span of the bridge (Refer to Figure 3.3.a). In the study by Jabakhanji (1998) on non-skewed concrete bridges, it is shown that minor deviations in maximum positive moment occur if the truck is positioned with its center load coinciding with the mid span of the bridge (Refer to Figure 3.3.b). It was decided to adopt the same simplification mentioned above for both straight and skewed bridges.

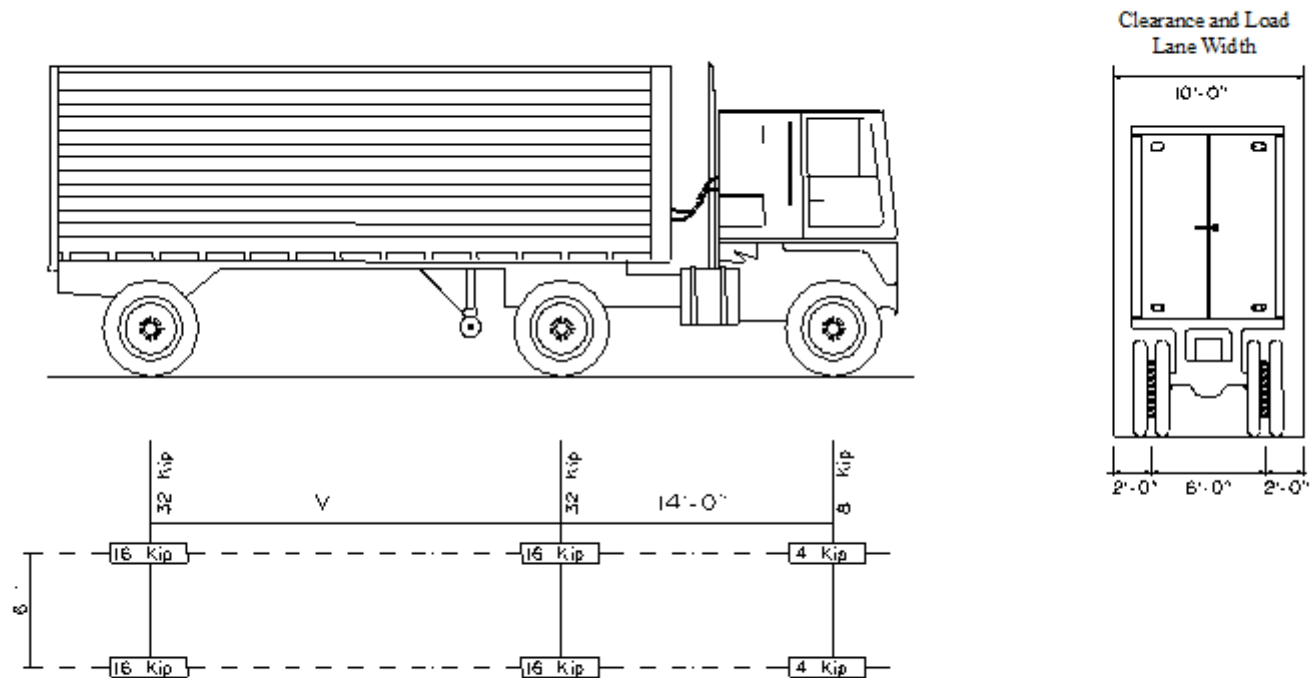
Table 3.2 shows the longitudinal truck position for the various span lengths considered.

3.2.5 Transverse Loading Position of Design Trucks

AASHTO HS20 design trucks are assumed to be traveling in the same direction on the bridge. Transversally, three loading conditions are considered, Center Lane, Center-Center and Edge loading conditions. In the Center-Lane loading condition, the design trucks are placed centered each in its own lane (Refer to Figure 3.4). While in the Center-Center loading condition, the design trucks are placed side-by-side at the middle of the bridge with a distance between adjacent trucks of 4 ft (Refer to Figure 3.5). And in the Edge loading condition the design trucks are placed side-by-side close to one edge (left) of the slab, such that the center of the left wheel of the leftmost truck

is positioned at one foot from the left edge of the slab; the distance between the adjacent trucks is selected to be 4 ft and produce worst loading condition on the bridge (Refer to Figure 3.6). The results of an investigation undertaken at the beginning of this study have shown that the Edge loading condition is always governing and thus only Edge loading conditions are considered for analysis. But because of the One Railing Case, there are two edge loading conditions E1 and E2. E1 where the design truck is placed from the side of the railing in order to get maximum moment in the railing and E2 where the design is placed on the opposite side of the railing to get maximum moment in the slab.

For skewed bridges, it is worth noting that only the left-most truck is placed longitudinally with adjacent trucks placed side by side as shown in Figure 3.7.a, but not centered longitudinally as shown in Figure 3.7.b. According to a previous study done by Menassa, this “longitudinal” condition results in higher moments than for the cases where each truck is centered longitudinally in its lane.



V=Variable: 14 ft to 30 ft inclusive. Spacing to be used is that which produces maximum moment in slab.

Figure 3.2: AASHTO HS-20 Design Truck (Source: AASHTO Standard Specifications for Highway Bridges, 2002).

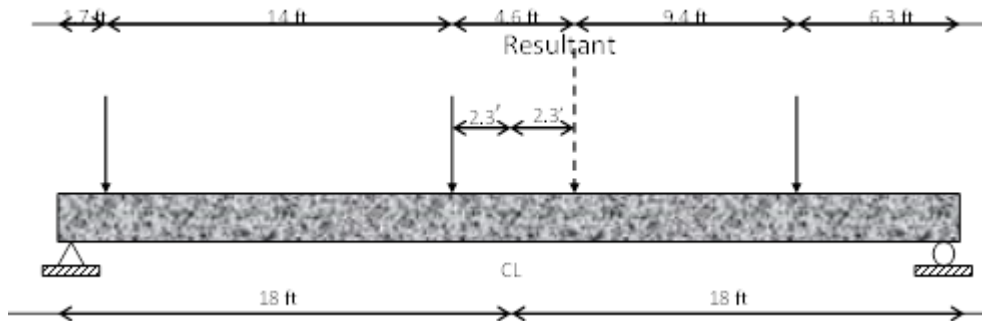


Figure 3.3 (a): Longitudinal Truck Position in a Typical 36 ft One-Span Bridge for Maximum Positive Bending Moment.

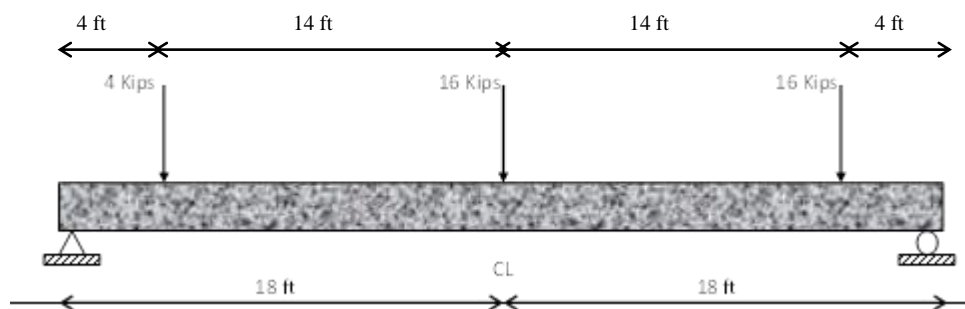
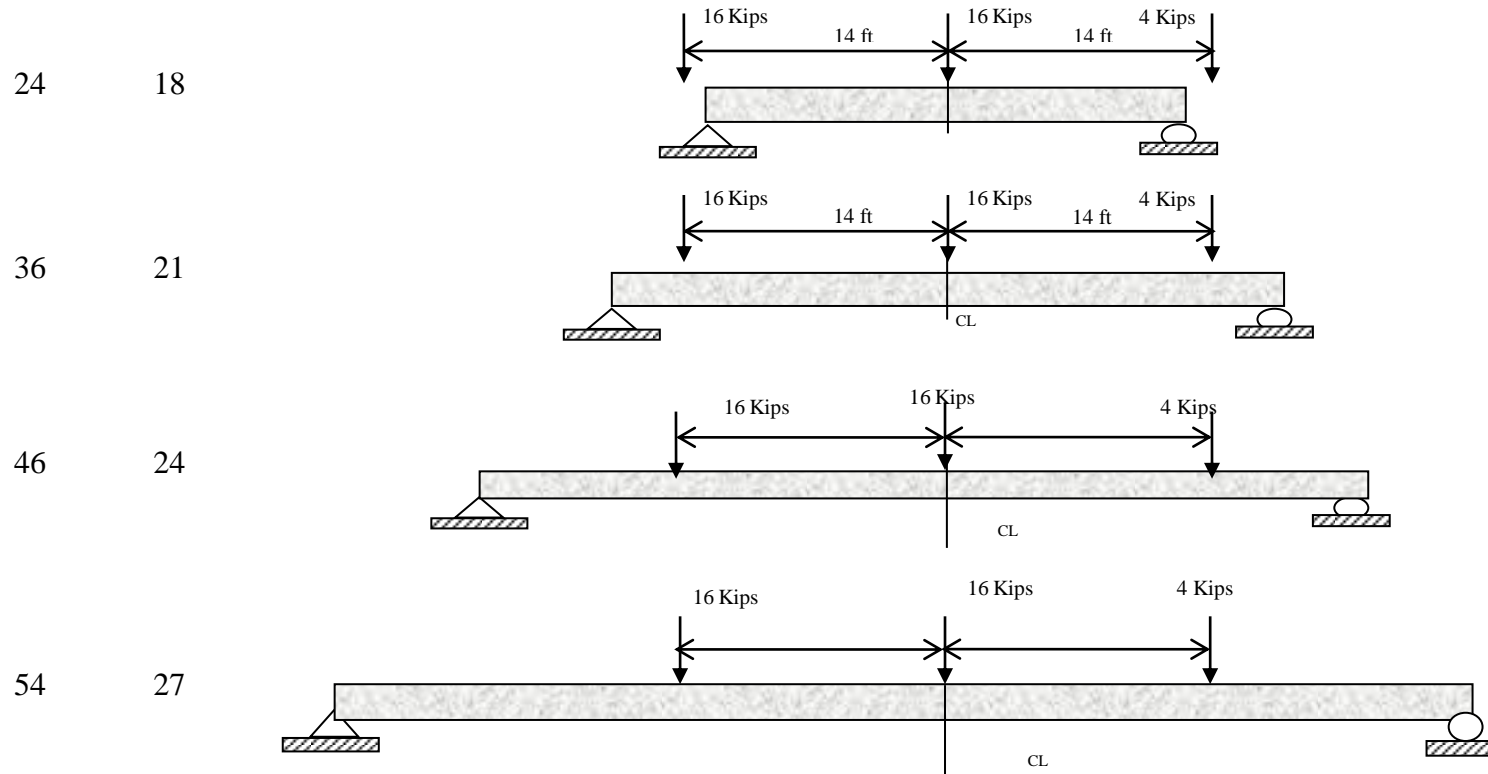


Figure 3.3 (b): Assumed Longitudinal Truck Position in a Typical 36 ft One-Span Bridge for Maximum Positive Bending Moment in the Current Study.

Table 3.2: Longitudinal Truck Position in One-Span Bridges for Maximum Positive Moment at Centerline

**Span
S
(ft)** **Thick
t
(in)**

Truck Loading Position



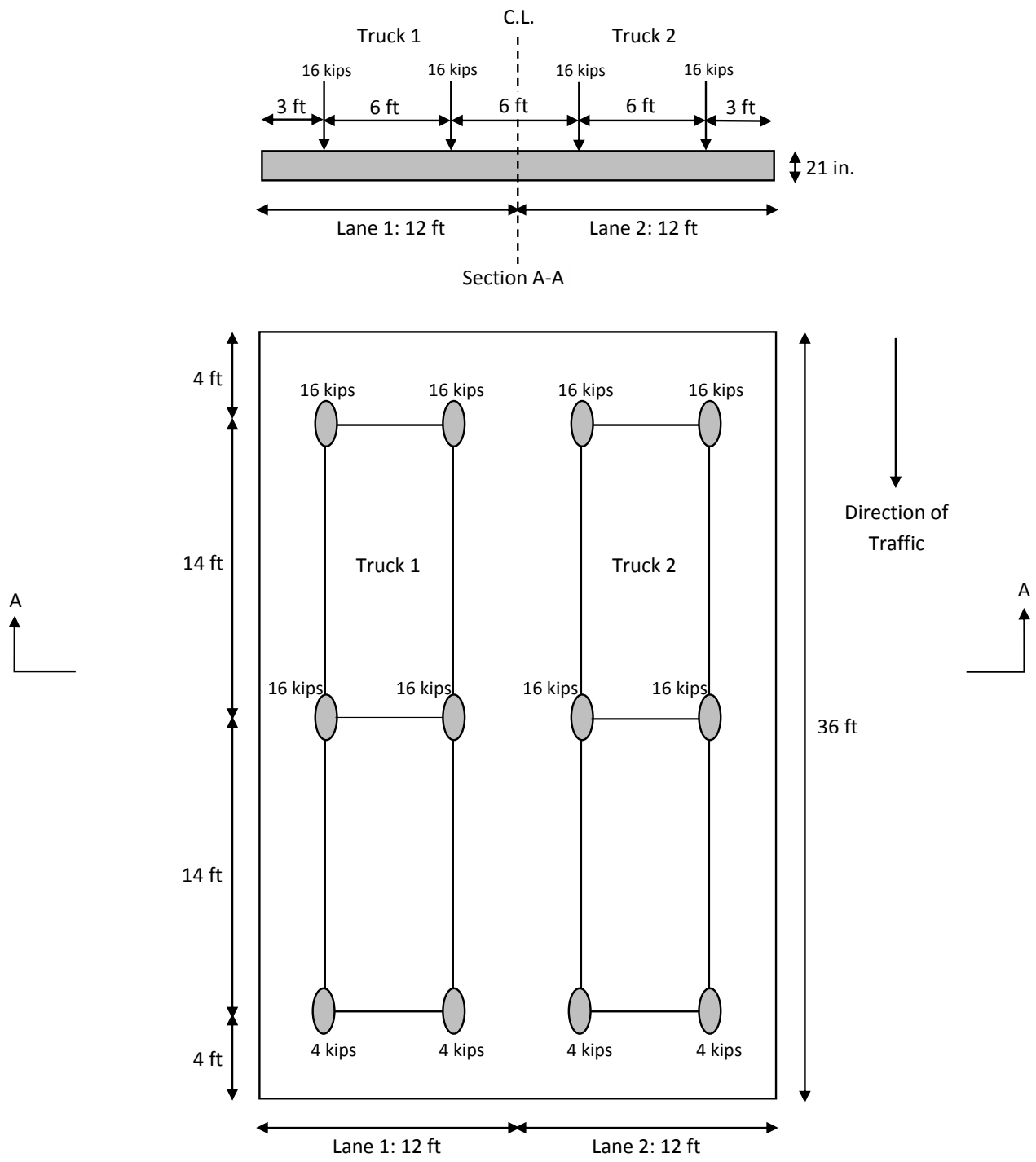


Figure 3.4: Typical Cross-Section and Plan of Two-Lane 36 ft Span Bridge under Center-Lane Loading Condition.

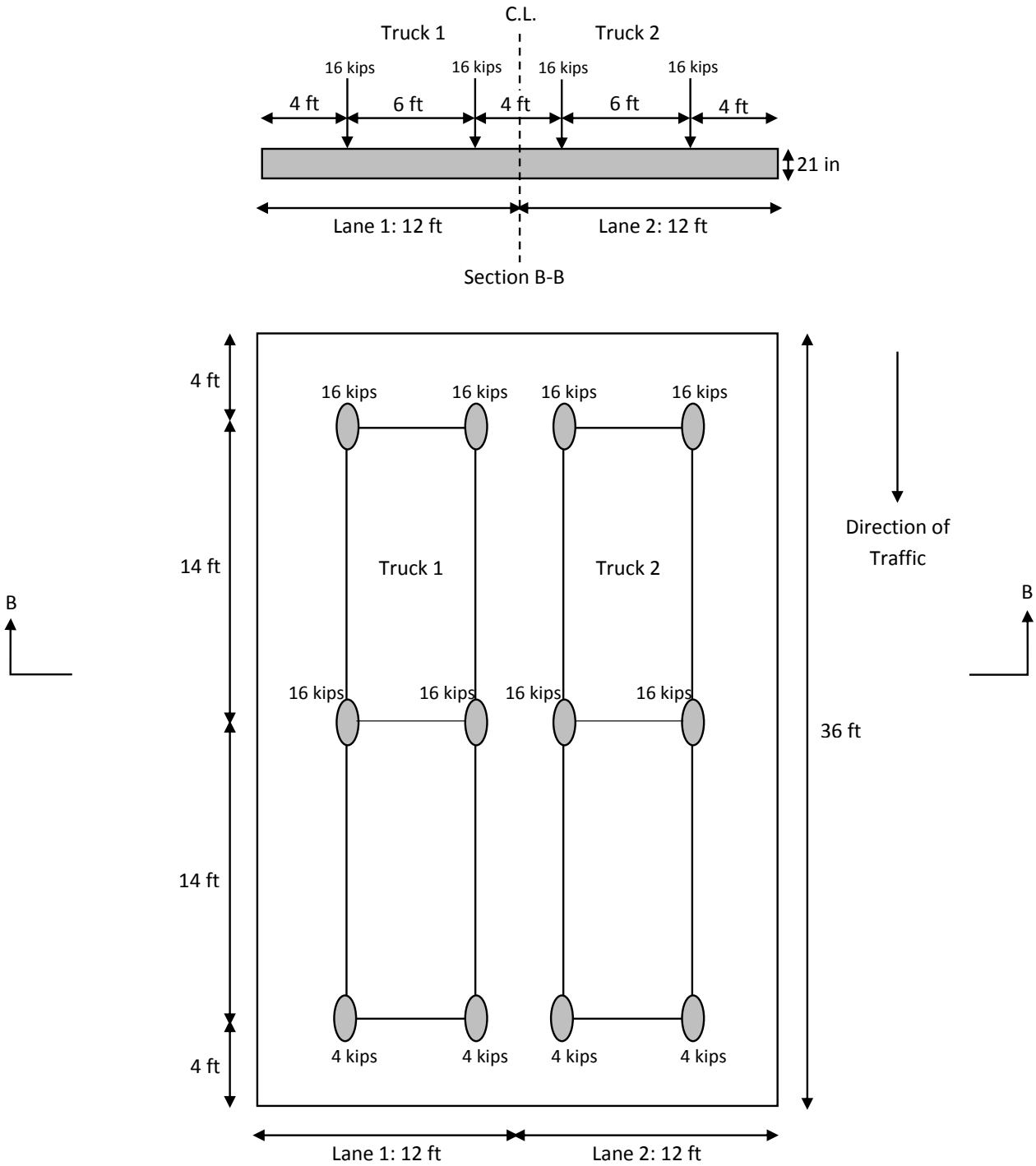


Figure 3.5: Typical Cross-Section and Plan of Two-Lane 36 ft Span Bridge under Center-Center Loading Condition.

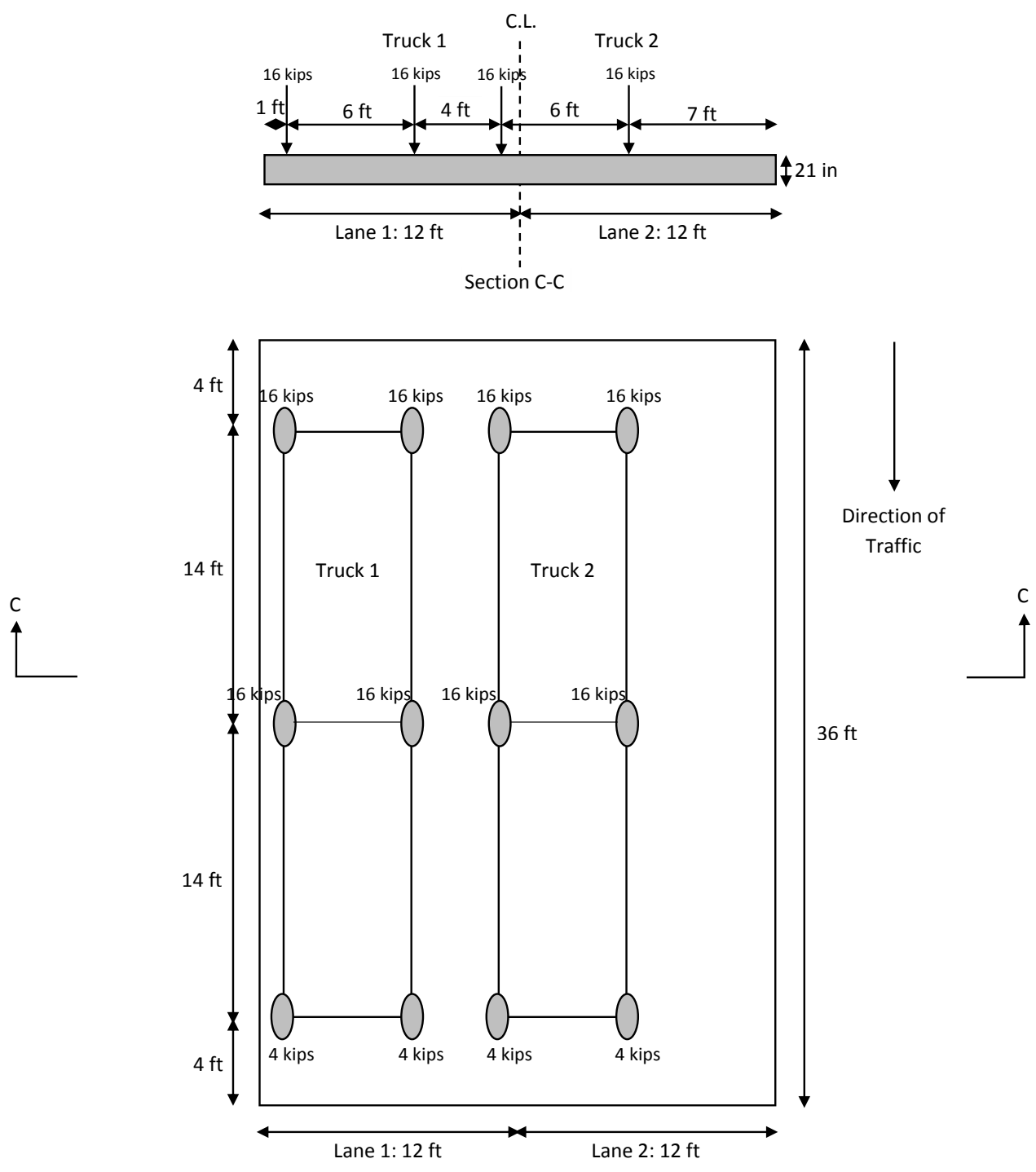


Figure 3.6: Typical Cross-Section and Plan of Two-Lane 36 ft Span Bridge under Edge Loading Condition.

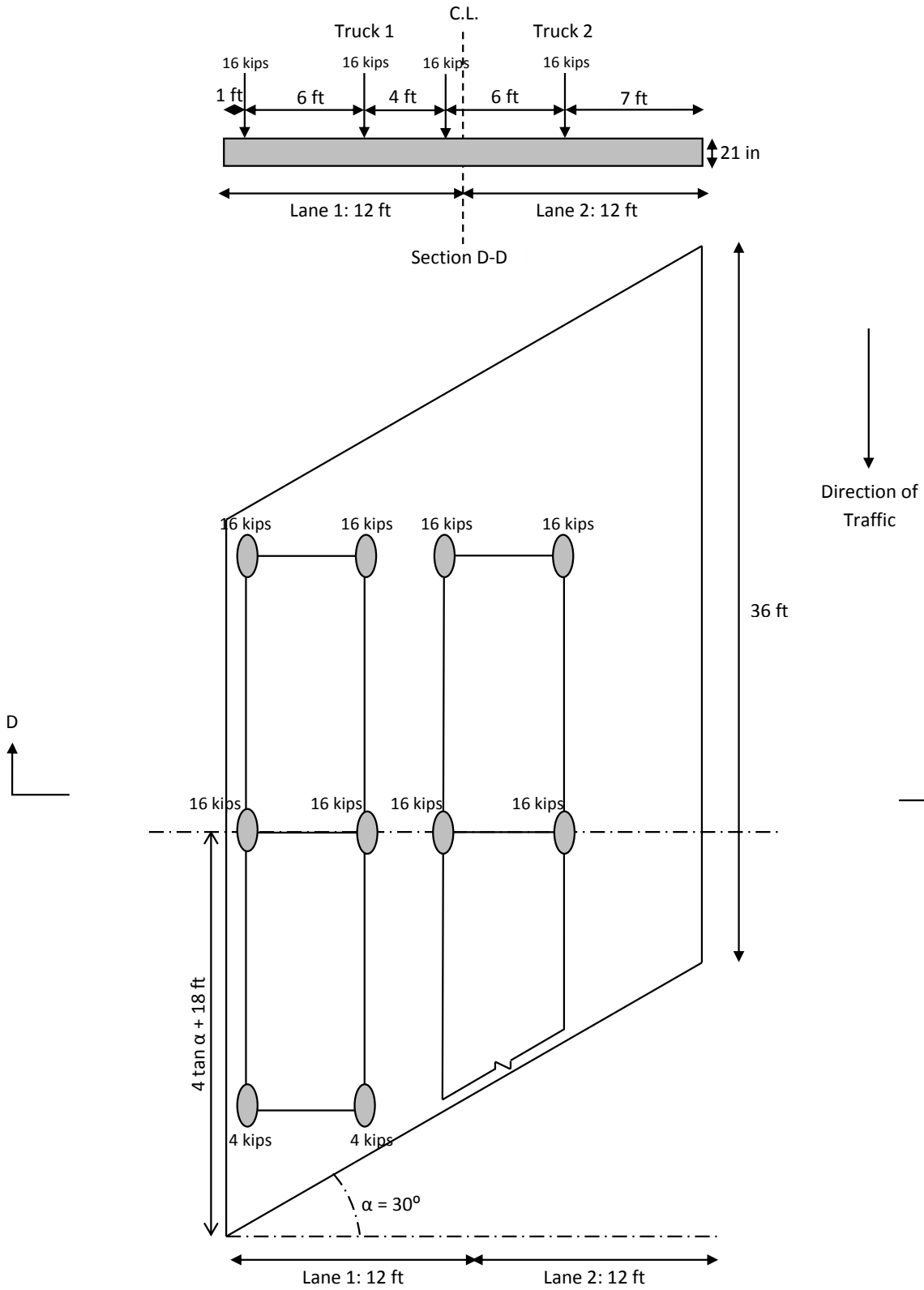


Figure 3.7(a): Edge Truck Centered Longitudinally with Adjacent Truck Placed Side-By-Side

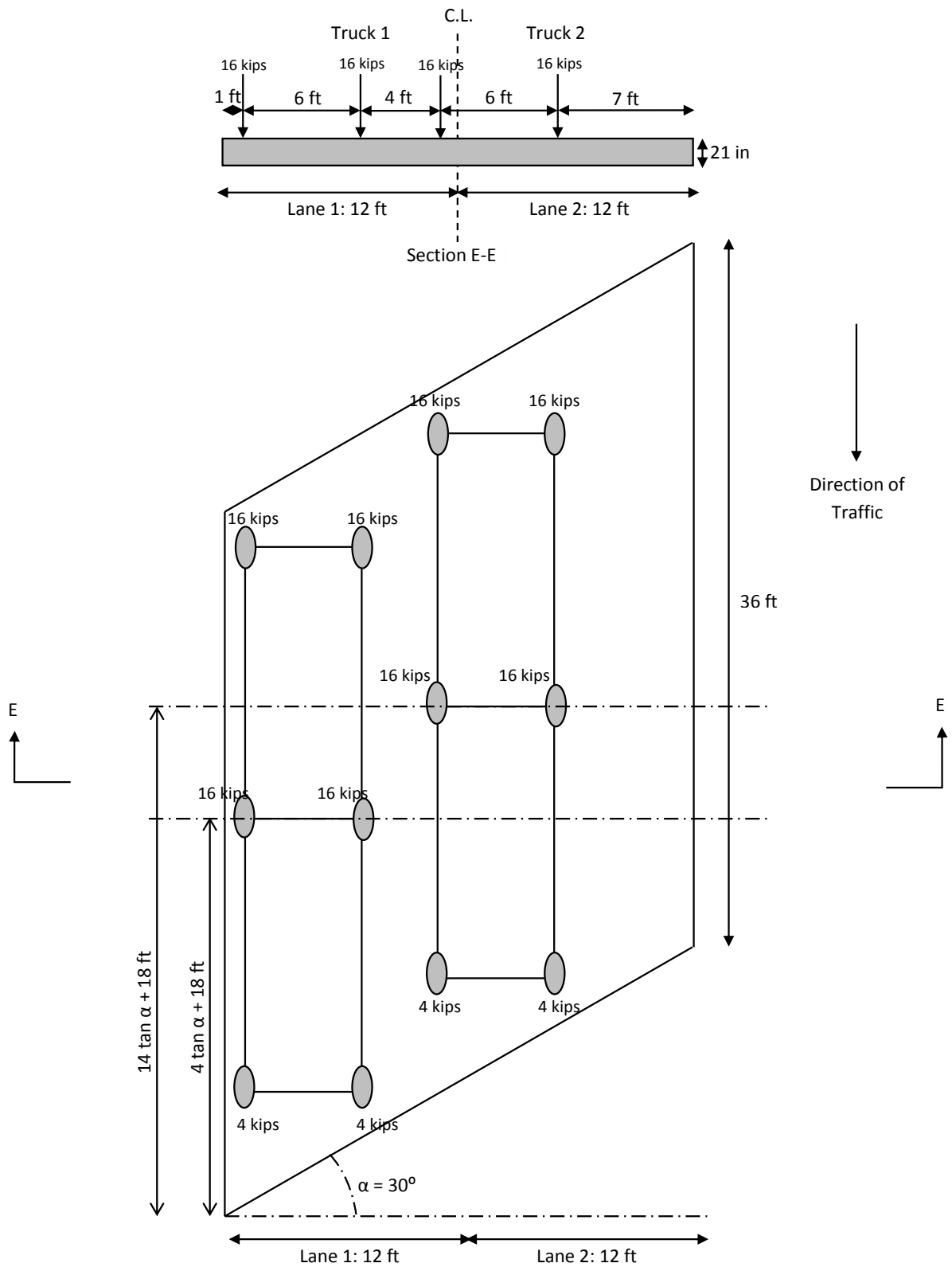


Figure 3.7(b): Edge Truck Centered Longitudinally Each in Its Lane.

3.2.6 Railings Implementation Methodology

Various positions of the design trucks are assumed, longitudinally and transversally, in order to produce maximum bending moments. The cases without railings are first analyzed and considered as the reference cases. Railings are then placed integrally at either or both ends of the slab edges. The wheel load distribution on the bridge slab at the critical section for the reference and railings cases are calculated and compared. The results are also assessed with the AASHTO Standard Specifications (2002) and AASHTO LRFD (2010) procedures. Figures 3.8 to 3.15 show typical cross sections and plans of straight and skewed bridges with different combinations of transverse loading conditions and railings.

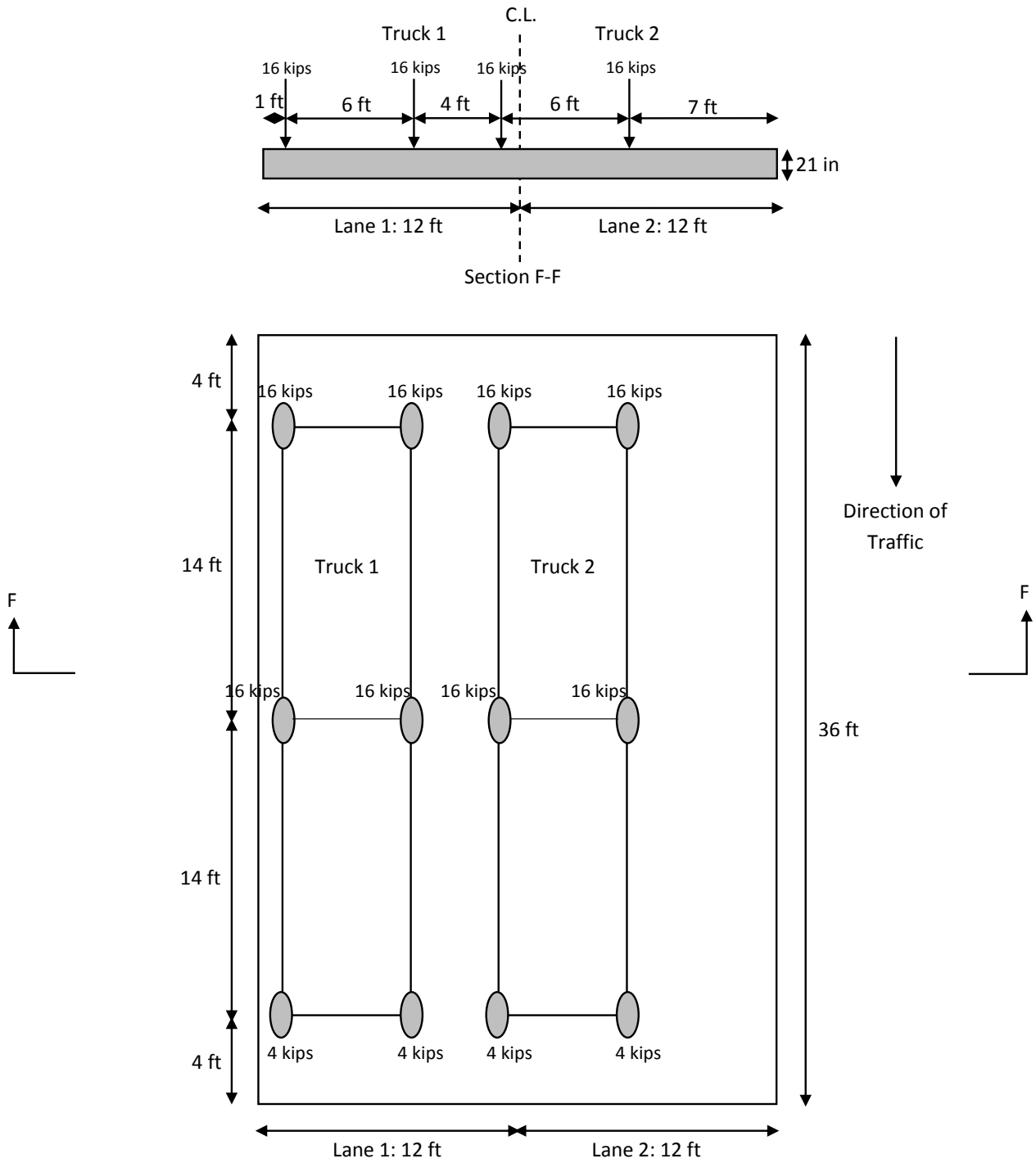


Figure 3.8: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with No Railings under Edge Loading E1.

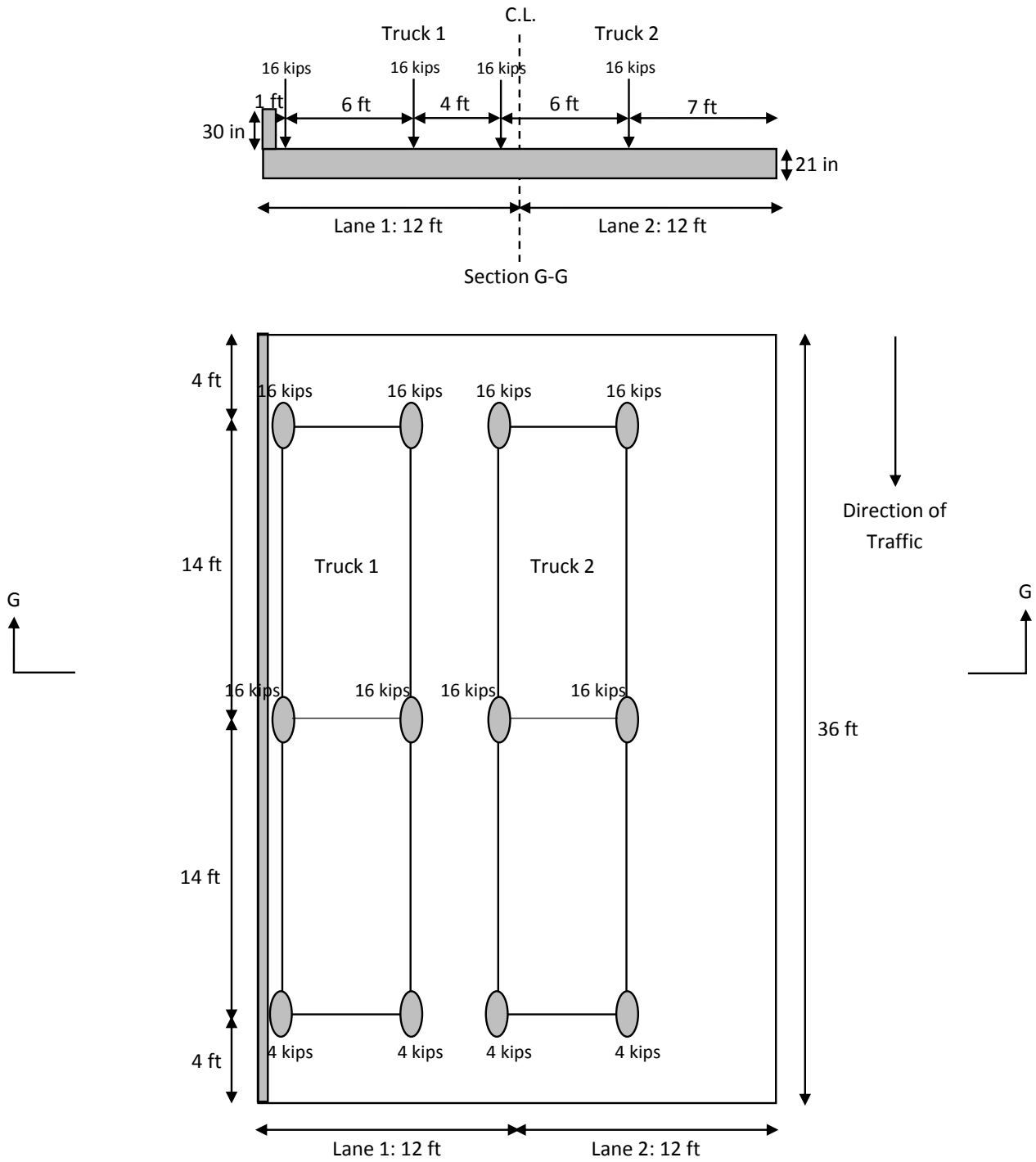


Figure 3.9: Typical Cross-Section and Plan of a Two-Lane 36 ft Skewed Bridge (30 degrees) with No Railings under Edge Loading E1.

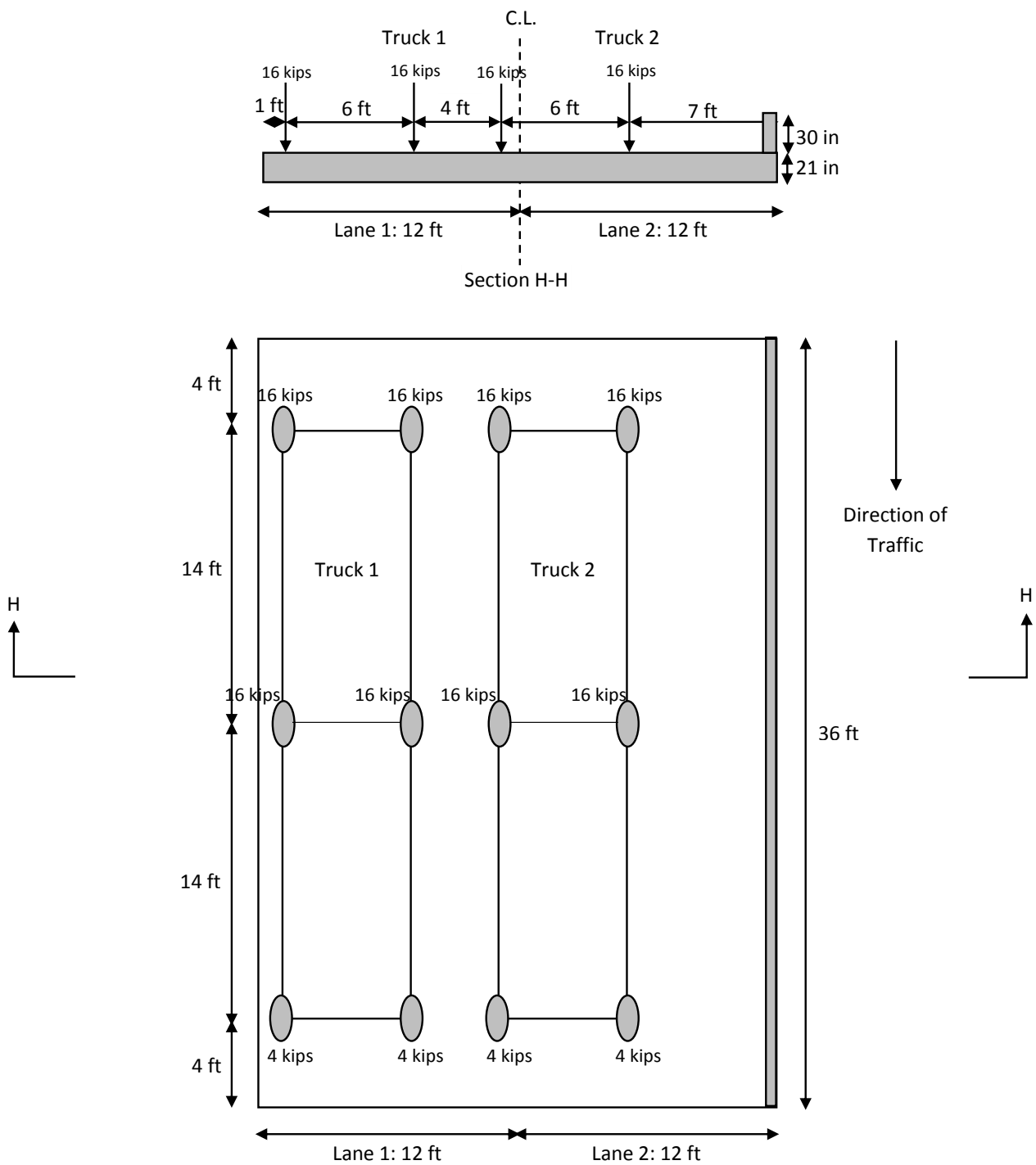


Figure 3.10: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with One Railing under Edge Loading E1.

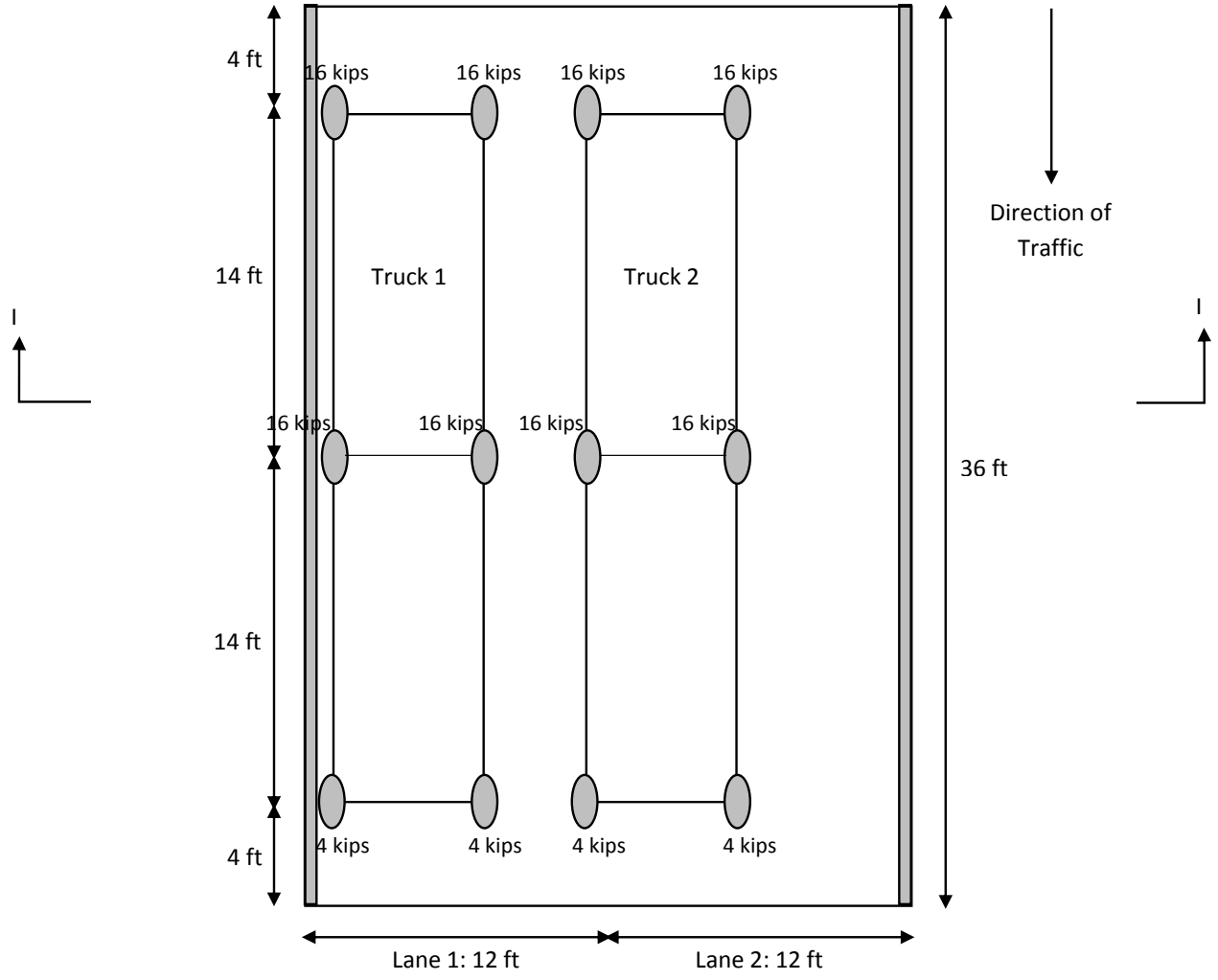
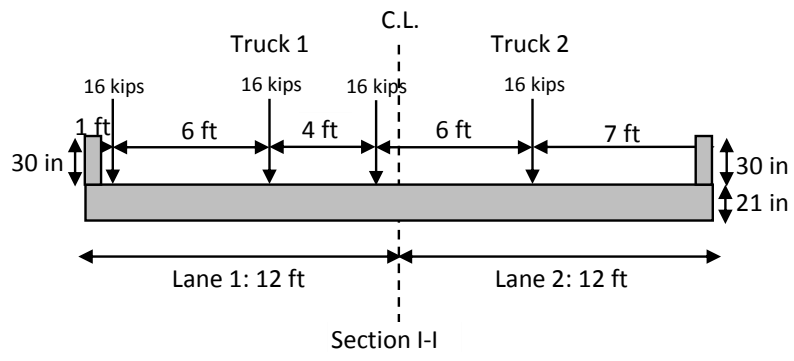


Figure 3.11: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Skewed Bridge (30 degrees) with One Railing under Edge Loading E1.

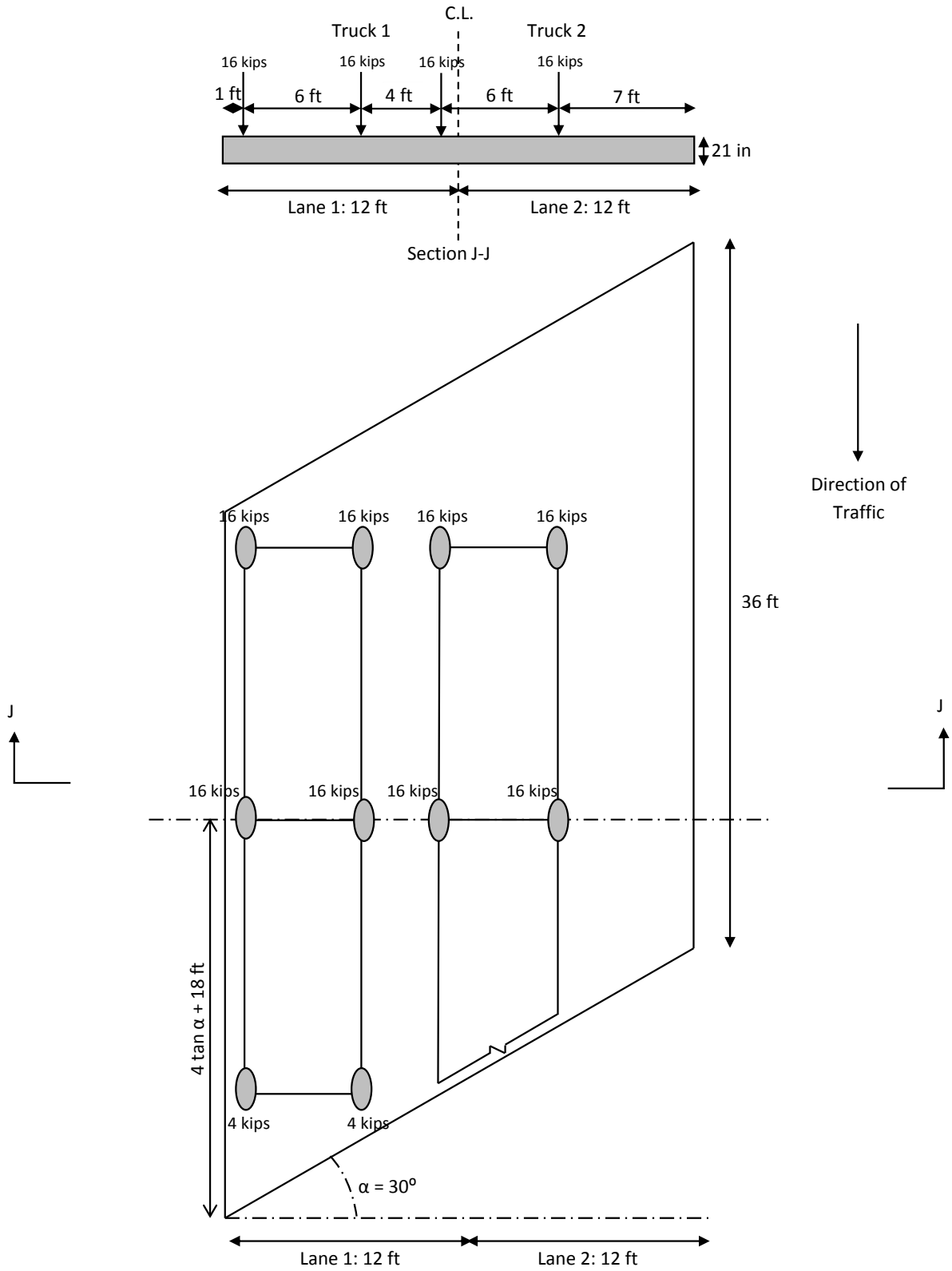


Figure 3.12: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with One Railing under Edge Loading

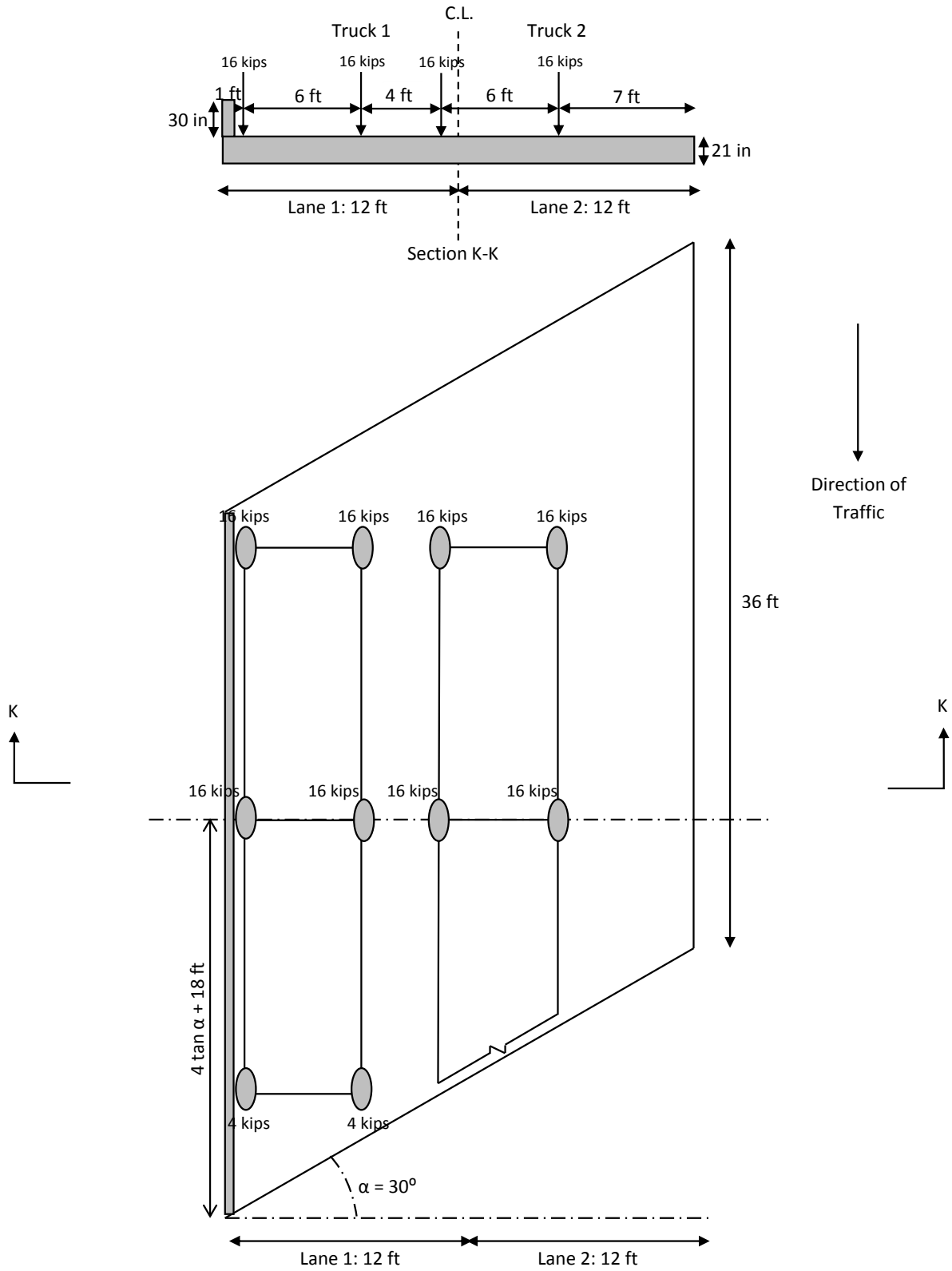


Figure 3.13: Typical Cross-Section and Plan of a Two-Lane 36 ft Skewed Bridge (30 degrees) with One Railing under Edge Loading E2.

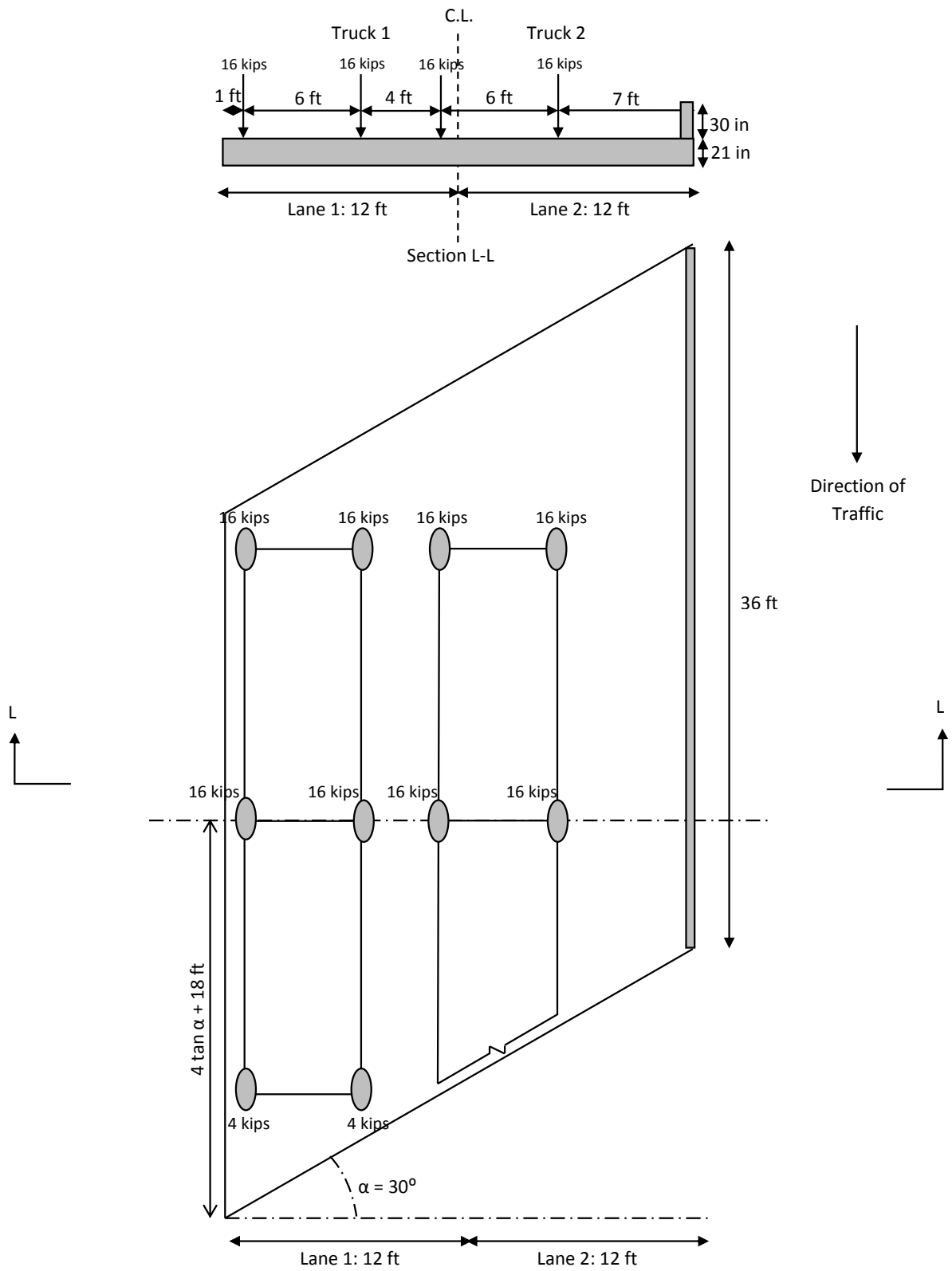


Figure 3.14: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Straight Bridge with Two Railings under Edge Loading E1

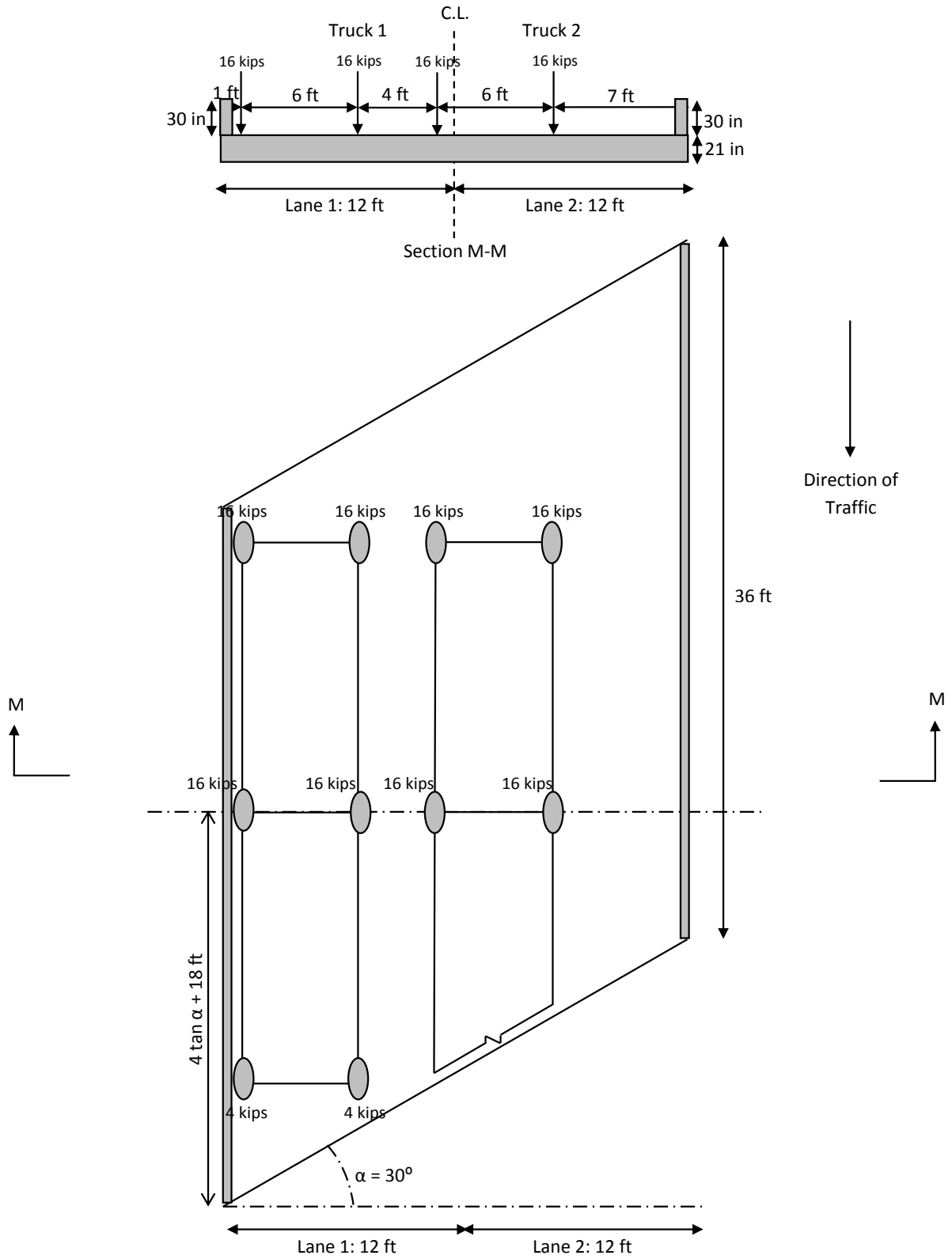


Figure 3.15: Typical Cross-Section and Plan of a Two-Lane 36 ft Span Skewed Bridge (30 degrees) with Two Railings under Edge Loading E1.

3.3 Finite Element Modeling and Analysis

The finite element method is used to investigate the effect of span length and slab width on simply supported one to four lanes skewed concrete slab bridges. Using SAP2000 (2012), the bridge is discretized into a convenient number of square four-node shell elements with six degrees of freedom per node, capable of simulating the membrane and plate-bending behavior. All elements are assumed to be linear elastic and the analysis assumed small deformations and deflections, and shear deformation was neglected. The selection of shell elements dimensions was based on the previous study by Mabsout et al. (2004) on simply supported concrete slab bridges which investigated the appropriate mesh discretization. A comparison was made on 0.5x0.5 ft, 1x1 ft and 2x2 ft elements, and the results obtained were nearly identical for the three cases. Thus, the 1x1 ft element size was adopted as sufficient for the bridge cases modeling. This mesh is also convenient for placing truck loads at 1 ft intervals to investigate maximum moments.

Railings modeling was based on the previous study by Waked et al. (2010) on simply supported concrete bridges which investigated the appropriate railing modeling. According to this study, railings were modeled as eccentric frame elements with moment of inertia equivalent to top shells ($bh^3/3$) which represent the realistic case.

The support condition for the simply supported bridges was modeled as follows:

For the one-span bridges, the left pier is assigned as hinge support and the right one as roller. Concentrated wheel loads of the HS-20 truck are applied at nodes to produce the maximum bending moment.

Longitudinal bending moments and deflections are reported and investigated in this study. SAP2000 generates the finite element models and contour plots of bending moments and deflections.

The geometry, loading, deflection diagram and longitudinal moment contours for a typical 36 ft length, two-lane Bridge having an angle of skewness of 30 degrees with two railings are presented in Figures 3.16.a, 3.16.b and 3.16.c below.

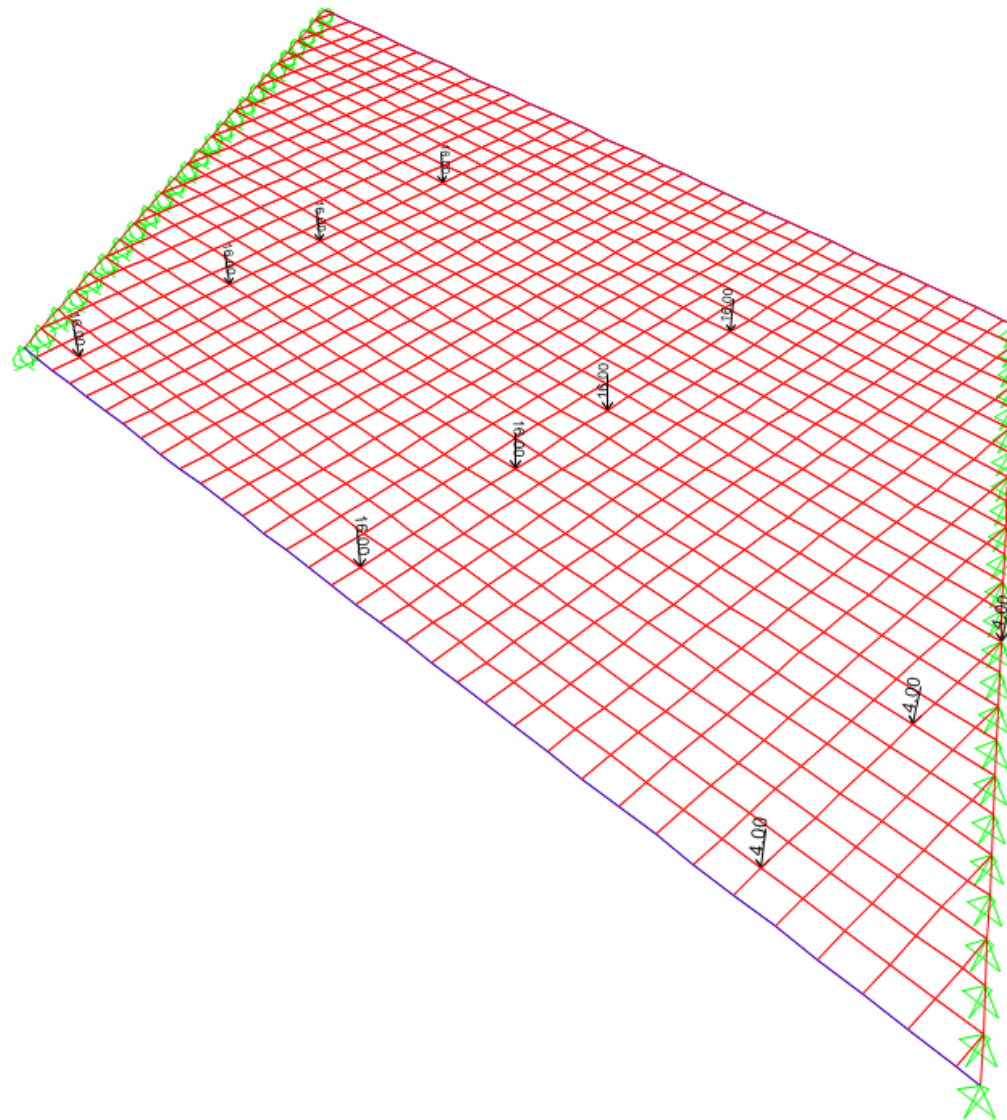


Figure 3.16(a): Finite Element Model for a Two-Lane, 36 ft Span Bridge, Angle of Skewness = 30 degrees, Two Railings - Geometry and Loading.

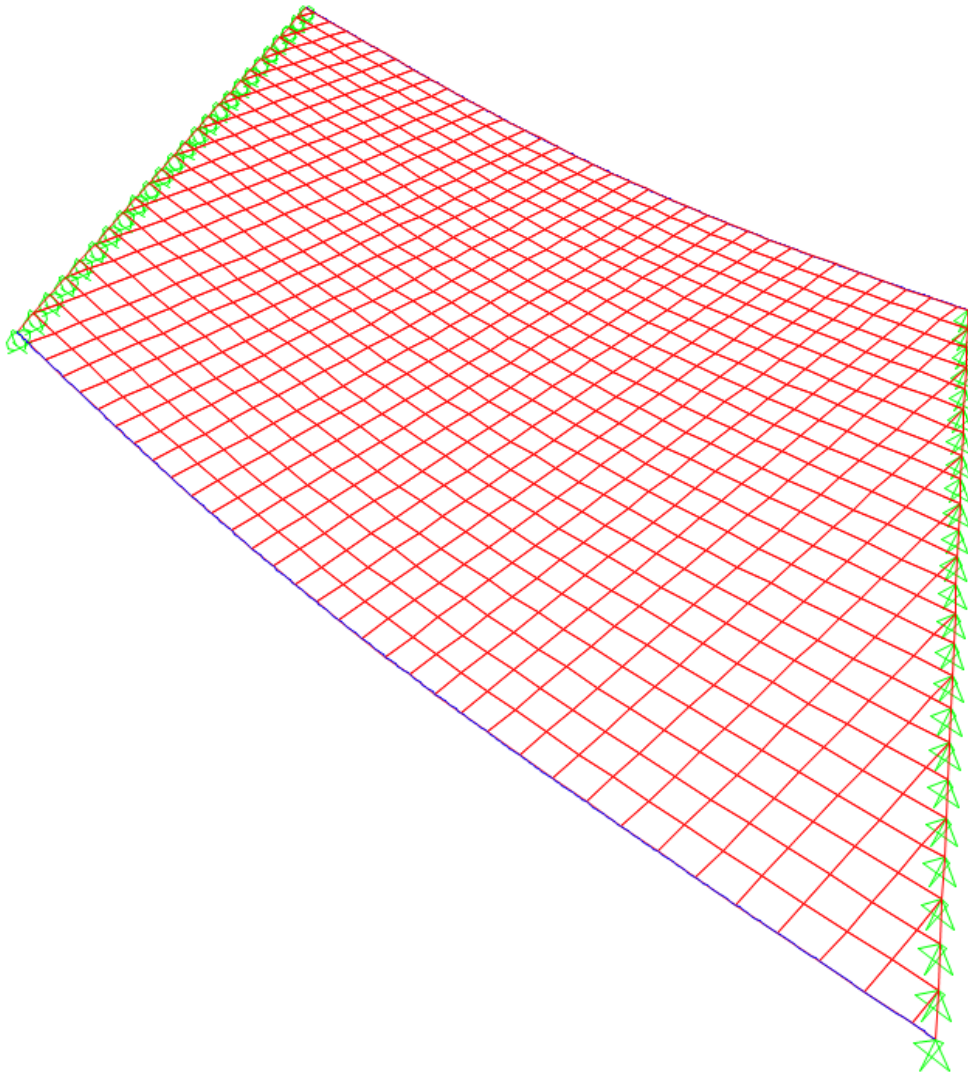


Figure 3.16(b): Finite Element Model for a Two-Lane, 36 ft Span Bridge, Angle of Skewness =30 degrees, Two Railings - Deformed Shape.

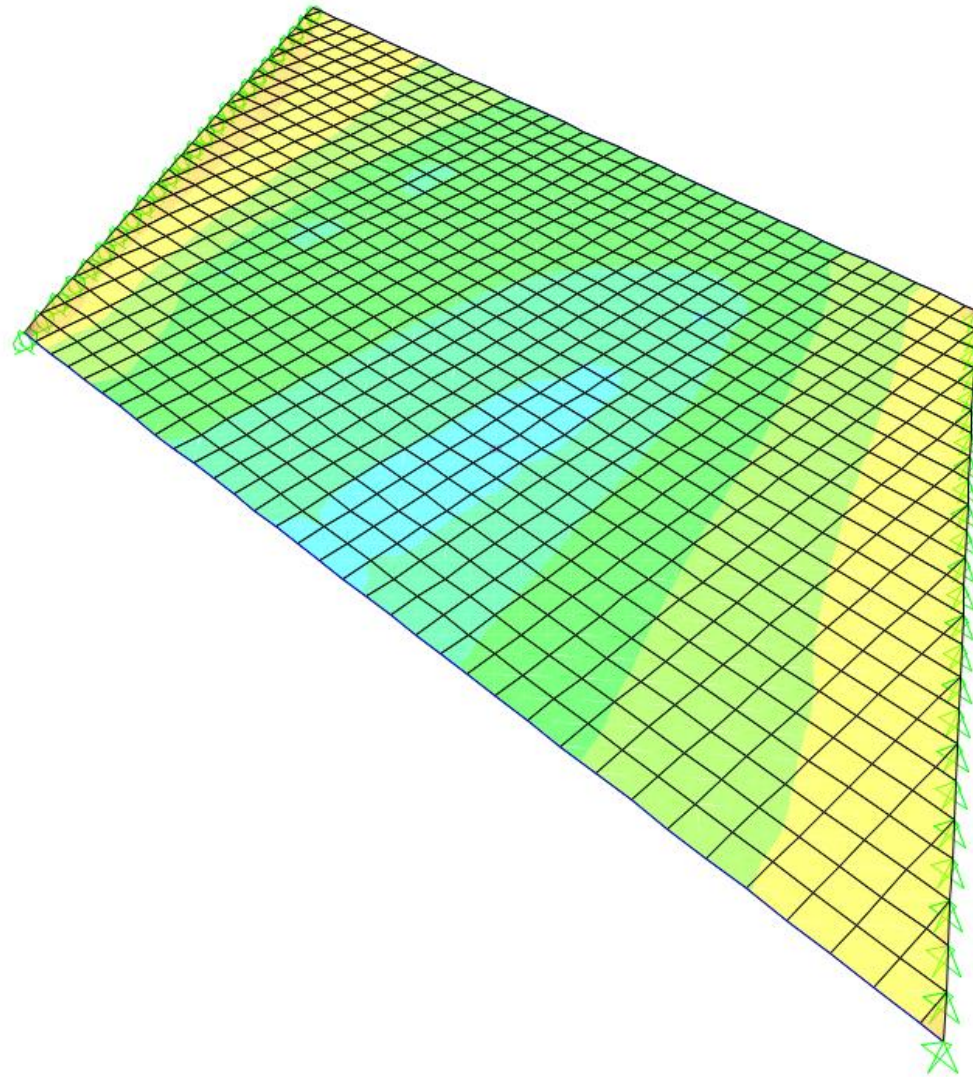


Figure 3.16(c): Finite Element Model for a Two-Lane, 36 ft Span Bridge, Angle of Skewness = 30 degrees, Two Railings - Longitudinal Bending Moment Contour Plots.

3.4 Summary

A total number of 384 bridge cases are analyzed based on the variation of the geometric parameters, loading distribution and railings presence.

Four different span sizes were adopted with a total number of four span widths and with six skew angles.

The case of straight bridges with no railings will serve as reference bridges in order to investigate the influence of railings on skewed concrete slab bridges.

For organizational purposes, the SAP2000 files are conveniently labeled for the various geometric, loading and railings presence configurations. For example, “R0L1S46EK20E1”, where “R0” stands for the absence of railings presence, “L1” for 1 lane, “S46” for the 46 ft span length and “E1” for E1 loading case. Similarly for “R1L1S46EK20E2”, where “R1” stands for the presence of one railing and “E2” for the E2 loading case. The labeling for the 384 bridge cases is tabulated in Tables 3.3, 3.4, 3.5 and 3.6.

Table 3.3: SAP2000 Files Organization and Labeling for all Bridges with No Railings and with E1 Transverse Loading Condition (SET 1)

| No. of Lanes n | Span Length S (ft) | Angle of Skewness | | | | | |
|-------------------|--------------------------|-------------------|--------------|--------------|--------------|--------------|--------------|
| | | 0 | 10 | 20 | 30 | 40 | 50 |
| 1 | 24 | R0L1S24K00E1 | R0L1S24K10E1 | R0L1S24K20E1 | R0L1S24K30E1 | R0L1S24K40E1 | R0L1S24K50E1 |
| | 36 | R0L1S36K00E1 | R0L1S36K10E1 | R0L1S36K20E1 | R0L1S36K30E1 | R0L1S36K40E1 | R0L1S36K50E1 |
| | 46 | R0L1S46K00E1 | R0L1S46K10E1 | R0L1S46K20E1 | R0L1S46K30E1 | R0L1S46K40E1 | R0L1S46K50E1 |
| | 54 | R0L1S54K00E1 | R0L1S54K10E1 | R0L1S54K20E1 | R0L1S54K30E1 | R0L1S54K40E1 | R0L1S54K50E1 |
| 2 | 24 | R0L2S24K00E1 | R0L2S24K10E1 | R0L2S24K20E1 | R0L2S24K30E1 | R0L2S24K40E1 | R0L2S24K50E1 |
| | 36 | R0L2S36K00E1 | R0L2S36K10E1 | R0L2S36K20E1 | R0L2S36K30E1 | R0L2S36K40E1 | R0L2S36K50E1 |
| | 46 | R0L2S46K00E1 | R0L2S46K10E1 | R0L2S46K20E1 | R0L2S46K30E1 | R0L2S46K40E1 | R0L2S46K50E1 |
| | 54 | R0L2S54K00E1 | R0L2S54K10E1 | R0L2S54K20E1 | R0L2S54K30E1 | R0L2S54K40E1 | R0L2S54K50E1 |
| 3 | 24 | R0L3S24K00E1 | R0L3S24K10E1 | R0L3S24K20E1 | R0L3S24K30E1 | R0L3S24K40E1 | R0L3S24K50E1 |
| | 36 | R0L3S36K00E1 | R0L3S36K10E1 | R0L3S36K20E1 | R0L3S36K30E1 | R0L3S36K40E1 | R0L3S36K50E1 |
| | 46 | R0L3S46K00E1 | R0L3S46K10E1 | R0L3S46K20E1 | R0L3S46K30E1 | R0L3S46K40E1 | R0L3S46K50E1 |
| | 54 | R0L3S54K00E1 | R0L3S54K10E1 | R0L3S54K20E1 | R0L3S54K30E1 | R0L3S54K40E1 | R0L3S54K50E1 |
| 4 | 24 | R0L4S24K00E1 | R0L4S24K10E1 | R0L4S24K20E1 | R0L4S24K30E1 | R0L4S24K40E1 | R0L4S24K50E1 |
| | 36 | R0L4S36K00E1 | R0L4S36K10E1 | R0L4S36K20E1 | R0L4S36K30E1 | R0L4S36K40E1 | R0L4S36K50E1 |
| | 46 | R0L4S46K00E1 | R0L4S46K10E1 | R0L4S46K20E1 | R0L4S46K30E1 | R0L4S46K40E1 | R0L4S46K50E1 |
| | 54 | R0L4S54K00E1 | R0L4S54K10E1 | R0L4S54K20E1 | R0L4S54K30E1 | R0L4S54K40E1 | R0L4S54K50E1 |

Table 3.4: SAP2000 Files Organization and Labelling for all Bridges with One Railing and with E1 Transverse Loading Condition (SET 2)

| No. of Lanes n | Span Length S (ft) | Angle of Skewness | | | | | |
|-------------------|--------------------------|-------------------|--------------|--------------|--------------|--------------|--------------|
| | | 0 | 10 | 20 | 30 | 40 | 50 |
| 1 | 24 | R1L1S24K00E1 | R1L1S24K10E1 | R1L1S24K20E1 | R1L1S24K30E1 | R1L1S24K40E1 | R1L1S24K50E1 |
| | 36 | R1L1S36K00E1 | R1L1S36K10E1 | R1L1S36K20E1 | R1L1S36K30E1 | R1L1S36K40E1 | R1L1S36K50E1 |
| | 46 | R1L1S46K00E1 | R1L1S46K10E1 | R1L1S46K20E1 | R1L1S46K30E1 | R1L1S46K40E1 | R1L1S46K50E1 |
| | 54 | R1L1S54K00E1 | R1L1S54K10E1 | R1L1S54K20E1 | R1L1S54K30E1 | R1L1S54K40E1 | R1L1S54K50E1 |
| 2 | 24 | R1L2S24K00E1 | R1L2S24K10E1 | R1L2S24K20E1 | R1L2S24K30E1 | R1L2S24K40E1 | R1L2S24K50E1 |
| | 36 | R1L2S36K00E1 | R1L2S36K10E1 | R1L2S36K20E1 | R1L2S36K30E1 | R1L2S36K40E1 | R1L2S36K50E1 |
| | 46 | R1L2S46K00E1 | R1L2S46K10E1 | R1L2S46K20E1 | R1L2S46K30E1 | R1L2S46K40E1 | R1L2S46K50E1 |
| | 54 | R1L2S54K00E1 | R1L2S54K10E1 | R1L2S54K20E1 | R1L2S54K30E1 | R1L2S54K40E1 | R1L2S54K50E1 |
| 3 | 24 | R1L3S24K00E1 | R1L3S24K10E1 | R1L3S24K20E1 | R1L3S24K30E1 | R1L3S24K40E1 | R1L3S24K50E1 |
| | 36 | R1L3S36K00E1 | R1L3S36K10E1 | R1L3S36K20E1 | R1L3S36K30E1 | R1L3S36K40E1 | R1L3S36K50E1 |
| | 46 | R1L3S46K00E1 | R1L3S46K10E1 | R1L3S46K20E1 | R1L3S46K30E1 | R1L3S46K40E1 | R1L3S46K50E1 |
| | 54 | R1L3S54K00E1 | R1L3S54K10E1 | R1L3S54K20E1 | R1L3S54K30E1 | R1L3S54K40E1 | R1L3S54K50E1 |
| 4 | 24 | R1L4S24K00E1 | R1L4S24K10E1 | R1L4S24K20E1 | R1L4S24K30E1 | R1L4S24K40E1 | R1L4S24K50E1 |
| | 36 | R1L4S36K00E1 | R1L4S36K10E1 | R1L4S36K20E1 | R1L4S36K30E1 | R1L4S36K40E1 | R1L4S36K50E1 |
| | 46 | R1L4S46K00E1 | R1L4S46K10E1 | R1L4S46K20E1 | R1L4S46K30E1 | R1L4S46K40E1 | R1L4S46K50E1 |
| | 54 | R1L4S54K00E1 | R1L4S54K10E1 | R1L4S54K20E1 | R1L4S54K30E1 | R1L4S54K40E1 | R1L4S54K50E1 |

Table 3.5: SAP2000 Files Organization and Labelling for all Bridges with One Railing and with E2 Transverse Loading Condition (SET 3)

| No. of Lanes n | Span Length S (ft) | Angle of Skewness | | | | | |
|-------------------|--------------------------|-------------------|--------------|--------------|--------------|--------------|--------------|
| | | 0 | 10 | 20 | 30 | 40 | 50 |
| 1 | 24 | R1L1S24K00E2 | R1L1S24K10E2 | R1L1S24K20E2 | R1L1S24K30E2 | R1L1S24K40E2 | R1L1S24K50E2 |
| | 36 | R1L1S36K00E2 | R1L1S36K10E2 | R1L1S36K20E2 | R1L1S36K30E2 | R1L1S36K40E2 | R1L1S36K50E2 |
| | 46 | R1L1S46K00E2 | R1L1S46K10E2 | R1L1S46K20E2 | R1L1S46K30E2 | R1L1S46K40E2 | R1L1S46K50E2 |
| | 54 | R1L1S54K00E2 | R1L1S54K10E2 | R1L1S54K20E2 | R1L1S54K30E2 | R1L1S54K40E2 | R1L1S54K50E2 |
| 2 | 24 | R1L2S24K00E2 | R1L2S24K10E2 | R1L2S24K20E2 | R1L2S24K30E2 | R1L2S24K40E2 | R1L2S24K50E2 |
| | 36 | R1L2S36K00E2 | R1L2S36K10E2 | R1L2S36K20E2 | R1L2S36K30E2 | R1L2S36K40E2 | R1L2S36K50E2 |
| | 46 | R1L2S46K00E2 | R1L2S46K10E2 | R1L2S46K20E2 | R1L2S46K30E2 | R1L2S46K40E2 | R1L2S46K50E2 |
| | 54 | R1L2S54K00E2 | R1L2S54K10E2 | R1L2S54K20E2 | R1L2S54K30E2 | R1L2S54K40E2 | R1L2S54K50E2 |
| 3 | 24 | R1L3S24K00E2 | R1L3S24K10E2 | R1L3S24K20E2 | R1L3S24K30E2 | R1L3S24K40E2 | R1L3S24K50E2 |
| | 36 | R1L3S36K00E2 | R1L3S36K10E2 | R1L3S36K20E2 | R1L3S36K30E2 | R1L3S36K40E2 | R1L3S36K50E2 |
| | 46 | R1L3S46K00E2 | R1L3S46K10E2 | R1L3S46K20E2 | R1L3S46K30E2 | R1L3S46K40E2 | R1L3S46K50E2 |
| | 54 | R1L3S54K00E2 | R1L3S54K10E2 | R1L3S54K20E2 | R1L3S54K30E2 | R1L3S54K40E2 | R1L3S54K50E2 |
| 4 | 24 | R1L4S24K00E2 | R1L4S24K10E2 | R1L4S24K20E2 | R1L4S24K30E2 | R1L4S24K40E2 | R1L4S24K50E2 |
| | 36 | R1L4S36K00E2 | R1L4S36K10E2 | R1L4S36K20E2 | R1L4S36K30E2 | R1L4S36K40E2 | R1L4S36K50E2 |
| | 46 | R1L4S46K00E2 | R1L4S46K10E2 | R1L4S46K20E2 | R1L4S46K30E2 | R1L4S46K40E2 | R1L4S46K50E2 |
| | 54 | R1L4S54K00E2 | R1L4S54K10E2 | R1L4S54K20E2 | R1L4S54K30E2 | R1L4S54K40E2 | R1L4S54K50E2 |

Table 3.6: SAP2000 Files Organization and Labelling for all Bridges with Two Railings and with E1 Transverse Loading Condition (SET 4)

| No. of Lanes n | Span Length S (ft) | Angle of Skewness | | | | | |
|-------------------|--------------------------|-------------------|--------------|--------------|--------------|--------------|--------------|
| | | 0 | 10 | 20 | 30 | 40 | 50 |
| 1 | 24 | R2L1S24K00E1 | R2L1S24K10E1 | R2L1S24K20E1 | R2L1S24K30E1 | R2L1S24K40E1 | R2L1S24K50E1 |
| | 36 | R2L1S36K00E1 | R2L1S36K10E1 | R2L1S36K20E1 | R2L1S36K30E1 | R2L1S36K40E1 | R2L1S36K50E1 |
| | 46 | R2L1S46K00E1 | R2L1S46K10E1 | R2L1S46K20E1 | R2L1S46K30E1 | R2L1S46K40E1 | R2L1S46K50E1 |
| | 54 | R2L1S54K00E1 | R2L1S54K10E1 | R2L1S54K20E1 | R2L1S54K30E1 | R2L1S54K40E1 | R2L1S54K50E1 |
| 2 | 24 | R2L2S24K00E1 | R2L2S24K10E1 | R2L2S24K20E1 | R2L2S24K30E1 | R2L2S24K40E1 | R2L2S24K50E1 |
| | 36 | R2L2S36K00E1 | R2L2S36K10E1 | R2L2S36K20E1 | R2L2S36K30E1 | R2L2S36K40E1 | R2L2S36K50E1 |
| | 46 | R2L2S46K00E1 | R2L2S46K10E1 | R2L2S46K20E1 | R2L2S46K30E1 | R2L2S46K40E1 | R2L2S46K50E1 |
| | 54 | R2L2S54K00E1 | R2L2S54K10E1 | R2L2S54K20E1 | R2L2S54K30E1 | R2L2S54K40E1 | R2L2S54K50E1 |
| 3 | 24 | R2L3S24K00E1 | R2L3S24K10E1 | R2L3S24K20E1 | R2L3S24K30E1 | R2L3S24K40E1 | R2L3S24K50E1 |
| | 36 | R2L3S36K00E1 | R2L3S36K10E1 | R2L3S36K20E1 | R2L3S36K30E1 | R2L3S36K40E1 | R2L3S36K50E1 |
| | 46 | R2L3S46K00E1 | R2L3S46K10E1 | R2L3S46K20E1 | R2L3S46K30E1 | R2L3S46K40E1 | R2L3S46K50E1 |
| | 54 | R2L3S54K00E1 | R2L3S54K10E1 | R2L3S54K20E1 | R2L3S54K30E1 | R2L3S54K40E1 | R2L3S54K50E1 |
| 4 | 24 | R2L4S24K00E1 | R2L4S24K10E1 | R2L4S24K20E1 | R2L4S24K30E1 | R2L4S24K40E1 | R2L4S24K50E1 |
| | 36 | R2L4S36K00E1 | R2L4S36K10E1 | R2L4S36K20E1 | R2L4S36K30E1 | R2L4S36K40E1 | R2L4S36K50E1 |
| | 46 | R2L4S46K00E1 | R2L4S46K10E1 | R2L4S46K20E1 | R2L4S46K30E1 | R2L4S46K40E1 | R2L4S46K50E1 |
| | 54 | R2L4S54K00E1 | R2L4S54K10E1 | R2L4S54K20E1 | R2L4S54K30E1 | R2L4S54K40E1 | R2L4S54K50E1 |

CHAPTER 4

ANALYSIS RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the parametric study of the bridge cases presented in Chapter 3. The bridge cases are analyzed using the SAP2000 software for various bridge and load configurations and summarized by using contour plots, tables, and graphs. The results are interpreted and compared with the AASHTO design procedures for validation purposes.

4.2 Presentation of Results

The FEA and AASHTO results evaluated and assessed consist the maximum longitudinal bending moments, edge beam moments, and deflections at critical locations of the bridge slabs. Also, the FEA results of skewed bridges are compared to their corresponding FEA values of straight bridges.

For every span length (24, 36, 46 and 54 ft), number of lanes from 1 to 4, bridge width (14, 24, 36 and 48 ft), angle of skewness (0, 10, 20, 30, 40 and 50 degrees), and loading condition (E1 and E2), with/without the presence of railings (R0, R1 and R2), longitudinal bending moments are extracted from SAP2000 output files. These FEA moments per unit foot along the critical cross-section are tabulated for all bridge cases as shown in Tables 4.1, 4.2, 4.3 and 4.4 for the two-lane bridge with span length of 36 ft with no railings E1 loading condition, one railing E1 loading condition, one railing E2 loading condition and two railings E1 loading condition respectively. For a complete set of moment distribution tables, refer to Appendix-1. These results are also presented in graph plots to facilitate comparison of the longitudinal moment distribution for various bridges. Figures 4.1, 4.2, 4.3 and 4.4 are

sample plots, which include longitudinal moment distribution values for the same tabulated bridges respectively. For a complete set of these plots, refer to Appendix-2.

A total of 384 bridges were analyzed, and for the purposes of comparison and results tabulation, the bridges were grouped in three categories:

Case 1: “Skewed bridges with no railings”

Case 2: “Skewed bridges with one railing”

Case 3: “Skewed bridges with two railings”

4.2.1 Maximum Longitudinal Bending Moment

The maximum longitudinal bending moment in slab is defined as the first peak value after the left edge peak moment (Figures 4.1 to 4.4). The maximum peak moment at the edge is resisted by an edge beam.

$M_i/\alpha\alpha$ is the maximum FEA moment in the bridge, where “i” represents the presence of railings. It is 0 for no railings, 1 for one railing and 2 for two railings. On the other and, $\alpha\alpha$ represents the angle of skewness which varies between 00 and 50 degrees. M0/00 represents the moment of straight bridges with no railings.

4.2.2 Edge Beam Moment

The edge beam moment is defined by the maximum moment at or near the leftmost node along the critical cross-section (Figures 4.1 to 4.4).

$M_i/\alpha\alpha$ is the maximum FEA moment in the bridge, where “i” represents the presence of railings. It is 0 for no railings, 1 for one railing and 2 for two railings. On the other and, $\alpha\alpha$ represents the angle of skewness which varies between 00 and 50 degrees. M0/00 represents the FEA edge beam moment of straight bridges with no railings.

4.2.3 Maximum Transverse Moment

The maximum transverse moment occurs underneath the concentrated wheel loads in the slab. The maximum transverse moment is compared to its corresponding maximum moment value in the longitudinal direction. The maximum transverse moment for the skewed bridges is further compared to that of straight bridges.

$M_{i/\alpha}$ is the maximum FEA moment in the bridge, where “i” represents the presence of railings. It is 0 for no railings, 1 for one railing and 2 for two railings. On the other hand, α represents the angle of skewness which varies between 00 and 50 degrees. $M_{0/00}$ represents the transverse moment of straight bridges with no railings.

4.2.4 Maximum Live Load Deflection

Live load deflection obtained from FEA for all the cases are obtained and compared to the AASHTO criterion of $S/800$. It is worth noting that the FEA is an elastic analysis, and not the actual cracked section analysis, which would yield higher deflection values.

$\Delta_{i/\alpha}$ is the FEA edge beam moment in the bridge, where “i” represents the presence of railings. It is 0 for no railings, 1 for one railing and 2 for two railings. On the other hand, α represents the angle of skewness which varies between 00 and 50 degrees. $\Delta_{0/00}$ represents the FEA live load deflection of straight bridges with no railings.

Table 4.1: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge Deck Span = 36 ft, Deck Width = 24 ft, No Railings with Edge Loading E1

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 37.2 | 45.6 | 36.7 | 45.6 | 34.0 | 43.8 | 29.8 | 41.0 | 24.7 | 38.3 | 20.3 | 34.2 | 32.4 |
| 1 | 38.5 | 45.6 | 38.0 | 45.6 | 35.2 | 43.8 | 31.0 | 41.0 | 26.3 | 38.3 | 21.1 | 34.2 | 32.4 |
| 2 | 34.8 | 45.6 | 34.3 | 45.6 | 31.5 | 43.8 | 27.2 | 41.0 | 22.2 | 38.3 | 17.5 | 34.2 | 32.4 |
| 3 | 33.3 | 45.6 | 32.7 | 45.6 | 29.9 | 43.8 | 25.6 | 41.0 | 20.5 | 38.3 | 15.8 | 34.2 | 32.4 |
| 4 | 32.6 | 45.6 | 32.0 | 45.6 | 29.1 | 43.8 | 24.7 | 41.0 | 19.6 | 38.3 | 14.8 | 34.2 | 32.4 |
| 5 | 32.3 | 45.6 | 31.7 | 45.6 | 28.8 | 43.8 | 24.4 | 41.0 | 19.2 | 38.3 | 14.4 | 34.2 | 32.4 |
| 6 | 32.9 | 45.6 | 32.3 | 45.6 | 29.4 | 43.8 | 24.8 | 41.0 | 19.5 | 38.3 | 14.8 | 34.2 | 32.4 |
| 7 | 35.3 | 45.6 | 34.7 | 45.6 | 31.7 | 43.8 | 27.1 | 41.0 | 22.1 | 38.3 | 16.7 | 34.2 | 32.4 |
| 8 | 32.5 | 45.6 | 31.8 | 45.6 | 28.8 | 43.8 | 24.2 | 41.0 | 18.7 | 38.3 | 13.9 | 34.2 | 32.4 |
| 9 | 31.6 | 45.6 | 30.9 | 45.6 | 27.9 | 43.8 | 23.1 | 41.0 | 17.7 | 38.3 | 12.7 | 34.2 | 32.4 |
| 10 | 31.8 | 45.6 | 31.1 | 45.6 | 28.1 | 43.8 | 23.2 | 41.0 | 17.6 | 38.3 | 12.6 | 34.2 | 32.4 |
| 11 | 33.9 | 45.6 | 33.3 | 45.6 | 30.2 | 43.8 | 25.2 | 41.0 | 19.8 | 38.3 | 14.2 | 34.2 | 32.4 |
| 12 | 30.8 | 45.6 | 30.1 | 45.6 | 27.0 | 43.8 | 21.9 | 41.0 | 16.0 | 38.3 | 10.9 | 34.2 | 32.4 |
| 13 | 29.4 | 45.6 | 28.8 | 45.6 | 25.6 | 43.8 | 20.5 | 41.0 | 14.4 | 38.3 | 9.2 | 34.2 | 32.4 |
| 14 | 28.8 | 45.6 | 28.2 | 45.6 | 25.0 | 43.8 | 19.7 | 41.0 | 13.4 | 38.3 | 8.1 | 34.2 | 32.4 |
| 15 | 28.6 | 45.6 | 28.0 | 45.6 | 24.7 | 43.8 | 19.3 | 41.0 | 12.8 | 38.3 | 7.4 | 34.2 | 32.4 |
| 16 | 29.1 | 45.6 | 28.5 | 45.6 | 25.2 | 43.8 | 19.7 | 41.0 | 12.7 | 38.3 | 7.4 | 34.2 | 32.4 |
| 17 | 31.4 | 45.6 | 30.8 | 45.6 | 27.5 | 43.8 | 21.8 | 41.0 | 14.8 | 38.3 | 8.8 | 34.2 | 32.4 |
| 18 | 28.3 | 45.6 | 27.6 | 45.6 | 24.4 | 43.8 | 18.5 | 41.0 | 10.7 | 38.3 | 5.8 | 34.2 | 32.4 |
| 19 | 26.9 | 45.6 | 26.3 | 45.6 | 23.0 | 43.8 | 17.0 | 41.0 | 8.7 | 38.3 | 3.2 | 34.2 | 32.4 |
| 20 | 26.1 | 45.6 | 25.5 | 45.6 | 22.2 | 43.8 | 16.2 | 41.0 | 7.0 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 25.6 | 45.6 | 25.0 | 45.6 | 21.7 | 43.8 | 15.6 | 41.0 | 5.3 | 38.3 | | 34.2 | 32.4 |
| 22 | 25.3 | 45.6 | 24.7 | 45.6 | 21.4 | 43.8 | 15.2 | 41.0 | 3.4 | 38.3 | | 34.2 | 32.4 |
| 23 | 25.1 | 45.6 | 24.5 | 45.6 | 21.2 | 43.8 | 15.0 | 41.0 | 1.9 | 38.3 | | 34.2 | 32.4 |
| 24 | 25.0 | 45.6 | 24.4 | 45.6 | 21.1 | 43.8 | 14.9 | 41.0 | 1.5 | 38.3 | | 34.2 | 32.4 |

Table 4.2: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E1

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 24.3 | 45.6 | 24.0 | 45.6 | 22.5 | 43.8 | 19.9 | 41.0 | 15.9 | 38.3 | 13.8 | 34.2 | 32.4 |
| 1 | 25.3 | 45.6 | 25.0 | 45.6 | 23.4 | 43.8 | 20.8 | 41.0 | 17.7 | 38.3 | 13.9 | 34.2 | 32.4 |
| 2 | 23.5 | 45.6 | 23.2 | 45.6 | 21.6 | 43.8 | 18.9 | 41.0 | 15.3 | 38.3 | 12.1 | 34.2 | 32.4 |
| 3 | 22.8 | 45.6 | 22.5 | 45.6 | 20.8 | 43.8 | 18.0 | 41.0 | 14.5 | 38.3 | 11.0 | 34.2 | 32.4 |
| 4 | 22.9 | 45.6 | 22.6 | 45.6 | 20.8 | 43.8 | 17.9 | 41.0 | 14.3 | 38.3 | 10.8 | 34.2 | 32.4 |
| 5 | 23.3 | 45.6 | 23.0 | 45.6 | 21.2 | 43.8 | 18.2 | 41.0 | 14.5 | 38.3 | 10.9 | 34.2 | 32.4 |
| 6 | 24.4 | 45.6 | 24.1 | 45.6 | 22.2 | 43.8 | 19.1 | 41.0 | 15.2 | 38.3 | 11.7 | 34.2 | 32.4 |
| 7 | 27.4 | 45.6 | 27.0 | 45.6 | 25.1 | 43.8 | 21.9 | 41.0 | 18.2 | 38.3 | 13.9 | 34.2 | 32.4 |
| 8 | 25.0 | 45.6 | 24.6 | 45.6 | 22.6 | 43.8 | 19.3 | 41.0 | 15.2 | 38.3 | 11.4 | 34.2 | 32.4 |
| 9 | 24.4 | 45.6 | 24.1 | 45.6 | 22.0 | 43.8 | 18.6 | 41.0 | 14.4 | 38.3 | 10.5 | 34.2 | 32.4 |
| 10 | 25.0 | 45.6 | 24.6 | 45.6 | 22.5 | 43.8 | 19.0 | 41.0 | 14.6 | 38.3 | 10.6 | 34.2 | 32.4 |
| 11 | 27.5 | 45.6 | 27.1 | 45.6 | 25.0 | 43.8 | 21.3 | 41.0 | 17.0 | 38.3 | 12.3 | 34.2 | 32.4 |
| 12 | 24.6 | 45.6 | 24.2 | 45.6 | 22.0 | 43.8 | 18.2 | 41.0 | 13.4 | 38.3 | 9.2 | 34.2 | 32.4 |
| 13 | 23.6 | 45.6 | 23.2 | 45.6 | 20.9 | 43.8 | 17.0 | 41.0 | 12.0 | 38.3 | 7.6 | 34.2 | 32.4 |
| 14 | 23.2 | 45.6 | 22.8 | 45.6 | 20.5 | 43.8 | 16.4 | 41.0 | 11.2 | 38.3 | 6.6 | 34.2 | 32.4 |
| 15 | 23.3 | 45.6 | 22.9 | 45.6 | 20.5 | 43.8 | 16.2 | 41.0 | 10.7 | 38.3 | 6.0 | 34.2 | 32.4 |
| 16 | 24.0 | 45.6 | 23.6 | 45.6 | 21.2 | 43.8 | 16.7 | 41.0 | 10.8 | 38.3 | 6.1 | 34.2 | 32.4 |
| 17 | 26.4 | 45.6 | 26.0 | 45.6 | 23.6 | 43.8 | 19.0 | 41.0 | 13.0 | 38.3 | 7.6 | 34.2 | 32.4 |
| 18 | 23.5 | 45.6 | 23.1 | 45.6 | 20.6 | 43.8 | 15.9 | 41.0 | 9.0 | 38.3 | 4.6 | 34.2 | 32.4 |
| 19 | 22.3 | 45.6 | 21.9 | 45.6 | 19.4 | 43.8 | 14.5 | 41.0 | 7.1 | 38.3 | 2.1 | 34.2 | 32.4 |
| 20 | 21.6 | 45.6 | 21.3 | 45.6 | 18.7 | 43.8 | 13.7 | 41.0 | 5.5 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 21.2 | 45.6 | 20.9 | 45.6 | 18.3 | 43.8 | 13.2 | 41.0 | 3.8 | 38.3 | | 34.2 | 32.4 |
| 22 | 21.0 | 45.6 | 20.6 | 45.6 | 18.1 | 43.8 | 12.9 | 41.0 | 2.0 | 38.3 | | 34.2 | 32.4 |
| 23 | 20.9 | 45.6 | 20.5 | 45.6 | 18.0 | 43.8 | 12.8 | 41.0 | 0.6 | 38.3 | | 34.2 | 32.4 |
| 24 | 20.9 | 45.6 | 20.5 | 45.6 | 18.0 | 43.8 | 12.8 | 41.0 | 0.4 | 38.3 | | 34.2 | 32.4 |

Table 4.3: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E2

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 34.1 | 45.6 | 33.7 | 45.6 | 31.7 | 43.8 | 28.5 | 41.0 | 24.3 | 38.3 | 20.2 | 34.2 | 32.4 |
| 1 | 35.3 | 45.6 | 34.9 | 45.6 | 32.9 | 43.8 | 29.7 | 41.0 | 25.8 | 38.3 | 21.0 | 34.2 | 32.4 |
| 2 | 31.6 | 45.6 | 31.2 | 45.6 | 29.1 | 43.8 | 25.9 | 41.0 | 21.7 | 38.3 | 17.5 | 34.2 | 32.4 |
| 3 | 29.9 | 45.6 | 29.5 | 45.6 | 27.5 | 43.8 | 24.2 | 41.0 | 20.1 | 38.3 | 15.7 | 34.2 | 32.4 |
| 4 | 29.1 | 45.6 | 28.7 | 45.6 | 26.6 | 43.8 | 23.3 | 41.0 | 19.2 | 38.3 | 14.8 | 34.2 | 32.4 |
| 5 | 28.8 | 45.6 | 28.3 | 45.6 | 26.3 | 43.8 | 23.0 | 41.0 | 18.8 | 38.3 | 14.4 | 34.2 | 32.4 |
| 6 | 29.2 | 45.6 | 28.8 | 45.6 | 26.7 | 43.8 | 23.4 | 41.0 | 19.1 | 38.3 | 14.8 | 34.2 | 32.4 |
| 7 | 31.5 | 45.6 | 31.1 | 45.6 | 29.0 | 43.8 | 25.7 | 41.0 | 21.7 | 38.3 | 16.7 | 34.2 | 32.4 |
| 8 | 28.5 | 45.6 | 28.1 | 45.6 | 26.0 | 43.8 | 22.6 | 41.0 | 18.3 | 38.3 | 13.9 | 34.2 | 32.4 |
| 9 | 27.4 | 45.6 | 27.0 | 45.6 | 24.9 | 43.8 | 21.6 | 41.0 | 17.3 | 38.3 | 12.8 | 34.2 | 32.4 |
| 10 | 27.5 | 45.6 | 27.1 | 45.6 | 25.0 | 43.8 | 21.6 | 41.0 | 17.2 | 38.3 | 12.7 | 34.2 | 32.4 |
| 11 | 29.4 | 45.6 | 29.0 | 45.6 | 26.9 | 43.8 | 23.5 | 41.0 | 19.4 | 38.3 | 14.3 | 34.2 | 32.4 |
| 12 | 26.1 | 45.6 | 25.6 | 45.6 | 23.6 | 43.8 | 20.2 | 41.0 | 15.7 | 38.3 | 11.1 | 34.2 | 32.4 |
| 13 | 24.5 | 45.6 | 24.1 | 45.6 | 22.0 | 43.8 | 18.6 | 41.0 | 14.2 | 38.3 | 9.3 | 34.2 | 32.4 |
| 14 | 23.6 | 45.6 | 23.3 | 45.6 | 21.2 | 43.8 | 17.7 | 41.0 | 13.3 | 38.3 | 8.3 | 34.2 | 32.4 |
| 15 | 23.2 | 45.6 | 22.8 | 45.6 | 20.8 | 43.8 | 17.3 | 41.0 | 12.7 | 38.3 | 7.7 | 34.2 | 32.4 |
| 16 | 23.4 | 45.6 | 23.0 | 45.6 | 21.0 | 43.8 | 17.5 | 41.0 | 12.8 | 38.3 | 7.7 | 34.2 | 32.4 |
| 17 | 25.4 | 45.6 | 25.0 | 45.6 | 23.0 | 43.8 | 19.4 | 41.0 | 15.0 | 38.3 | 9.2 | 34.2 | 32.4 |
| 18 | 21.9 | 45.6 | 21.6 | 45.6 | 19.5 | 43.8 | 15.9 | 41.0 | 11.1 | 38.3 | 6.2 | 34.2 | 32.4 |
| 19 | 20.2 | 45.6 | 19.9 | 45.6 | 17.8 | 43.8 | 14.2 | 41.0 | 9.2 | 38.3 | 3.7 | 34.2 | 32.4 |
| 20 | 19.1 | 45.6 | 18.7 | 45.6 | 16.7 | 43.8 | 13.0 | 41.0 | 7.9 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 18.1 | 45.6 | 17.8 | 45.6 | 15.7 | 43.8 | 11.9 | 41.0 | 6.6 | 38.3 | | 34.2 | 32.4 |
| 22 | 17.4 | 45.6 | 17.1 | 45.6 | 15.0 | 43.8 | 11.1 | 41.0 | 5.5 | 38.3 | | 34.2 | 32.4 |
| 23 | 16.5 | 45.6 | 16.2 | 45.6 | 14.1 | 43.8 | 10.1 | 41.0 | 3.3 | 38.3 | | 34.2 | 32.4 |
| 24 | 16.5 | 45.6 | 16.2 | 45.6 | 14.1 | 43.8 | 10.1 | 41.0 | 2.4 | 38.3 | | 34.2 | 32.4 |

Table 4.4: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge –Deck Span = 36 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 22.5 | 45.6 | 22.3 | 45.6 | 21.1 | 43.8 | 19.1 | 41.0 | 15.5 | 38.3 | 13.7 | 34.2 | 32.4 |
| 1 | 23.4 | 45.6 | 23.2 | 45.6 | 22.0 | 43.8 | 19.9 | 41.0 | 17.4 | 38.3 | 13.8 | 34.2 | 32.4 |
| 2 | 21.6 | 45.6 | 21.3 | 45.6 | 20.1 | 43.8 | 18.0 | 41.0 | 15.0 | 38.3 | 12.1 | 34.2 | 32.4 |
| 3 | 20.7 | 45.6 | 20.5 | 45.6 | 19.2 | 43.8 | 17.1 | 41.0 | 14.1 | 38.3 | 11.0 | 34.2 | 32.4 |
| 4 | 20.7 | 45.6 | 20.5 | 45.6 | 19.2 | 43.8 | 17.0 | 41.0 | 14.0 | 38.3 | 10.8 | 34.2 | 32.4 |
| 5 | 21.0 | 45.6 | 20.8 | 45.6 | 19.4 | 43.8 | 17.2 | 41.0 | 14.2 | 38.3 | 10.9 | 34.2 | 32.4 |
| 6 | 22.0 | 45.6 | 21.8 | 45.6 | 20.4 | 43.8 | 18.1 | 41.0 | 14.9 | 38.3 | 11.7 | 34.2 | 32.4 |
| 7 | 24.8 | 45.6 | 24.5 | 45.6 | 23.2 | 43.8 | 20.8 | 41.0 | 17.9 | 38.3 | 13.9 | 34.2 | 32.4 |
| 8 | 22.2 | 45.6 | 22.0 | 45.6 | 20.6 | 43.8 | 18.2 | 41.0 | 14.9 | 38.3 | 11.5 | 34.2 | 32.4 |
| 9 | 21.5 | 45.6 | 21.3 | 45.6 | 19.9 | 43.8 | 17.4 | 41.0 | 14.2 | 38.3 | 10.5 | 34.2 | 32.4 |
| 10 | 21.9 | 45.6 | 21.7 | 45.6 | 20.3 | 43.8 | 17.8 | 41.0 | 14.3 | 38.3 | 10.7 | 34.2 | 32.4 |
| 11 | 24.2 | 45.6 | 24.0 | 45.6 | 22.5 | 43.8 | 20.0 | 41.0 | 16.8 | 38.3 | 12.4 | 34.2 | 32.4 |
| 12 | 21.2 | 45.6 | 20.9 | 45.6 | 19.5 | 43.8 | 16.9 | 41.0 | 13.3 | 38.3 | 9.4 | 34.2 | 32.4 |
| 13 | 19.9 | 45.6 | 19.7 | 45.6 | 18.2 | 43.8 | 15.5 | 41.0 | 11.9 | 38.3 | 7.8 | 34.2 | 32.4 |
| 14 | 19.3 | 45.6 | 19.1 | 45.6 | 17.6 | 43.8 | 14.9 | 41.0 | 11.2 | 38.3 | 6.8 | 34.2 | 32.4 |
| 15 | 19.1 | 45.6 | 18.9 | 45.6 | 17.4 | 43.8 | 14.6 | 41.0 | 10.8 | 38.3 | 6.3 | 34.2 | 32.4 |
| 16 | 19.5 | 45.6 | 19.3 | 45.6 | 17.8 | 43.8 | 15.0 | 41.0 | 11.0 | 38.3 | 6.4 | 34.2 | 32.4 |
| 17 | 21.7 | 45.6 | 21.5 | 45.6 | 20.0 | 43.8 | 17.1 | 41.0 | 13.3 | 38.3 | 8.0 | 34.2 | 32.4 |
| 18 | 18.5 | 45.6 | 18.3 | 45.6 | 16.7 | 43.8 | 13.8 | 41.0 | 9.5 | 38.3 | 5.0 | 34.2 | 32.4 |
| 19 | 17.0 | 45.6 | 16.8 | 45.6 | 15.2 | 43.8 | 12.2 | 41.0 | 7.7 | 38.3 | 2.6 | 34.2 | 32.4 |
| 20 | 16.0 | 45.6 | 15.8 | 45.6 | 14.2 | 43.8 | 11.1 | 41.0 | 6.5 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 15.2 | 45.6 | 15.1 | 45.6 | 13.4 | 43.8 | 10.2 | 41.0 | 5.3 | 38.3 | | 34.2 | 32.4 |
| 22 | 14.7 | 45.6 | 14.5 | 45.6 | 12.8 | 43.8 | 9.6 | 41.0 | 4.3 | 38.3 | | 34.2 | 32.4 |
| 23 | 14.0 | 45.6 | 13.8 | 45.6 | 12.1 | 43.8 | 8.8 | 41.0 | 2.4 | 38.3 | | 34.2 | 32.4 |
| 24 | 14.0 | 45.6 | 13.9 | 45.6 | 12.2 | 43.8 | 8.8 | 41.0 | 1.8 | 38.3 | | 34.2 | 32.4 |

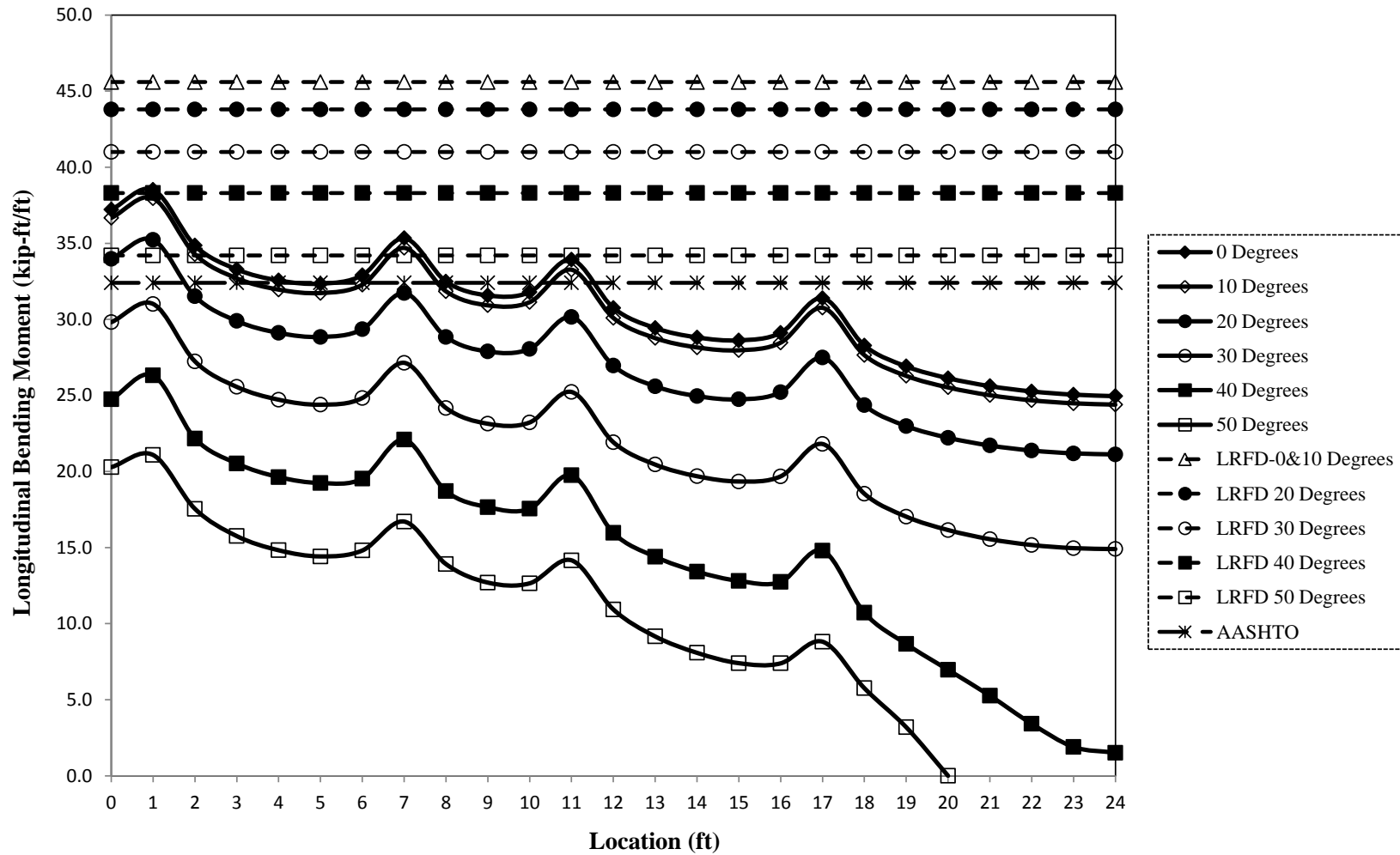


Figure 4.1: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, No Railings with Edge Loading E1.

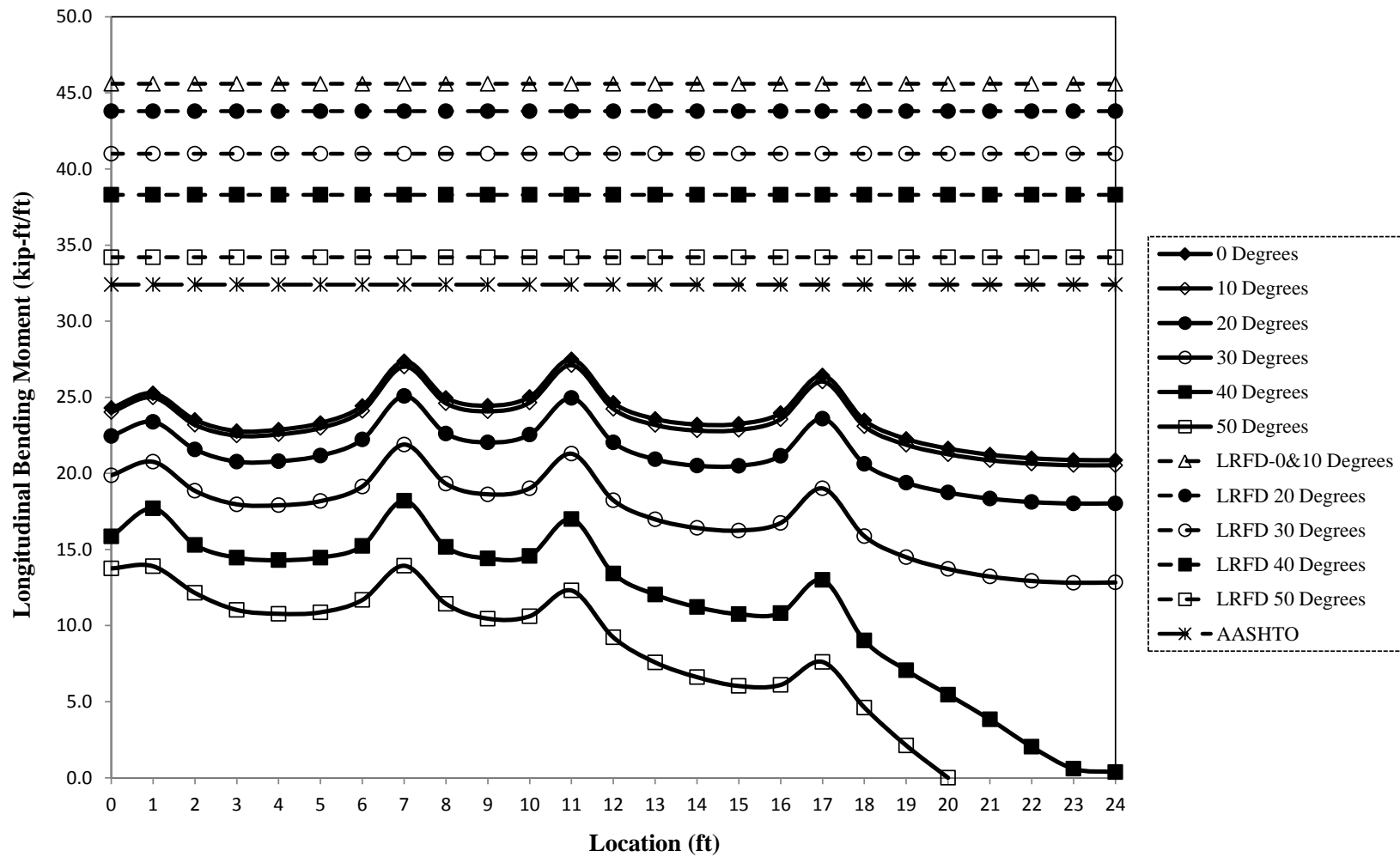


Figure 4.2: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E1

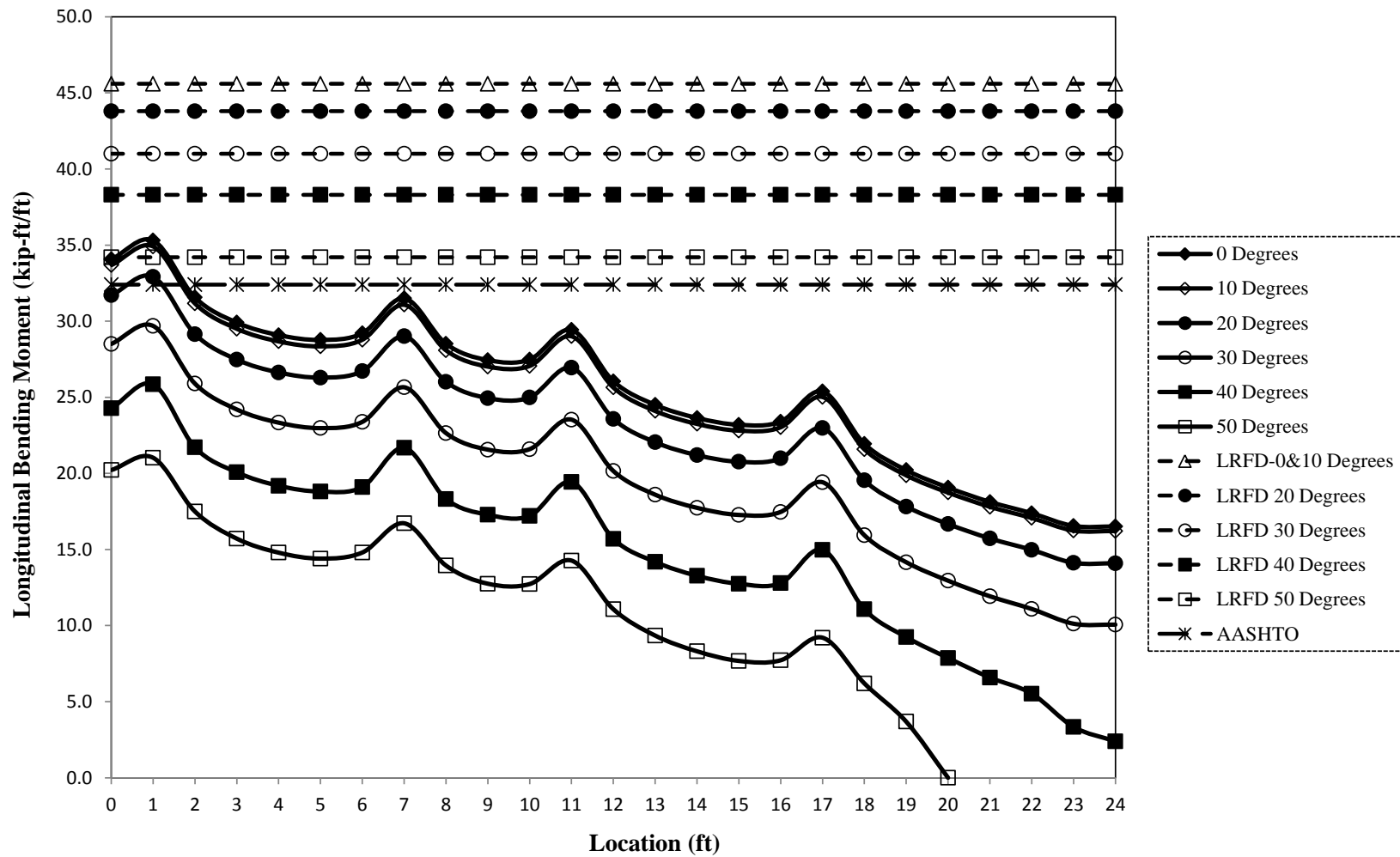


Figure 4.3: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E2

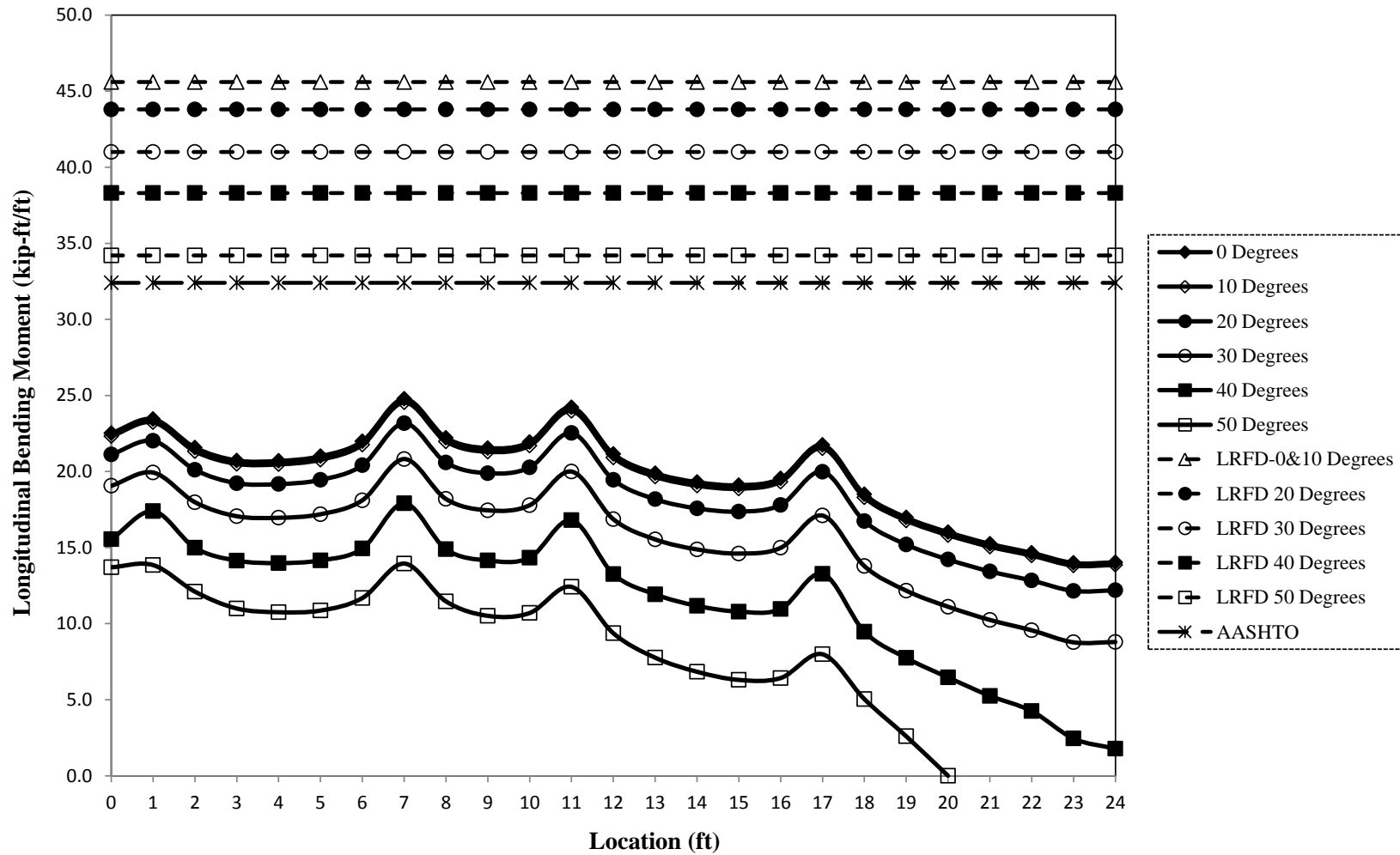


Figure 4.4: Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1

4.3 Finite Element Analysis (FEA) Results and Discussion

The FEA results for each bridge category (Case 1, Case2 and Case3) were primarily compared with AASHTO Standard Specifications and AASHTO LRFD procedures. After that, the effects of the increase in bridge slab skewness on the maximum longitudinal moment, edge beam moment, transverse moment, and live load deflection for a given bridge span and number of lanes were also evaluated. Thus, the finite-element results for skew angles ranging between 10 and 50° are compared to their corresponding FEA values for straight bridges for each bridge category. The FEA bending moments are presented in the form of the ratio ($M_i/\alpha\alpha / M_i/00$), where $M_i/\alpha\alpha$ is the maximum FEA moment in the bridge for a given skew angle $\alpha\alpha$ between 10 and 50°, and $M_i/00$ is the FEA moment for nonskewed bridges (0° skewness). Similarly, the ratio ($\Delta_i/\alpha\alpha / \Delta_i/00$) is calculated from the FEA deflection results.

4.3.1 *Skewed Bridges with No Railings “Case 1”*

4.3.1.1 FEA Results versus AASHTO

4.3.1.1.1 Maximum Longitudinal Bending Moment and Edge Beam Moment

The maximum slab and edge beam longitudinal bending moments are summarized in Tables 4.5 to 4.8, for all “Case 1” bridges analyzed along with the corresponding AASHTO bending moments.

The AASHTO moments are computed using Eqs. (1) and (2) for the standard specifications, and Eq. (5) for LRFD after applying the necessary reduction for all skew angles Eq. (6).

The FEA maximum longitudinal bending moment and edge beam moments for skew angles less than 30° were first compared to the AASHTO standard

specifications equations. For one lane bridges with span lengths less than 36 ft, AASHTO overestimates the maximum longitudinal bending moment by about 30%, and the edge beam moment by about 25%. AASHTO gives similar results to the FEA for both moment values for bridges with span lengths greater than 46 ft. For two lane bridges, AASHTO gives longitudinal bending moment similar to the FEA results for span lengths less than 46 ft, and underestimates the maximum moment by about 25% when the span length is greater than 46 ft. The FEA edge beam moment results are similar to the AASHTO recommended moment for all two lane bridges. For three and four lane bridges, AASHTO recommended moment are similar to FEA maximum longitudinal moment results for bridges with spans less than 24 ft, and underestimates the maximum moments by about 30% for bridges with span lengths greater than 36 ft. The AASHTO procedure recommended edge beam moment are similar to FEA edge beam moment results for all three and four lane bridges with spans less than 46 ft, and underestimates the maximum edge beam moment by about 25% for bridges with span length greater than 46 ft. Considering the skew angle between 30 and 40°, and for span lengths between 24 ft and 54 ft, the AASHTO procedure overestimates the maximum longitudinal moment and edge beam moment by about 65% for one lane bridges, 40% for two lane bridges, and 30% for three and four lane bridges. At relatively high skew angles, reaching 50°, AASHTO overestimates the maximum longitudinal moment and edge beam moment by about 100% for all span lengths and slab widths considered in the analysis. It is worth noting here that this overestimation is counter balanced by a significant increase in the maximum transverse moment as detailed later.

The maximum FEA longitudinal bending moments were also compared to the AASHTO LRFD moments. For skew angles less than 30°, LRFD overestimates

the maximum longitudinal moment by about 65% for one lane bridges, 30% for two lane bridges, 25% for three lane bridges, and gives similar results for four lane bridges. The LRFD overestimate of the maximum longitudinal moment increases almost linearly with the skew angle as it varies from 30 to 50°. The LRFD overestimates the bending moment by about 120% for one lane bridges, 100% for two lane bridges, and 80% for three and four lane bridges.

As for the maximum FEA longitudinal bending moments, FEA edge beam moments were also compared to AASHTO LRFD moments. For skew angles less than 30°, LRFD overestimates FEA maximum edge beam moment by about 25% for one lane bridges with span length less than 36 ft, and 30 % for bridges with span length greater than 46 ft. For two lane bridges with span length less than 36 ft, LRFD gives similar results to FEA maximum edge beam moment and overestimates FEA maximum edge beam moment by about 25% for bridges with span length greater than 46 ft. For three and four lanes, LRFD underestimates FEA edge beam moment by about 25 % for bridges with span length less than 36 ft and gives similar results to FEA edge beam moments for bridges with span length greater than 36 ft. Considering the skew angle greater than 30°, and for bridges with span length less than 36 ft, LRFD overestimates FEA edge beam moment by about 25 % for one lane bridges and gives similar results to FEA edge beam moment for two, three and four lane bridges. For span length greater than 36 ft LRFD overestimates increases linearly with the skew angle till it reaches 65% for one and two lane bridges, and 55% for three and four lane bridges.

4.3.1.1.2 Maximum Transverse Moment

Table 4.9 summarizes the FEA maximum transverse moments for all “Case 1” bridges. The maximum transverse moment was compared with the corresponding

maximum moment value in the longitudinal direction. The ratio of transverse to longitudinal moments is also reported in Table 4.9.

The maximum FEA transverse moments increased with the increase in the skew angle even though the maximum longitudinal moment is decreasing. The ratio of maximum FEA transverse to longitudinal moment increases significantly when the skew angle is increased, from about 20% for straight bridges up to 65% for bridges with 50° skewness. AASHTO accommodates the transverse bending moment by specifying a percentage of the main reinforcement equal to $100/\sqrt{S}$, where S is in ft. For the span lengths considered in this study, the percent decrease of the main reinforcement from 20% for short span bridges of 24 ft to 15% for the long span bridges 54 ft. The results for all skew angles indicated a conformance with AASHTO requirements whereby the percent difference with the maximum longitudinal moment is decreasing with the increase in span length. Generally, this transverse reinforcement is low so that shrinkage and temperature reinforcement governs. For skew angles equal to 40 and 50°, the percent difference decreases with the span length and is in the range of 50 to 65% for two, three, and four lane bridges.

4.3.1.1.3 Maximum Live Load Deflection

Table 4.10 summarizes the maximum FEA live load deflection as compared to the AASHTO criterion of $(S/800)$. The FEA results are directly related to the assumed slab thickness, which was a reasonable assumption for deflection control. But one can always assume a different thickness and obtain different deflection results.

For any given span length and its corresponding slab thickness, the maximum live load deflection results decrease as the skew angle increases from 0 to 50°. On the other hand, the FEA deflection results range from 1/5 to 1/2 the limiting

value ($S/800$) given by AASHTO, and the percent difference with the AASHTO limiting criteria increases with the skew angle. The percent difference is higher for short spans, and decreases as the span length increases to 54 ft for a given skew angle. Moreover, the basic assumption of the FEA model is the elastic section behavior, an actual cracked section analysis would yield higher deflections in the slabs. The results will increase to approximately 2/5 to 1 of AASHTO limiting deflection value.

Table 4.5: Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 16.6 | -23% | 16.1 | -25% | 15.3 | -29% | 13.5 | -38% | 11.7 | -46% | 9.6 | -55% | 21.6 |
| | 36 | 29.1 | -10% | 28.3 | -13% | 25.9 | -20% | 22.6 | -30% | 18.8 | -42% | 15.2 | -53% | 32.4 |
| | 46 | 42.0 | 1% | 40.8 | -1% | 37.3 | -10% | 32.4 | -22% | 27.0 | -35% | 21.1 | -49% | 41.4 |
| | 54 | 52.2 | 4% | 50.7 | 1% | 46.6 | -7% | 40.6 | -19% | 33.9 | -32% | 26.3 | -48% | 50.2 |
| 2 | 24 | 20.5 | -5% | 19.9 | -8% | 18.7 | -13% | 16.3 | -25% | 13.8 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 35.3 | 9% | 34.7 | 7% | 31.7 | -2% | 27.2 | -16% | 22.2 | -32% | 17.5 | -46% | 32.4 |
| | 46 | 50.4 | 22% | 49.2 | 19% | 44.8 | 8% | 38.3 | -7% | 31.1 | -25% | 23.9 | -42% | 41.4 |
| | 54 | 62.3 | 24% | 60.8 | 21% | 55.5 | 11% | 47.6 | -5% | 38.5 | -23% | 28.3 | -44% | 50.2 |
| 3 | 24 | 21.7 | 1% | 21.3 | -1% | 19.9 | -8% | 16.8 | -22% | 13.9 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 37.5 | 16% | 37.0 | 14% | 33.8 | 4% | 28.9 | -11% | 22.9 | -29% | 17.8 | -45% | 32.4 |
| | 46 | 52.9 | 28% | 51.9 | 25% | 47.2 | 14% | 40.2 | -3% | 32.1 | -23% | 24.6 | -41% | 41.4 |
| | 54 | 65.0 | 30% | 63.6 | 27% | 58.1 | 16% | 49.5 | -1% | 40.0 | -20% | 30.7 | -39% | 50.2 |
| 4 | 24 | 22.3 | 3% | 21.9 | 1% | 20.2 | -6% | 16.9 | -22% | 13.9 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 39.1 | 21% | 38.7 | 20% | 35.1 | 8% | 29.4 | -9% | 23.1 | -29% | 17.8 | -45% | 32.4 |
| | 46 | 55.2 | 33% | 54.3 | 31% | 49.1 | 19% | 41.4 | 0% | 32.4 | -22% | 24.4 | -41% | 41.4 |
| | 54 | 67.7 | 35% | 66.3 | 32% | 60.3 | 20% | 51.0 | 2% | 40.7 | -19% | 30.7 | -39% | 50.2 |

Table 4.6: Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|--|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 16.6 | 28.1 | -41% | 16.1 | 28.1 | -43% | 15.3 | 27.0 | -43% | 13.5 | 25.3 | -47% | 11.7 | 23.6 | -50% | 9.6 | 21.1 | -54% |
| | 36 | 29.1 | 47.2 | -38% | 28.3 | 47.2 | -40% | 25.9 | 45.3 | -43% | 22.6 | 42.5 | -47% | 18.8 | 39.6 | -53% | 15.2 | 35.4 | -57% |
| | 46 | 42.0 | 62.9 | -33% | 40.8 | 62.9 | -35% | 37.3 | 60.4 | -38% | 32.4 | 56.6 | -43% | 27.0 | 52.8 | -49% | 21.1 | 47.2 | -55% |
| | 54 | 52.2 | 75.3 | -31% | 50.7 | 75.3 | -33% | 46.6 | 72.3 | -36% | 40.6 | 67.8 | -40% | 33.9 | 63.3 | -46% | 26.3 | 56.5 | -53% |
| 2 | 24 | 20.5 | 24.1 | -15% | 19.9 | 24.1 | -17% | 18.7 | 23.2 | -19% | 16.3 | 21.7 | -25% | 13.8 | 20.2 | -32% | 10.6 | 18.1 | -42% |
| | 36 | 35.3 | 45.6 | -23% | 34.7 | 45.6 | -24% | 31.7 | 43.8 | -28% | 27.2 | 41.0 | -34% | 22.2 | 38.3 | -42% | 17.5 | 34.2 | -49% |
| | 46 | 50.4 | 65.3 | -23% | 49.2 | 65.3 | -25% | 44.8 | 62.7 | -29% | 38.3 | 58.8 | -35% | 31.1 | 54.9 | -43% | 23.9 | 49.0 | -51% |
| | 54 | 62.3 | 81.7 | -24% | 60.8 | 81.7 | -26% | 55.5 | 78.4 | -29% | 47.6 | 73.5 | -35% | 38.5 | 68.6 | -44% | 28.3 | 61.3 | -54% |
| 3 | 24 | 21.7 | 22.6 | -4% | 21.3 | 22.6 | -6% | 19.9 | 21.7 | -8% | 16.8 | 20.3 | -17% | 13.9 | 19.0 | -27% | 10.6 | 17.0 | -38% |
| | 36 | 37.5 | 42.3 | -11% | 37.0 | 42.3 | -12% | 33.8 | 40.6 | -17% | 28.9 | 38.1 | -24% | 22.9 | 35.5 | -35% | 17.8 | 31.7 | -44% |
| | 46 | 52.9 | 60.4 | -12% | 51.9 | 60.4 | -14% | 47.2 | 58.0 | -19% | 40.2 | 54.4 | -26% | 32.1 | 50.7 | -37% | 24.6 | 45.3 | -46% |
| | 54 | 65.0 | 77.1 | -16% | 63.6 | 77.1 | -18% | 58.1 | 74.0 | -22% | 49.5 | 69.4 | -29% | 40.0 | 64.8 | -38% | 30.7 | 57.8 | -47% |
| 4 | 24 | 22.3 | 21.5 | 4% | 21.9 | 21.5 | 2% | 20.2 | 20.6 | -2% | 16.9 | 19.4 | -13% | 13.9 | 18.1 | -23% | 10.6 | 16.1 | -34% |
| | 36 | 39.1 | 40.0 | -2% | 38.7 | 40.0 | -3% | 35.1 | 38.4 | -8% | 29.4 | 36.0 | -18% | 23.1 | 33.6 | -31% | 17.8 | 30.0 | -41% |
| | 46 | 55.2 | 59.8 | -8% | 54.3 | 59.8 | -9% | 49.1 | 57.4 | -15% | 41.4 | 53.8 | -23% | 32.4 | 50.2 | -35% | 24.4 | 44.8 | -46% |
| | 54 | 67.7 | 77.1 | -12% | 66.3 | 77.1 | -14% | 60.3 | 74.0 | -19% | 51.0 | 69.4 | -27% | 40.7 | 64.8 | -37% | 30.7 | 57.8 | -47% |

Table 4.7: Comparison of FEA Edge Beam Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 20.1 | -22% | 19.6 | -23% | 18.8 | -27% | 16.9 | -34% | 15.5 | -40% | 13.1 | -49% | 25.6 |
| | 36 | 32.7 | -15% | 31.9 | -17% | 29.6 | -23% | 26.3 | -31% | 22.7 | -41% | 18.6 | -51% | 38.4 |
| | 46 | 45.6 | -7% | 44.5 | -9% | 41.0 | -16% | 36.1 | -26% | 30.7 | -38% | 24.5 | -50% | 49.1 |
| | 54 | 55.9 | -3% | 54.4 | -6% | 50.2 | -13% | 44.3 | -23% | 37.7 | -35% | 30.0 | -48% | 57.6 |
| 2 | 24 | 23.1 | -10% | 22.6 | -12% | 21.6 | -16% | 19.4 | -24% | 17.2 | -33% | 14.0 | -45% | 25.6 |
| | 36 | 38.5 | 0% | 38.0 | -1% | 35.2 | -8% | 31.0 | -19% | 26.3 | -31% | 21.1 | -45% | 38.4 |
| | 46 | 53.7 | 9% | 52.7 | 7% | 48.5 | -1% | 42.1 | -14% | 35.0 | -29% | 27.5 | -44% | 49.1 |
| | 54 | 65.8 | 14% | 64.3 | 12% | 59.2 | 3% | 51.5 | -11% | 42.6 | -26% | 32.2 | -44% | 57.6 |
| 3 | 24 | 24.1 | -6% | 23.7 | -7% | 22.5 | -12% | 19.9 | -22% | 17.4 | -32% | 14.0 | -45% | 25.6 |
| | 36 | 40.6 | 6% | 40.3 | 5% | 37.4 | -3% | 32.5 | -15% | 27.1 | -30% | 21.3 | -44% | 38.4 |
| | 46 | 56.5 | 15% | 55.6 | 13% | 51.0 | 4% | 44.1 | -10% | 36.3 | -26% | 28.2 | -43% | 49.1 |
| | 54 | 68.8 | 19% | 67.4 | 17% | 61.9 | 8% | 53.5 | -7% | 44.2 | -23% | 34.3 | -40% | 57.6 |
| 4 | 24 | 24.5 | -4% | 24.1 | -6% | 22.8 | -11% | 20.0 | -22% | 17.4 | -32% | 14.0 | -45% | 25.6 |
| | 36 | 42.1 | 10% | 41.8 | 9% | 38.6 | 0% | 33.0 | -14% | 27.2 | -29% | 21.3 | -44% | 38.4 |
| | 46 | 58.8 | 20% | 57.9 | 18% | 52.9 | 8% | 45.1 | -8% | 36.6 | -25% | 28.0 | -43% | 49.1 |
| | 54 | 71.5 | 24% | 70.1 | 22% | 64.1 | 11% | 55.1 | -4% | 44.9 | -22% | 34.4 | -40% | 57.6 |

Table 4.8: Comparison of FEA Edge Beam Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|---|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 20.1 | 23.0 | -13% | 19.6 | 23.0 | -15% | 18.8 | 22.1 | -15% | 16.9 | 20.7 | -18% | 15.5 | 19.3 | -20% | 13.1 | 17.3 | -24% |
| | 36 | 32.7 | 39.5 | -17% | 31.9 | 39.5 | -19% | 29.6 | 37.9 | -22% | 26.3 | 35.6 | -26% | 22.7 | 33.2 | -32% | 18.6 | 29.7 | -37% |
| | 46 | 45.6 | 60.9 | -25% | 44.5 | 60.9 | -27% | 41.0 | 58.5 | -30% | 36.1 | 54.9 | -34% | 30.7 | 51.2 | -40% | 24.5 | 45.7 | -46% |
| | 54 | 55.9 | 76.1 | -27% | 54.4 | 76.1 | -29% | 50.2 | 73.1 | -31% | 44.3 | 68.5 | -35% | 37.7 | 64.0 | -41% | 30.0 | 57.1 | -48% |
| 2 | 24 | 23.1 | 21.2 | 9% | 22.6 | 21.2 | 7% | 21.6 | 20.3 | 6% | 19.4 | 19.1 | 2% | 17.2 | 17.8 | -3% | 14.0 | 15.9 | -12% |
| | 36 | 38.5 | 41.4 | -7% | 38.0 | 41.4 | -8% | 35.2 | 39.7 | -11% | 31.0 | 37.3 | -17% | 26.3 | 34.8 | -24% | 21.1 | 31.1 | -32% |
| | 46 | 53.7 | 62.3 | -14% | 52.7 | 62.3 | -15% | 48.5 | 59.8 | -19% | 42.1 | 56.1 | -25% | 35.0 | 52.3 | -33% | 27.5 | 46.7 | -41% |
| | 54 | 65.8 | 79.9 | -18% | 64.3 | 79.9 | -20% | 59.2 | 76.7 | -23% | 51.5 | 72.0 | -28% | 42.6 | 67.2 | -37% | 32.2 | 60.0 | -46% |
| 3 | 24 | 24.1 | 20.5 | 18% | 23.7 | 20.5 | 16% | 22.5 | 19.6 | 15% | 19.9 | 18.4 | 8% | 17.4 | 17.2 | 1% | 14.0 | 15.4 | -9% |
| | 36 | 40.6 | 39.7 | 2% | 40.3 | 39.7 | 1% | 37.4 | 38.1 | -2% | 32.5 | 35.8 | -9% | 27.1 | 33.4 | -19% | 21.3 | 29.8 | -28% |
| | 46 | 56.5 | 59.5 | -5% | 55.6 | 59.5 | -7% | 51.0 | 57.1 | -11% | 44.1 | 53.6 | -18% | 36.3 | 50.0 | -27% | 28.2 | 44.6 | -37% |
| | 54 | 68.8 | 77.3 | -11% | 67.4 | 77.3 | -13% | 61.9 | 74.2 | -16% | 53.5 | 69.6 | -23% | 44.2 | 64.9 | -32% | 34.3 | 58.0 | -41% |
| 4 | 24 | 24.5 | 19.9 | 23% | 24.1 | 19.9 | 21% | 22.8 | 19.1 | 19% | 20.0 | 17.9 | 12% | 17.4 | 16.7 | 4% | 14.0 | 14.9 | -6% |
| | 36 | 42.1 | 38.4 | 10% | 41.8 | 38.4 | 9% | 38.6 | 36.9 | 5% | 33.0 | 34.6 | -5% | 27.2 | 32.3 | -16% | 21.3 | 28.8 | -26% |
| | 46 | 58.8 | 59.1 | -1% | 57.9 | 59.1 | -2% | 52.9 | 56.7 | -7% | 45.1 | 53.2 | -15% | 36.6 | 49.7 | -26% | 28.0 | 44.4 | -37% |
| | 54 | 71.5 | 77.3 | -7% | 70.1 | 77.3 | -9% | 64.1 | 74.2 | -14% | 55.1 | 69.6 | -21% | 44.9 | 64.9 | -31% | 34.4 | 58.0 | -41% |

Table 4.9: Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Transverse Moment (Kip-ft/ft) | | | | | | | | | | | |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|
| | | Angle of Skewness | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | |
| 1 | 24 | 5.4 | 0.33 | 5.5 | 0.34 | 5.6 | 0.37 | 5.8 | 0.43 | 6.1 | 0.52 | 6.1 | 0.63 |
| | 36 | 5.6 | 0.19 | 6.3 | 0.22 | 7.5 | 0.29 | 8.6 | 0.38 | 9.2 | 0.49 | 9.2 | 0.61 |
| | 46 | 5.6 | 0.13 | 6.1 | 0.15 | 7.0 | 0.19 | 8.0 | 0.25 | 8.9 | 0.33 | 9.7 | 0.46 |
| | 54 | 5.6 | 0.11 | 5.9 | 0.12 | 6.4 | 0.14 | 7.0 | 0.17 | 7.6 | 0.22 | 8.1 | 0.31 |
| 2 | 24 | 6.9 | 0.33 | 7.0 | 0.35 | 7.3 | 0.39 | 7.4 | 0.45 | 7.9 | 0.57 | 8.6 | 0.81 |
| | 36 | 8.0 | 0.23 | 8.3 | 0.24 | 9.7 | 0.31 | 11.3 | 0.41 | 12.4 | 0.56 | 12.7 | 0.72 |
| | 46 | 8.5 | 0.17 | 9.0 | 0.18 | 10.7 | 0.24 | 12.3 | 0.32 | 13.8 | 0.44 | 14.4 | 0.60 |
| | 54 | 8.6 | 0.14 | 9.1 | 0.15 | 10.5 | 0.19 | 12.0 | 0.25 | 14.2 | 0.37 | 13.9 | 0.49 |
| 3 | 24 | 7.5 | 0.35 | 7.6 | 0.36 | 7.8 | 0.39 | 9.0 | 0.53 | 9.5 | 0.68 | 8.7 | 0.82 |
| | 36 | 9.9 | 0.26 | 10.4 | 0.28 | 11.8 | 0.35 | 13.7 | 0.47 | 14.1 | 0.61 | 13.3 | 0.75 |
| | 46 | 11.3 | 0.21 | 11.9 | 0.23 | 14.0 | 0.30 | 16.0 | 0.40 | 16.9 | 0.53 | 16.3 | 0.66 |
| | 54 | 12.0 | 0.18 | 12.5 | 0.20 | 14.7 | 0.25 | 16.8 | 0.34 | 18.0 | 0.45 | 17.6 | 0.57 |
| 4 | 24 | 7.8 | 0.35 | 7.8 | 0.36 | 8.9 | 0.44 | 9.2 | 0.54 | 9.5 | 0.68 | 8.7 | 0.82 |
| | 36 | 10.9 | 0.28 | 11.4 | 0.30 | 13.2 | 0.38 | 14.4 | 0.49 | 14.2 | 0.61 | 13.3 | 0.75 |
| | 46 | 13.3 | 0.24 | 13.9 | 0.26 | 16.2 | 0.33 | 17.9 | 0.43 | 17.6 | 0.54 | 16.1 | 0.66 |
| | 54 | 14.6 | 0.22 | 15.2 | 0.23 | 17.8 | 0.30 | 19.7 | 0.39 | 19.7 | 0.48 | 17.7 | 0.58 |

Table 4.10: Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion

| Number of Lanes | Span Length (ft) | FEA Maximum Slab Deflection (in) | | | | | | | | | | | | AASHTO Deflection (in) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.066 | -82% | 0.064 | -82% | 0.059 | -84% | 0.049 | -87% | 0.039 | -89% | 0.028 | -92% | 0.360 |
| | 36 | 0.180 | -67% | 0.172 | -68% | 0.151 | -72% | 0.124 | -77% | 0.094 | -83% | 0.066 | -88% | 0.540 |
| | 46 | 0.291 | -58% | 0.279 | -60% | 0.247 | -64% | 0.202 | -71% | 0.155 | -78% | 0.107 | -84% | 0.690 |
| | 54 | 0.352 | -57% | 0.337 | -58% | 0.300 | -63% | 0.247 | -70% | 0.190 | -77% | 0.131 | -84% | 0.810 |
| 2 | 24 | 0.080 | -78% | 0.078 | -78% | 0.071 | -80% | 0.059 | -84% | 0.045 | -87% | 0.031 | -91% | 0.360 |
| | 36 | 0.219 | -59% | 0.213 | -61% | 0.189 | -65% | 0.154 | -71% | 0.115 | -79% | 0.080 | -85% | 0.540 |
| | 46 | 0.352 | -49% | 0.340 | -51% | 0.303 | -56% | 0.246 | -64% | 0.186 | -73% | 0.127 | -82% | 0.690 |
| | 54 | 0.423 | -48% | 0.408 | -50% | 0.364 | -55% | 0.298 | -63% | 0.226 | -72% | 0.151 | -81% | 0.810 |
| 3 | 24 | 0.085 | -76% | 0.083 | -77% | 0.076 | -79% | 0.061 | -83% | 0.046 | -87% | 0.031 | -91% | 0.360 |
| | 36 | 0.233 | -57% | 0.229 | -58% | 0.203 | -62% | 0.165 | -69% | 0.121 | -78% | 0.081 | -85% | 0.540 |
| | 46 | 0.373 | -46% | 0.363 | -47% | 0.322 | -53% | 0.261 | -62% | 0.195 | -72% | 0.132 | -81% | 0.690 |
| | 54 | 0.445 | -45% | 0.431 | -47% | 0.384 | -53% | 0.313 | -61% | 0.237 | -71% | 0.161 | -80% | 0.810 |
| 4 | 24 | 0.087 | -76% | 0.085 | -76% | 0.077 | -79% | 0.062 | -83% | 0.046 | -87% | 0.031 | -91% | 0.360 |
| | 36 | 0.243 | -55% | 0.239 | -56% | 0.211 | -61% | 0.168 | -69% | 0.122 | -77% | 0.081 | -85% | 0.540 |
| | 46 | 0.390 | -43% | 0.380 | -45% | 0.335 | -51% | 0.269 | -61% | 0.197 | -71% | 0.131 | -81% | 0.690 |
| | 54 | 0.465 | -43% | 0.451 | -44% | 0.400 | -51% | 0.324 | -60% | 0.241 | -70% | 0.161 | -80% | 0.810 |

4.3.1.2 FEA Results of Skewed Versus Straight Bridge

4.3.1.2.1 Maximum longitudinal Bending Moment and Edge Beam Moment

The ratios $M_{0/\alpha\alpha} / M_{0/00}$ for the maximum longitudinal moment are shown in Table 4.11 and Figure 4.5, for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. Table 4.12 and Figure 4.6 correspond to edge beam moments. Such Tables/Figures indicate a uniform pattern of decrease in the maximum longitudinal and edge moment values with the increase in the skew angle, compared to that of straight bridges regardless of the number of lanes and span length. This decrease appears to be significant when the skew angle exceeds 20°. Also, for skew angles greater than 20°, the ratio $M_{0/\alpha\alpha} / M_{0/00}$ decreases with the increase in the number of lanes from one to four. For both the maximum longitudinal moment and edge beam moment, the ratio $M_{0/\alpha\alpha} / M_{0/00}$ is almost one for bridges with skew angles less than 20°, decreases to about 0.75 for bridges with skew angles between 30 and 40°, and further decreases to about 0.5 as the bridge skew angle increases to 50°.

4.3.1.2.2 Maximum Transverse Moment

The ratios $M_{0/\alpha\alpha} / M_{0/00}$ for the maximum transverse moment are shown in Table 4.13 and Figure 4.7 for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. In contrast with the longitudinal moment results, the maximum transverse moment increases almost linearly as the skew angle increases from 10 to 40°, where it reaches a peak value. The $M_{0/\alpha\alpha} / M_{0/00}$ ratio decreases slightly again for skew angles between 40 and 50°. The ratio $M_{0/\alpha\alpha} / M_{0/00}$ varies with the variation in the span length and width, thus no general pattern can be deduced as for the results discussed in previous sections. For span bridges less than 36 ft in combination with three bridges, the ratio $M_{0/\alpha\alpha} / M_{0/00}$ reaches a maximum of

1.25 at a skew angle of 40°. For bridge spans between 46 and 54 ft , the ratio $M_0/\alpha\alpha / M_0/00$ is less than 1.3 for skew angles up to 20° regardless of the number of lanes. At 30°, the ratio is in the range of 1.4 for the one lane bridge to 1.35 for the four lane bridge. This range becomes wider at 40 and 50° skew angle whereby it reaches a maximum of 1.75 for one lane bridges and a minimum of 1.2 for four lane bridges.

4.3.1.2.3 Maximum Live Load Deflection

The ratio $\Delta_0/\alpha\alpha / \Delta_0/00$ values obtained are presented in Table 4.14 and Figure 4.8 for each of the four span lengths considered (24, 36, 46, and 54 ft). The maximum live load deflection pattern is consistent and expected to be similar to the maximum longitudinal bending moment as well as the edge beam moment. These values indicate that the maximum live load deflection for skewed bridges compared to that of straight bridges decreases with the skew angle for all span lengths and the number of lanes. This decrease is summarized as follows: The ratio is about one for a skew angle up to 10° and is approximately equal to 0.9 for a skew angle equal to 20°; this ratio further decreases to about 0.75 as the skew angle increases to 30° and reaches a minimum of 0.35 at a skew angle of 50°.

Table 4.11: FEA Maximum Longitudinal Bending Moment – Ratio $M_0/\alpha\alpha$ / $M_0/00$

| Number of Lanes | Span Length (ft) | Maximum Longitudinal Moment - $M_0/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M_0/00$ (Kip-ft/ft) |
|-----------------|------------------|--|------|------------|------|------------|------|------------|------|------------|------|------------|------|-------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 16.6 | 1.00 | 16.1 | 0.97 | 15.3 | 0.92 | 13.5 | 0.81 | 11.7 | 0.71 | 9.6 | 0.58 | 16.6 |
| | 36 | 29.1 | 1.00 | 28.3 | 0.97 | 25.9 | 0.89 | 22.6 | 0.78 | 18.8 | 0.65 | 15.2 | 0.52 | 29.1 |
| | 46 | 42.0 | 1.00 | 40.8 | 0.97 | 37.3 | 0.89 | 32.4 | 0.77 | 27.0 | 0.64 | 21.1 | 0.50 | 42.0 |
| | 54 | 52.2 | 1.00 | 50.7 | 0.97 | 46.6 | 0.89 | 40.6 | 0.78 | 33.9 | 0.65 | 26.3 | 0.50 | 52.2 |
| 2 | 24 | 20.5 | 1.00 | 19.9 | 0.97 | 18.7 | 0.91 | 16.3 | 0.80 | 13.8 | 0.67 | 10.6 | 0.52 | 20.5 |
| | 36 | 35.3 | 1.00 | 34.7 | 0.98 | 31.7 | 0.90 | 27.2 | 0.77 | 22.2 | 0.63 | 17.5 | 0.50 | 35.3 |
| | 46 | 50.4 | 1.00 | 49.2 | 0.98 | 44.8 | 0.89 | 38.3 | 0.76 | 31.1 | 0.62 | 23.9 | 0.47 | 50.4 |
| | 54 | 62.3 | 1.00 | 60.8 | 0.97 | 55.5 | 0.89 | 47.6 | 0.76 | 38.5 | 0.62 | 28.3 | 0.45 | 62.3 |
| 3 | 24 | 21.7 | 1.00 | 21.3 | 0.98 | 19.9 | 0.92 | 16.8 | 0.77 | 13.9 | 0.64 | 10.6 | 0.49 | 21.7 |
| | 36 | 37.5 | 1.00 | 37.0 | 0.99 | 33.8 | 0.90 | 28.9 | 0.77 | 22.9 | 0.61 | 17.8 | 0.47 | 37.5 |
| | 46 | 52.9 | 1.00 | 51.9 | 0.98 | 47.2 | 0.89 | 40.2 | 0.76 | 32.1 | 0.61 | 24.6 | 0.47 | 52.9 |
| | 54 | 65.0 | 1.00 | 63.6 | 0.98 | 58.1 | 0.89 | 49.5 | 0.76 | 40.0 | 0.62 | 30.7 | 0.47 | 65.0 |
| 4 | 24 | 22.3 | 1.00 | 21.9 | 0.98 | 20.2 | 0.91 | 16.9 | 0.76 | 13.9 | 0.62 | 10.6 | 0.48 | 22.3 |
| | 36 | 39.1 | 1.00 | 38.7 | 0.99 | 35.1 | 0.90 | 29.4 | 0.75 | 23.1 | 0.59 | 17.8 | 0.45 | 39.1 |
| | 46 | 55.2 | 1.00 | 54.3 | 0.98 | 49.1 | 0.89 | 41.4 | 0.75 | 32.4 | 0.59 | 24.4 | 0.44 | 55.2 |
| | 54 | 67.7 | 1.00 | 66.3 | 0.98 | 60.3 | 0.89 | 51.0 | 0.75 | 40.7 | 0.60 | 30.7 | 0.45 | 67.7 |

Table 4.12: FEA Edge Beam Moment – Ratio $M0/\alpha\alpha$ / $M0/00$

| Number of Lanes | Span Length (ft) | Edge Beam Moment - $M0/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Edge Moment $M0/00$ (Kip-ft/ft) |
|-----------------|------------------|--|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 20.1 | 1.00 | 19.6 | 0.98 | 18.8 | 0.94 | 16.9 | 0.84 | 15.5 | 0.77 | 13.1 | 0.65 | 20.1 |
| | 36 | 32.7 | 1.00 | 31.9 | 0.98 | 29.6 | 0.91 | 26.3 | 0.80 | 22.7 | 0.70 | 18.6 | 0.57 | 32.7 |
| | 46 | 45.6 | 1.00 | 44.5 | 0.98 | 41.0 | 0.90 | 36.1 | 0.79 | 30.7 | 0.67 | 24.5 | 0.54 | 45.6 |
| | 54 | 55.9 | 1.00 | 54.4 | 0.97 | 50.2 | 0.90 | 44.3 | 0.79 | 37.7 | 0.67 | 30.0 | 0.54 | 55.9 |
| 2 | 24 | 23.1 | 1.00 | 22.6 | 0.98 | 21.6 | 0.93 | 19.4 | 0.84 | 17.2 | 0.74 | 14.0 | 0.60 | 23.1 |
| | 36 | 38.5 | 1.00 | 38.0 | 0.99 | 35.2 | 0.91 | 31.0 | 0.81 | 26.3 | 0.68 | 21.1 | 0.55 | 38.5 |
| | 46 | 53.7 | 1.00 | 52.7 | 0.98 | 48.5 | 0.90 | 42.1 | 0.78 | 35.0 | 0.65 | 27.5 | 0.51 | 53.7 |
| | 54 | 65.8 | 1.00 | 64.3 | 0.98 | 59.2 | 0.90 | 51.5 | 0.78 | 42.6 | 0.65 | 32.2 | 0.49 | 65.8 |
| 3 | 24 | 24.1 | 1.00 | 23.7 | 0.98 | 22.5 | 0.93 | 19.9 | 0.82 | 17.4 | 0.72 | 14.0 | 0.58 | 24.1 |
| | 36 | 40.6 | 1.00 | 40.3 | 0.99 | 37.4 | 0.92 | 32.5 | 0.80 | 27.1 | 0.67 | 21.3 | 0.52 | 40.6 |
| | 46 | 56.5 | 1.00 | 55.6 | 0.98 | 51.0 | 0.90 | 44.1 | 0.78 | 36.3 | 0.64 | 28.2 | 0.50 | 56.5 |
| | 54 | 68.8 | 1.00 | 67.4 | 0.98 | 61.9 | 0.90 | 53.5 | 0.78 | 44.2 | 0.64 | 34.3 | 0.50 | 68.8 |
| 4 | 24 | 24.5 | 1.00 | 24.1 | 0.99 | 22.8 | 0.93 | 20.0 | 0.82 | 17.4 | 0.71 | 14.0 | 0.57 | 24.5 |
| | 36 | 42.1 | 1.00 | 41.8 | 0.99 | 38.6 | 0.92 | 33.0 | 0.78 | 27.2 | 0.65 | 21.3 | 0.51 | 42.1 |
| | 46 | 58.8 | 1.00 | 57.9 | 0.99 | 52.9 | 0.90 | 45.1 | 0.77 | 36.6 | 0.62 | 28.0 | 0.48 | 58.8 |
| | 54 | 71.5 | 1.00 | 70.1 | 0.98 | 64.1 | 0.90 | 55.1 | 0.77 | 44.9 | 0.63 | 34.4 | 0.48 | 71.5 |

Table 4.13: FEA Maximum Transverse Moment – Ratio $M0/\alpha\alpha$ / $M0/00$

| Number of Lanes | Span Length (ft) | Maximum Transverse Moment - $M0/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M0/00$ (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 5.4 | 1.00 | 5.5 | 1.01 | 5.6 | 1.04 | 5.8 | 1.07 | 6.1 | 1.13 | 6.1 | 1.13 | 5.4 |
| | 36 | 5.6 | 1.00 | 6.3 | 1.12 | 7.5 | 1.35 | 8.6 | 1.54 | 9.2 | 1.65 | 9.2 | 1.65 | 5.6 |
| | 46 | 5.6 | 1.00 | 6.1 | 1.09 | 7.0 | 1.25 | 8.0 | 1.42 | 8.9 | 1.59 | 9.7 | 1.73 | 5.6 |
| | 54 | 5.6 | 1.00 | 5.9 | 1.05 | 6.4 | 1.14 | 7.0 | 1.25 | 7.6 | 1.35 | 8.1 | 1.44 | 5.6 |
| 2 | 24 | 6.9 | 1.00 | 7.0 | 1.01 | 7.3 | 1.06 | 7.4 | 1.08 | 7.9 | 1.15 | 8.6 | 1.25 | 6.9 |
| | 36 | 8.0 | 1.00 | 8.3 | 1.04 | 9.7 | 1.21 | 11.3 | 1.41 | 12.4 | 1.55 | 12.7 | 1.59 | 8.0 |
| | 46 | 8.5 | 1.00 | 9.0 | 1.06 | 10.7 | 1.26 | 12.3 | 1.45 | 13.8 | 1.62 | 14.4 | 1.70 | 8.5 |
| | 54 | 8.6 | 1.00 | 9.1 | 1.06 | 10.5 | 1.21 | 12.0 | 1.39 | 14.2 | 1.64 | 13.9 | 1.61 | 8.6 |
| 3 | 24 | 7.5 | 1.00 | 7.6 | 1.01 | 7.8 | 1.04 | 9.0 | 1.19 | 9.5 | 1.26 | 8.7 | 1.15 | 7.5 |
| | 36 | 9.9 | 1.00 | 10.4 | 1.05 | 11.8 | 1.19 | 13.7 | 1.38 | 14.1 | 1.42 | 13.3 | 1.34 | 9.9 |
| | 46 | 11.3 | 1.00 | 11.9 | 1.05 | 14.0 | 1.23 | 16.0 | 1.41 | 16.9 | 1.49 | 16.3 | 1.44 | 11.3 |
| | 54 | 12.0 | 1.00 | 12.5 | 1.04 | 14.7 | 1.23 | 16.8 | 1.40 | 18.0 | 1.50 | 17.6 | 1.47 | 12.0 |
| 4 | 24 | 7.8 | 1.00 | 7.8 | 1.00 | 8.9 | 1.13 | 9.2 | 1.18 | 9.5 | 1.22 | 8.7 | 1.11 | 7.8 |
| | 36 | 10.9 | 1.00 | 11.4 | 1.05 | 13.2 | 1.21 | 14.4 | 1.32 | 14.2 | 1.30 | 13.3 | 1.22 | 10.9 |
| | 46 | 13.3 | 1.00 | 13.9 | 1.05 | 16.2 | 1.22 | 17.9 | 1.35 | 17.6 | 1.32 | 16.1 | 1.21 | 13.3 |
| | 54 | 14.6 | 1.00 | 15.2 | 1.04 | 17.8 | 1.22 | 19.7 | 1.35 | 19.7 | 1.35 | 17.7 | 1.21 | 14.6 |

Table 4.14: FEA Maximum Live Load Deflection – Ratio $\Delta 0/\alpha\alpha / \Delta 0/00$

| Number of Lanes | Span Length (ft) | Maximum Live Load Deflection - $\Delta 0/\alpha\alpha$ (in) | | | | | | | | | | | | Maximum Deflection $\Delta 0/00$ (in) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.066 | 1.00 | 0.064 | 0.96 | 0.059 | 0.89 | 0.049 | 0.73 | 0.039 | 0.58 | 0.028 | 0.42 | 0.066 |
| | 36 | 0.180 | 1.00 | 0.172 | 0.96 | 0.151 | 0.84 | 0.124 | 0.69 | 0.094 | 0.52 | 0.066 | 0.37 | 0.180 |
| | 46 | 0.291 | 1.00 | 0.279 | 0.96 | 0.247 | 0.85 | 0.202 | 0.69 | 0.155 | 0.53 | 0.107 | 0.37 | 0.291 |
| | 54 | 0.352 | 1.00 | 0.337 | 0.96 | 0.300 | 0.85 | 0.247 | 0.70 | 0.190 | 0.54 | 0.131 | 0.37 | 0.352 |
| 2 | 24 | 0.080 | 1.00 | 0.078 | 0.96 | 0.071 | 0.88 | 0.059 | 0.74 | 0.045 | 0.56 | 0.031 | 0.38 | 0.080 |
| | 36 | 0.219 | 1.00 | 0.213 | 0.97 | 0.189 | 0.86 | 0.154 | 0.70 | 0.115 | 0.53 | 0.080 | 0.36 | 0.219 |
| | 46 | 0.352 | 1.00 | 0.340 | 0.97 | 0.303 | 0.86 | 0.246 | 0.70 | 0.186 | 0.53 | 0.127 | 0.36 | 0.352 |
| | 54 | 0.423 | 1.00 | 0.408 | 0.96 | 0.364 | 0.86 | 0.298 | 0.70 | 0.226 | 0.53 | 0.151 | 0.36 | 0.423 |
| 3 | 24 | 0.085 | 1.00 | 0.083 | 0.97 | 0.076 | 0.89 | 0.061 | 0.72 | 0.046 | 0.54 | 0.031 | 0.36 | 0.085 |
| | 36 | 0.233 | 1.00 | 0.229 | 0.98 | 0.203 | 0.87 | 0.165 | 0.71 | 0.121 | 0.52 | 0.081 | 0.35 | 0.233 |
| | 46 | 0.373 | 1.00 | 0.363 | 0.97 | 0.322 | 0.86 | 0.261 | 0.70 | 0.195 | 0.52 | 0.132 | 0.35 | 0.373 |
| | 54 | 0.445 | 1.00 | 0.431 | 0.97 | 0.384 | 0.86 | 0.313 | 0.70 | 0.237 | 0.53 | 0.161 | 0.36 | 0.445 |
| 4 | 24 | 0.087 | 1.00 | 0.085 | 0.97 | 0.077 | 0.88 | 0.062 | 0.71 | 0.046 | 0.53 | 0.031 | 0.36 | 0.087 |
| | 36 | 0.243 | 1.00 | 0.239 | 0.98 | 0.211 | 0.87 | 0.168 | 0.69 | 0.122 | 0.50 | 0.081 | 0.33 | 0.243 |
| | 46 | 0.390 | 1.00 | 0.380 | 0.97 | 0.335 | 0.86 | 0.269 | 0.69 | 0.197 | 0.50 | 0.131 | 0.33 | 0.390 |
| | 54 | 0.465 | 1.00 | 0.451 | 0.97 | 0.400 | 0.86 | 0.324 | 0.70 | 0.241 | 0.52 | 0.161 | 0.35 | 0.465 |

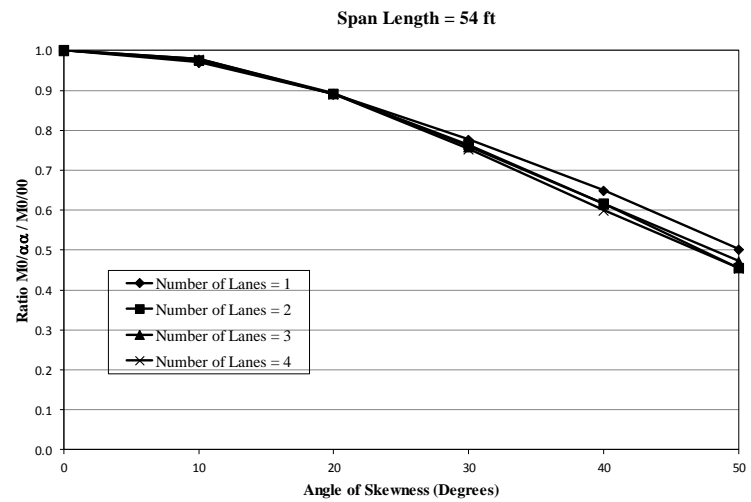
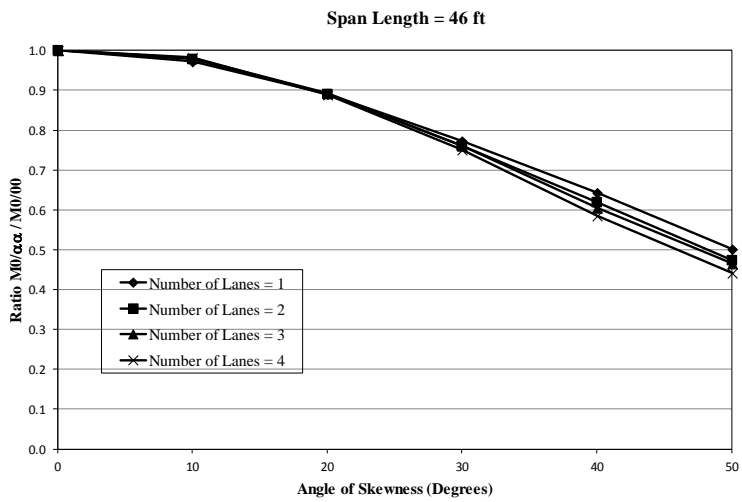
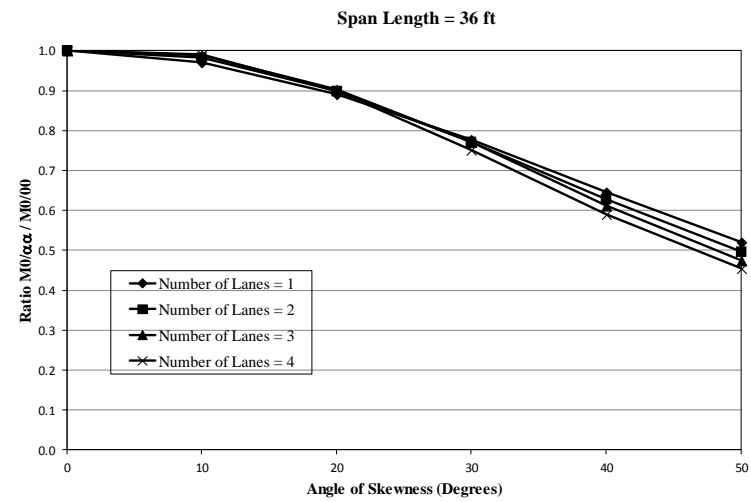
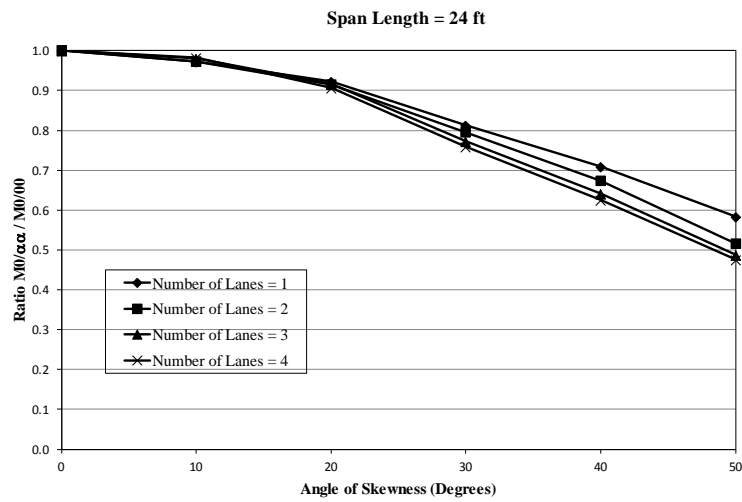


Figure 4.5: FEA Maximum Longitudinal Bending Moment – Ratio $M0/\alpha\alpha / M0/00$

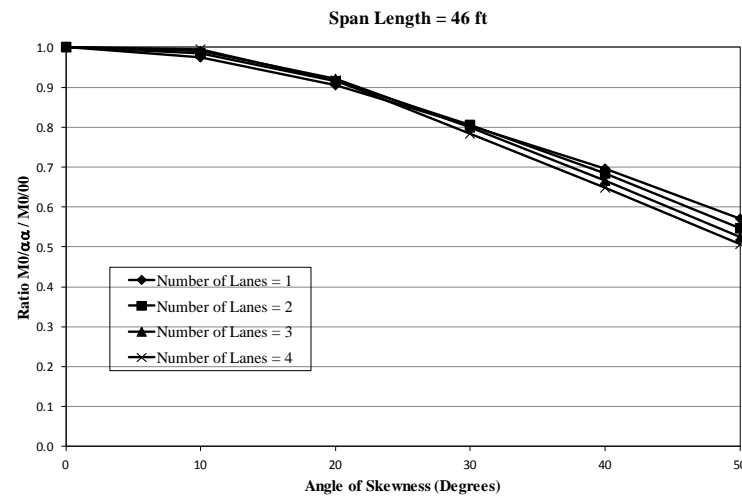
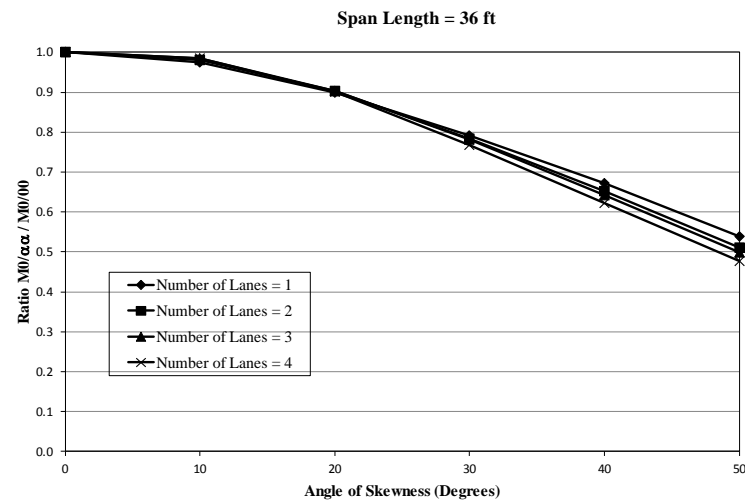
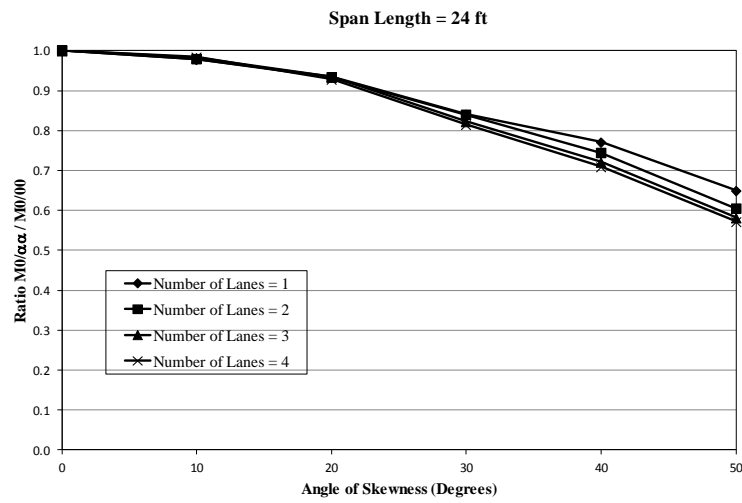


Figure 4.6: FEA Edge Beam Moment – Ratio $M0/\alpha\alpha / M0/00$

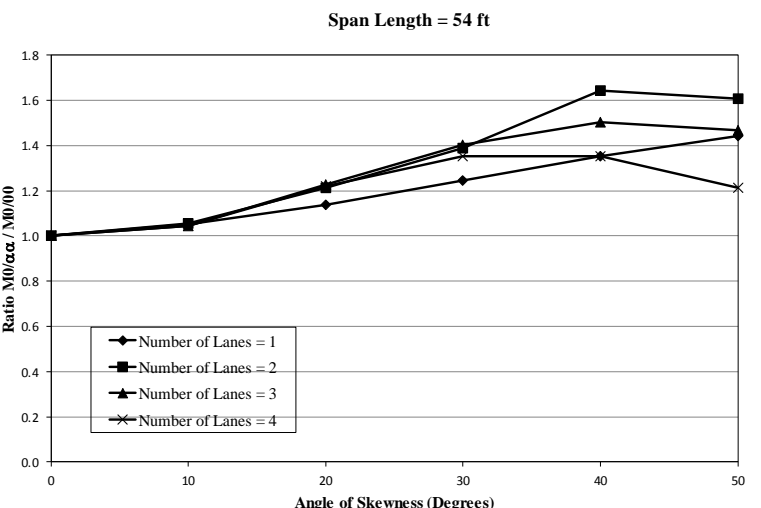
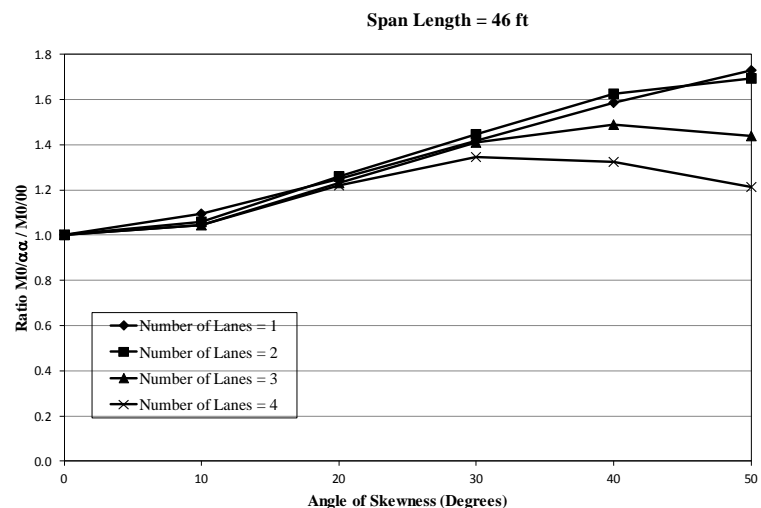
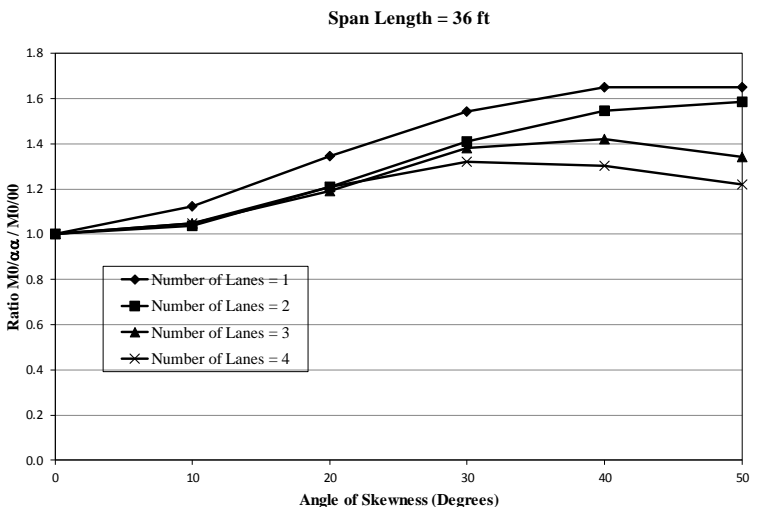
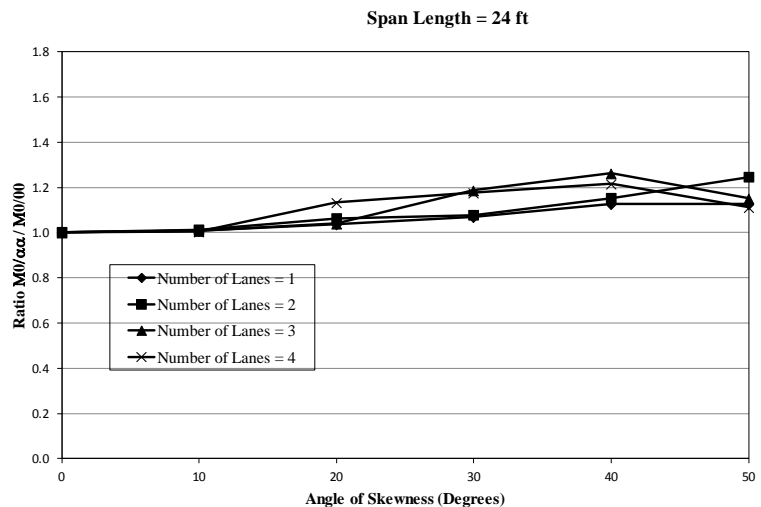


Figure 4.7: FEA Maximum Transverse Moment – Ratio $M0/\alpha\alpha / M0/00$

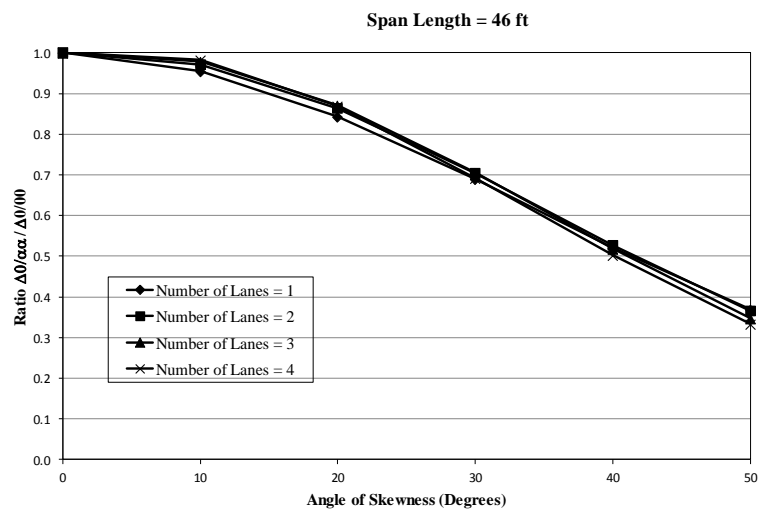
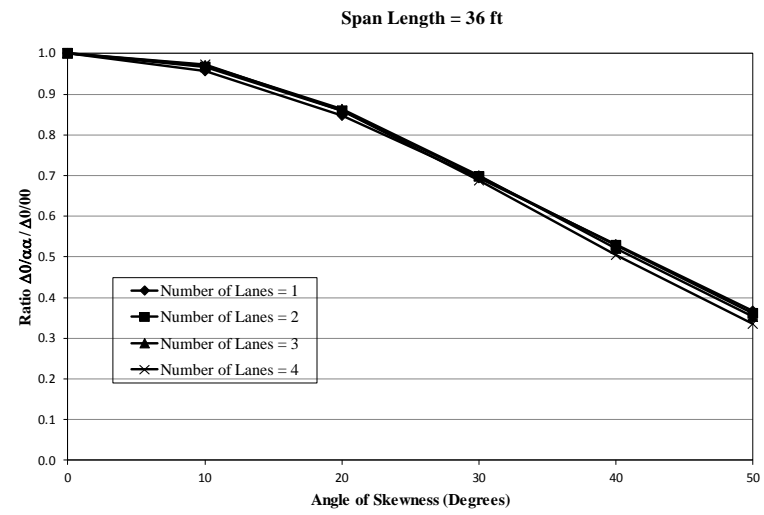
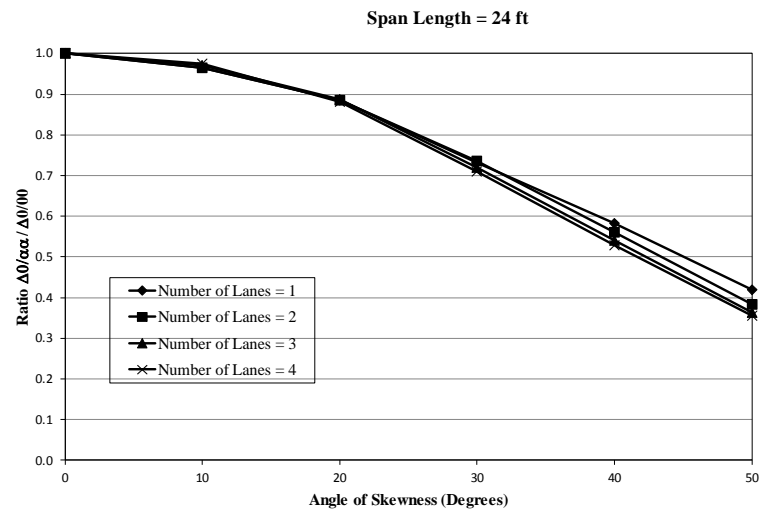


Figure 4.8: FEA Maximum Live Load Deflection – Ratio $\Delta 0/\alpha / \Delta 0/00$

4.3.1.3 Summary

The AASHTO Standard Specifications gave similar results to the FEA maximum longitudinal bending moment when the skew angle is less than or equal to 20°. As the skew angle increases, AASHTO Standard Specifications overestimated the maximum moment by about 20% for 30°, 80% for 40°, and 100% for 50°. The procedure presented in AASHTO LRFD Design Specifications overestimated the FEA maximum longitudinal bending moment by up to 65% for skew angles less than 30° and reaching 100% for 50°. The ratio between the FEA longitudinal moments for skewed and straight bridges was almost one for bridges with skew angle less than 20°. This ratio decreased to 0.75 for bridges with skew angles between 30 and 40°, and further decreased to 0.5 as the skew angle of the bridge increased to 50°. This decrease in the longitudinal moment ratio is offset by an increase by up to 65% in the maximum transverse moment ratio as the skew angle increases from 0 to 50°. The ratio between the FEA maximum live load deflection for skewed bridges and straight bridges decreases in a pattern consistent with that of the longitudinal moment. This ratio decreases from one for skew angles less than 10° to 0.6 for skew angles between 40 and 50°.

4.3.2 Skewed Bridges with One Railing “Case 2”

4.3.2.1 FEA Results versus AASHTO

4.3.2.1.1 Maximum Longitudinal Bending Moment and Edge Beam Moment

The maximum slab and edge beam longitudinal bending moments are summarized in Tables 4.15 to 4.18, for all “Case 2” bridges analyzed along with the corresponding AASHTO bending moments.

The AASHTO moments are computed using Eqs. (1) and (2) for the standard specifications, and Eq. (5) for LRFD after applying the necessary reduction for all skew angles Eq. (6).

The FEA maximum longitudinal bending moment and edge beam moments for skew angles less than 30° were first compared to the AASHTO standard specifications equations. For one lane bridges with span lengths less than 36 ft, AASHTO overestimates the maximum longitudinal bending moment by about 55%, and the edge beam moment by about 40%. AASHTO overestimates the FEA results for both moment values by about 25% for bridges with span lengths greater than 46 ft. For two lane bridges, AASHTO gives longitudinal bending moment similar to the FEA results for all span lengths greater than 24 ft, and overestimates the maximum moment by about 15% when the span length is less than 24 ft. The FEA edge beam moment results are similar to the AASHTO recommended moment for all two lane bridges except for bridges with span length less than 24 ft where AASHTO underestimates the FEA edge beam moment by 15%. For three and four lane bridges, AASHTO recommended moment are similar to FEA maximum longitudinal moment results for bridges with spans less than 24 ft, and underestimates the maximum moments by about 30% for bridges with span lengths greater than 36 ft. The AASHTO procedure recommended edge beam moment are similar to FEA edge beam moment results for all three and four lane bridges with spans less than 46 ft, and underestimates the maximum edge beam moment by about 25% for bridges with span length greater than 46 ft. Considering the skew angle between 30° and 40° , and for span lengths between 24 ft and 54 ft, the AASHTO procedure overestimates the maximum longitudinal moment and edge beam moment by about 65% for one lane bridges, 40% for two lane bridges, and 30% for three and four lane bridges. At

relatively high skew angles, reaching 50°, AASHTO overestimates the maximum longitudinal moment and edge beam moment by about 100% for all span lengths and slab widths considered in the analysis. It is worth noting here that this overestimation is counter balanced by a significant increase in the maximum transverse moment as detailed later.

The maximum FEA longitudinal bending moments were also compared to the AASHTO LRFD moments. For skew angles less than 30°, LRFD overestimates the maximum longitudinal moment by about 100% for one lane bridges, 40% for two lane bridges, 25% for three lane bridges, and gives similar results for four lane bridges. The LRFD overestimate of the maximum longitudinal moment increases almost linearly with the skew angle as it varies from 30 to 50°. The LRFD overestimates the bending moment by about 120% for one lane bridges, 100% for two lane bridges, and 80% for three and four lane bridges.

As for the maximum FEA longitudinal bending moments, FEA edge beam moments were also compared to AASHTO LRFD moments. For skew angles less than 30°, LRFD overestimates FEA maximum edge beam moment by about 40% for one lane bridges with span length less than 36 ft, and 65% for bridges with span length greater than 46 ft. For two lane bridges with span length less than 36 ft, LRFD gives similar results to FEA maximum edge beam moment and overestimates FEA maximum edge beam moment by about 25% for bridges with span length greater than 46 ft. For three and four lanes, LRFD underestimates FEA edge beam moment by about 25 % for bridges with span length less than 36 ft and gives similar results to FEA edge beam moments for bridges with span length greater than 36 ft. Considering the skew angle greater than 30°, and for bridges with span length less than 36 ft, LRFD overestimates FEA edge beam moment by about 30 % for one lane bridges and

gives similar results to FEA edge beam moment for two, three and four lane bridges. For span length greater than 36 ft LRFD overestimates increases linearly with the skew angle till it reaches 65% for one and two lane bridges, and 50% for three and four lane bridges.

4.3.2.1.2 Maximum Transverse Moment

Table 4.19 summarizes the FEA maximum transverse moments for all “Case 2” bridges. The maximum transverse moment was compared with the corresponding maximum moment value in the longitudinal direction. The ratio of transverse to longitudinal moments is also reported in Table 4.19.

The maximum FEA transverse moments increased with the increase in the skew angle even though the maximum longitudinal moment is decreasing. The ratio of maximum FEA transverse to longitudinal moment increases significantly when the skew angle is increased, from about 20% for straight bridges up to 65% for bridges with 50° skewness. AASHTO accommodates the transverse bending moment by specifying a percentage of the main reinforcement equal to $100/\sqrt{S}$, where S is in ft. For the span lengths considered in this study, the percent decrease of the main reinforcement from 20% for short span bridges of 24 ft to 15% for the long span bridges 54 ft. The results for all skew angles indicated a conformance with AASHTO requirements whereby the percent difference with the maximum longitudinal moment is decreasing with the increase in span length. Generally, this transverse reinforcement is low so that shrinkage and temperature reinforcement governs. For skew angles equal to 40 and 50°, the percent difference decreases with the span length and is in the range of 50 to 65% for two, three, and four lane bridges.

4.3.2.1.3 Maximum Live Load Deflection

Table 4.20 summarizes the maximum FEA live load deflection as compared to the AASHTO criterion of $(S/800)$. The FEA results are directly related to the assumed slab thickness, which was a reasonable assumption for deflection control. But one can always assume a different thickness and obtain different deflection results.

For any given span length and its corresponding slab thickness, the maximum live load deflection results decrease as the skew angle increases from 0 to 50°. On the other hand, the FEA deflection results range from 1/5 to 1/2 the limiting value $(S/800)$ given by AASHTO, and the percent difference with the AASHTO limiting criteria increases with the skew angle. The percent difference is higher for short spans, and decreases as the span length increases to 54 for a given skew angle. Moreover, the basic assumption of the FEA model is the elastic section behavior, an actual cracked section analysis would yield higher deflections in the slabs. The results will increase to approximately 2/5 to 1 of AASHTO limiting deflection value.

Table 4.15: Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 13.9 | -36% | 13.7 | -36% | 13.3 | -38% | 12.3 | -43% | 11.0 | -49% | 9.5 | -56% | 21.6 |
| | 36 | 22.9 | -29% | 22.4 | -31% | 21.2 | -35% | 19.3 | -40% | 16.8 | -48% | 14.4 | -56% | 32.4 |
| | 46 | 33.7 | -19% | 32.9 | -20% | 30.9 | -25% | 27.8 | -33% | 24.0 | -42% | 19.6 | -53% | 41.4 |
| | 54 | 43.7 | -13% | 42.7 | -15% | 39.9 | -20% | 35.5 | -29% | 30.4 | -39% | 24.3 | -52% | 50.2 |
| 2 | 24 | 19.2 | -11% | 18.9 | -13% | 18.0 | -17% | 16.0 | -26% | 13.8 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 31.6 | -3% | 31.2 | -4% | 29.1 | -10% | 25.9 | -20% | 21.7 | -33% | 17.5 | -46% | 32.4 |
| | 46 | 45.1 | 9% | 44.2 | 7% | 41.1 | -1% | 36.1 | -13% | 30.2 | -27% | 23.7 | -43% | 41.4 |
| | 54 | 56.8 | 13% | 55.6 | 11% | 51.5 | 3% | 45.0 | -10% | 37.2 | -26% | 28.0 | -44% | 50.2 |
| 3 | 24 | 21.4 | -1% | 21.1 | -3% | 19.8 | -8% | 16.8 | -22% | 13.9 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 36.0 | 11% | 35.7 | 10% | 33.0 | 2% | 28.6 | -12% | 22.9 | -29% | 17.8 | -45% | 32.4 |
| | 46 | 50.5 | 22% | 49.6 | 20% | 45.8 | 11% | 39.5 | -5% | 31.9 | -23% | 24.6 | -41% | 41.4 |
| | 54 | 62.3 | 24% | 61.1 | 22% | 56.3 | 12% | 48.5 | -3% | 39.7 | -21% | 30.7 | -39% | 50.2 |
| 4 | 24 | 22.2 | 3% | 21.9 | 1% | 20.2 | -7% | 16.9 | -22% | 13.9 | -36% | 10.6 | -51% | 21.6 |
| | 36 | 38.6 | 19% | 38.2 | 18% | 34.9 | 8% | 29.4 | -9% | 23.1 | -29% | 17.8 | -45% | 32.4 |
| | 46 | 54.1 | 31% | 53.2 | 28% | 48.5 | 17% | 41.2 | 0% | 32.4 | -22% | 24.4 | -41% | 41.4 |
| | 54 | 66.4 | 32% | 65.1 | 30% | 59.5 | 18% | 50.7 | 1% | 40.6 | -19% | 30.7 | -39% | 50.2 |

Table 4.16: Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|--|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 13.9 | 28.1 | -51% | 13.7 | 28.1 | -51% | 13.3 | 27.0 | -51% | 12.3 | 25.3 | -51% | 11.0 | 23.6 | -53% | 9.5 | 21.1 | -55% |
| | 36 | 22.9 | 47.2 | -52% | 22.4 | 47.2 | -52% | 21.2 | 45.3 | -53% | 19.3 | 42.5 | -55% | 16.8 | 39.6 | -58% | 14.4 | 35.4 | -59% |
| | 46 | 33.7 | 62.9 | -46% | 32.9 | 62.9 | -48% | 30.9 | 60.4 | -49% | 27.8 | 56.6 | -51% | 24.0 | 52.8 | -55% | 19.6 | 47.2 | -59% |
| | 54 | 43.7 | 75.3 | -42% | 42.7 | 75.3 | -43% | 39.9 | 72.3 | -45% | 35.5 | 67.8 | -48% | 30.4 | 63.3 | -52% | 24.3 | 56.5 | -57% |
| 2 | 24 | 19.2 | 24.1 | -20% | 18.9 | 24.1 | -22% | 18.0 | 23.2 | -22% | 16.0 | 21.7 | -26% | 13.8 | 20.2 | -32% | 10.6 | 18.1 | -42% |
| | 36 | 31.6 | 45.6 | -31% | 31.2 | 45.6 | -32% | 29.1 | 43.8 | -33% | 25.9 | 41.0 | -37% | 21.7 | 38.3 | -43% | 17.5 | 34.2 | -49% |
| | 46 | 45.1 | 65.3 | -31% | 44.2 | 65.3 | -32% | 41.1 | 62.7 | -34% | 36.1 | 58.8 | -39% | 30.2 | 54.9 | -45% | 23.7 | 49.0 | -52% |
| | 54 | 56.8 | 81.7 | -31% | 55.6 | 81.7 | -32% | 51.5 | 78.4 | -34% | 45.0 | 73.5 | -39% | 37.2 | 68.6 | -46% | 28.0 | 61.3 | -54% |
| 3 | 24 | 21.4 | 22.6 | -5% | 21.1 | 22.6 | -7% | 19.8 | 21.7 | -9% | 16.8 | 20.3 | -17% | 13.9 | 19.0 | -27% | 10.6 | 17.0 | -38% |
| | 36 | 36.0 | 42.3 | -15% | 35.7 | 42.3 | -16% | 33.0 | 40.6 | -19% | 28.6 | 38.1 | -25% | 22.9 | 35.5 | -36% | 17.8 | 31.7 | -44% |
| | 46 | 50.5 | 60.4 | -16% | 49.6 | 60.4 | -18% | 45.8 | 58.0 | -21% | 39.5 | 54.4 | -27% | 31.9 | 50.7 | -37% | 24.6 | 45.3 | -46% |
| | 54 | 62.3 | 77.1 | -19% | 61.1 | 77.1 | -21% | 56.3 | 74.0 | -24% | 48.5 | 69.4 | -30% | 39.7 | 64.8 | -39% | 30.7 | 57.8 | -47% |
| 4 | 24 | 22.2 | 21.5 | 3% | 21.9 | 21.5 | 2% | 20.2 | 20.6 | -2% | 16.9 | 19.4 | -13% | 13.9 | 18.1 | -23% | 10.6 | 16.1 | -34% |
| | 36 | 38.6 | 40.0 | -4% | 38.2 | 40.0 | -4% | 34.9 | 38.4 | -9% | 29.4 | 36.0 | -18% | 23.1 | 33.6 | -31% | 17.8 | 30.0 | -41% |
| | 46 | 54.1 | 59.8 | -10% | 53.2 | 59.8 | -11% | 48.5 | 57.3 | -15% | 41.2 | 53.8 | -23% | 32.4 | 50.2 | -36% | 24.4 | 44.8 | -46% |
| | 54 | 66.4 | 77.1 | -14% | 65.1 | 77.1 | -16% | 59.5 | 74.0 | -20% | 50.7 | 69.4 | -27% | 40.6 | 64.8 | -37% | 30.7 | 57.8 | -47% |

Table 4.17: Comparison of FEA Edge Beam Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 17.6 | -31% | 17.4 | -32% | 16.9 | -34% | 15.8 | -38% | 14.9 | -42% | 12.9 | -49% | 25.6 |
| | 36 | 26.6 | -31% | 26.2 | -32% | 24.9 | -35% | 23.0 | -40% | 20.9 | -46% | 17.9 | -53% | 38.4 |
| | 46 | 37.4 | -24% | 36.8 | -25% | 34.7 | -29% | 31.5 | -36% | 27.7 | -44% | 23.0 | -53% | 49.1 |
| | 54 | 47.4 | -18% | 46.4 | -19% | 43.6 | -24% | 39.4 | -32% | 34.4 | -40% | 28.0 | -51% | 57.6 |
| 2 | 24 | 22.3 | -13% | 21.9 | -15% | 21.0 | -18% | 19.1 | -25% | 17.1 | -33% | 14.0 | -45% | 25.6 |
| | 36 | 35.3 | -8% | 34.9 | -9% | 32.9 | -14% | 29.7 | -23% | 25.8 | -33% | 21.0 | -45% | 38.4 |
| | 46 | 48.9 | 0% | 48.1 | -2% | 44.9 | -8% | 39.9 | -19% | 34.0 | -31% | 27.3 | -44% | 49.1 |
| | 54 | 60.5 | 5% | 59.4 | 3% | 55.3 | -4% | 49.0 | -15% | 41.3 | -28% | 31.9 | -45% | 57.6 |
| 3 | 24 | 23.9 | -7% | 23.5 | -8% | 22.4 | -12% | 19.8 | -23% | 17.4 | -32% | 14.0 | -45% | 25.6 |
| | 36 | 39.5 | 3% | 39.2 | 2% | 36.6 | -5% | 32.2 | -16% | 27.0 | -30% | 21.3 | -44% | 38.4 |
| | 46 | 54.3 | 11% | 53.5 | 9% | 49.6 | 1% | 43.4 | -12% | 36.1 | -27% | 28.2 | -43% | 49.1 |
| | 54 | 66.2 | 15% | 64.9 | 13% | 60.1 | 4% | 52.6 | -9% | 43.9 | -24% | 34.3 | -40% | 57.6 |
| 4 | 24 | 24.5 | -4% | 24.1 | -6% | 22.8 | -11% | 20.0 | -22% | 17.4 | -32% | 14.0 | -45% | 25.6 |
| | 36 | 41.6 | 8% | 41.4 | 8% | 38.4 | 0% | 32.9 | -14% | 27.2 | -29% | 21.3 | -44% | 38.4 |
| | 46 | 57.8 | 18% | 57.0 | 16% | 52.3 | 7% | 44.9 | -9% | 36.6 | -26% | 28.0 | -43% | 49.1 |
| | 54 | 70.2 | 22% | 68.9 | 20% | 63.3 | 10% | 54.8 | -5% | 44.8 | -22% | 34.4 | -40% | 57.6 |

Table 4.18: Comparison of FEA Edge Beam Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|---|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 17.6 | 23.0 | -23% | 17.4 | 23.0 | -25% | 16.9 | 22.1 | -24% | 15.8 | 20.7 | -24% | 14.9 | 19.3 | -23% | 12.9 | 17.3 | -25% |
| | 36 | 26.6 | 39.5 | -33% | 26.2 | 39.5 | -34% | 24.9 | 37.9 | -34% | 23.0 | 35.6 | -35% | 20.9 | 33.2 | -37% | 17.9 | 29.7 | -40% |
| | 46 | 37.4 | 60.9 | -39% | 36.8 | 60.9 | -40% | 34.7 | 58.5 | -41% | 31.5 | 54.9 | -43% | 27.7 | 51.2 | -46% | 23.0 | 45.7 | -50% |
| | 54 | 47.4 | 76.1 | -38% | 46.4 | 76.1 | -39% | 43.6 | 73.1 | -40% | 39.4 | 68.5 | -42% | 34.4 | 64.0 | -46% | 28.0 | 57.1 | -51% |
| 2 | 24 | 22.3 | 21.2 | 5% | 21.9 | 21.2 | 3% | 21.0 | 20.3 | 3% | 19.1 | 19.1 | 0% | 17.1 | 17.8 | -4% | 14.0 | 15.9 | -12% |
| | 36 | 35.3 | 41.4 | -15% | 34.9 | 41.4 | -16% | 32.9 | 39.7 | -17% | 29.7 | 37.3 | -20% | 25.8 | 34.8 | -26% | 21.0 | 31.1 | -32% |
| | 46 | 48.9 | 62.3 | -22% | 48.1 | 62.3 | -23% | 44.9 | 59.8 | -25% | 39.9 | 56.1 | -29% | 34.0 | 52.3 | -35% | 27.3 | 46.7 | -42% |
| | 54 | 60.5 | 79.9 | -24% | 59.4 | 79.9 | -26% | 55.3 | 76.7 | -28% | 49.0 | 72.0 | -32% | 41.3 | 67.2 | -38% | 31.9 | 60.0 | -47% |
| 3 | 24 | 23.9 | 20.5 | 17% | 23.5 | 20.5 | 15% | 22.4 | 19.6 | 14% | 19.8 | 18.4 | 8% | 17.4 | 17.2 | 1% | 14.0 | 15.4 | -9% |
| | 36 | 39.5 | 39.7 | -1% | 39.2 | 39.7 | -1% | 36.6 | 38.1 | -4% | 32.2 | 35.8 | -10% | 27.0 | 33.4 | -19% | 21.3 | 29.8 | -28% |
| | 46 | 54.3 | 59.5 | -9% | 53.5 | 59.5 | -10% | 49.6 | 57.1 | -13% | 43.4 | 53.6 | -19% | 36.1 | 50.0 | -28% | 28.2 | 44.6 | -37% |
| | 54 | 66.2 | 77.3 | -14% | 64.9 | 77.3 | -16% | 60.1 | 74.2 | -19% | 52.6 | 69.6 | -24% | 43.9 | 64.9 | -32% | 34.3 | 58.0 | -41% |
| 4 | 24 | 24.5 | 19.9 | 23% | 24.1 | 19.9 | 21% | 22.8 | 19.1 | 19% | 20.0 | 17.9 | 12% | 17.4 | 16.7 | 4% | 14.0 | 14.9 | -6% |
| | 36 | 41.6 | 38.4 | 8% | 41.4 | 38.4 | 8% | 38.4 | 36.9 | 4% | 32.9 | 34.6 | -5% | 27.2 | 32.3 | -16% | 21.3 | 28.8 | -26% |
| | 46 | 57.8 | 59.1 | -2% | 57.0 | 59.1 | -4% | 52.3 | 56.7 | -8% | 44.9 | 53.2 | -16% | 36.6 | 49.7 | -26% | 28.0 | 44.4 | -37% |
| | 54 | 70.2 | 77.3 | -9% | 68.9 | 77.3 | -11% | 63.3 | 74.2 | -15% | 54.8 | 69.6 | -21% | 44.8 | 64.9 | -31% | 34.4 | 58.0 | -41% |

Table 4.19: Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Transverse Moment (Kip-ft/ft) | | | | | | | | | | | |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|
| | | Angle of Skewness | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | |
| 1 | 24 | 6.0 | 0.43 | 6.0 | 0.44 | 6.0 | 0.45 | 6.0 | 0.48 | 6.0 | 0.55 | 5.9 | 0.62 |
| | 36 | 6.3 | 0.27 | 6.8 | 0.30 | 8.0 | 0.38 | 8.8 | 0.46 | 9.3 | 0.55 | 9.2 | 0.64 |
| | 46 | 6.2 | 0.18 | 6.5 | 0.20 | 7.3 | 0.24 | 8.1 | 0.29 | 8.9 | 0.37 | 9.6 | 0.49 |
| | 54 | 6.1 | 0.14 | 6.4 | 0.15 | 6.7 | 0.17 | 7.2 | 0.20 | 7.7 | 0.25 | 8.1 | 0.34 |
| 2 | 24 | 7.4 | 0.39 | 7.4 | 0.39 | 7.5 | 0.42 | 7.7 | 0.48 | 8.2 | 0.59 | 8.6 | 0.81 |
| | 36 | 9.0 | 0.28 | 9.2 | 0.29 | 10.6 | 0.36 | 12.0 | 0.46 | 12.9 | 0.59 | 12.8 | 0.73 |
| | 46 | 9.4 | 0.21 | 9.9 | 0.22 | 11.5 | 0.28 | 12.9 | 0.36 | 14.2 | 0.47 | 14.6 | 0.61 |
| | 54 | 9.4 | 0.17 | 9.8 | 0.18 | 11.1 | 0.22 | 12.4 | 0.28 | 13.6 | 0.36 | 14.2 | 0.51 |
| 3 | 24 | 7.9 | 0.37 | 7.8 | 0.37 | 8.3 | 0.42 | 9.3 | 0.55 | 9.5 | 0.68 | 8.7 | 0.82 |
| | 36 | 10.7 | 0.30 | 11.0 | 0.31 | 12.6 | 0.38 | 14.2 | 0.50 | 14.2 | 0.62 | 13.4 | 0.75 |
| | 46 | 12.3 | 0.24 | 12.7 | 0.25 | 14.8 | 0.32 | 16.5 | 0.42 | 17.0 | 0.53 | 16.3 | 0.66 |
| | 54 | 12.8 | 0.21 | 13.3 | 0.22 | 15.4 | 0.27 | 17.2 | 0.36 | 18.1 | 0.46 | 17.6 | 0.57 |
| 4 | 24 | 8.0 | 0.36 | 8.0 | 0.36 | 9.1 | 0.45 | 9.2 | 0.55 | 9.5 | 0.68 | 8.7 | 0.82 |
| | 36 | 11.5 | 0.30 | 11.8 | 0.31 | 13.8 | 0.39 | 14.6 | 0.50 | 14.2 | 0.61 | 13.3 | 0.75 |
| | 46 | 14.0 | 0.26 | 14.5 | 0.27 | 16.7 | 0.35 | 18.2 | 0.44 | 17.7 | 0.55 | 16.1 | 0.66 |
| | 54 | 15.3 | 0.23 | 15.8 | 0.24 | 18.3 | 0.31 | 20.0 | 0.39 | 19.7 | 0.48 | 17.7 | 0.57 |

Table 4.20: Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion

| Number of Lanes | Span Length (ft) | FEA Maximum Slab Deflection (in) | | | | | | | | | | | | AASHTO Deflection (in) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.055 | -85% | 0.053 | -85% | 0.050 | -86% | 0.043 | -88% | 0.035 | -90% | 0.026 | -93% | 0.360 |
| | 36 | 0.139 | -74% | 0.134 | -75% | 0.122 | -78% | 0.104 | -81% | 0.082 | -85% | 0.061 | -89% | 0.540 |
| | 46 | 0.231 | -67% | 0.223 | -68% | 0.203 | -71% | 0.172 | -75% | 0.137 | -80% | 0.099 | -86% | 0.690 |
| | 54 | 0.291 | -64% | 0.282 | -65% | 0.255 | -68% | 0.216 | -73% | 0.172 | -79% | 0.122 | -85% | 0.810 |
| 2 | 24 | 0.076 | -79% | 0.074 | -79% | 0.068 | -81% | 0.057 | -84% | 0.044 | -88% | 0.029 | -92% | 0.360 |
| | 36 | 0.197 | -63% | 0.192 | -64% | 0.174 | -68% | 0.145 | -73% | 0.112 | -79% | 0.078 | -86% | 0.540 |
| | 46 | 0.316 | -54% | 0.307 | -55% | 0.277 | -60% | 0.231 | -67% | 0.179 | -74% | 0.125 | -82% | 0.690 |
| | 54 | 0.385 | -52% | 0.373 | -54% | 0.337 | -58% | 0.281 | -65% | 0.218 | -73% | 0.148 | -82% | 0.810 |
| 3 | 24 | 0.084 | -77% | 0.082 | -77% | 0.075 | -79% | 0.060 | -83% | 0.045 | -88% | 0.029 | -92% | 0.360 |
| | 36 | 0.226 | -58% | 0.221 | -59% | 0.198 | -63% | 0.163 | -70% | 0.121 | -78% | 0.080 | -85% | 0.540 |
| | 46 | 0.357 | -48% | 0.348 | -50% | 0.311 | -55% | 0.256 | -63% | 0.193 | -72% | 0.131 | -81% | 0.690 |
| | 54 | 0.426 | -47% | 0.414 | -49% | 0.371 | -54% | 0.306 | -62% | 0.235 | -71% | 0.160 | -80% | 0.810 |
| 4 | 24 | 0.087 | -76% | 0.084 | -77% | 0.076 | -79% | 0.061 | -83% | 0.045 | -88% | 0.029 | -92% | 0.360 |
| | 36 | 0.240 | -56% | 0.236 | -56% | 0.210 | -61% | 0.168 | -69% | 0.122 | -77% | 0.079 | -85% | 0.540 |
| | 46 | 0.383 | -45% | 0.373 | -46% | 0.331 | -52% | 0.267 | -61% | 0.196 | -72% | 0.130 | -81% | 0.690 |
| | 54 | 0.455 | -44% | 0.442 | -45% | 0.394 | -51% | 0.321 | -60% | 0.241 | -70% | 0.160 | -80% | 0.810 |

4.3.2.2 FEA Results of Skewed Versus Straight Bridges

4.3.2.2.1 Maximum Longitudinal Bending Moment and Edge Beam Moment

The ratios $M1/\alpha\alpha / M1/00$ for the maximum longitudinal moment are shown in Table 4.21 and Figure 4.9, for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. Table 4.22 and Figure 4.10 correspond to edge beam moments. Such Tables/Figures indicate a uniform pattern of decrease in the maximum longitudinal and edge moment values with the increase in the skew angle, compared to that of straight bridges regardless of the number of lanes and span length. This decrease appears to be significant when the skew angle exceeds 20° . Also, for skew angles greater than 20° , the ratio $M1/\alpha\alpha / M1/00$ decreases with the increase in the number of lanes from one to four. For both the maximum longitudinal moment and edge beam moment, the ratio $M1/\alpha\alpha / M1/00$ is almost one for bridges with skew angles less than 20° , decreases to about 0.75 for bridges with skew angles between 30° and 40° , and further decreases to about 0.5 as the bridge skew angle increases to 50° .

4.3.2.2.2 Maximum Transverse Moment

The ratios $M1/\alpha\alpha / M1/00$ for the maximum transverse moment are shown in Table 4.23 and Figure 4.11 for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. In contrast with the longitudinal moment results, the maximum transverse moment increases almost linearly as the skew angle increases from 10° to 40° , where it reaches a peak value. The $M1/\alpha\alpha / M1/00$ ratio decreases slightly again for skew angles between 40° and 50° . The ratio $M1/\alpha\alpha / M1/00$ varies with the variation in the span length and width, thus no general pattern can be deduced as for the results discussed in previous sections. For span bridges less than 36 ft in combination with three bridges, the ratio $M1/\alpha\alpha / M1/00$ reaches a maximum of

1.25 at a skew angle of 40°. For bridge spans between 46 and 54 ft, the ratio $M1/\alpha\alpha / M1/00$ is less than 1.3 for skew angles up to 20° regardless of the number of lanes. At 30°, the ratio is in the range of 1.4 for the one lane bridge to 1.3 for the four lane bridge. This range becomes wider at 40 and 50° skew angle whereby it reaches a maximum of 1.55 for one lane bridges and a minimum of 1.1 for four lane bridges.

4.3.2.2.3 Maximum Live Load Deflection

The ratio $\Delta1/\alpha\alpha / \Delta1/00$ values obtained are presented in Table 4.24 and Figure 4.12 for each of the four span lengths considered (24, 36, 46, and 54 ft). The maximum live load deflection pattern is consistent and expected to be similar to the maximum longitudinal bending moment as well as the edge beam moment. These values indicate that the maximum live load deflection for skewed bridges compared to that of straight bridges decreases with the skew angle for all span lengths and the number of lanes. This decrease is summarized as follows: The ratio is about one for a skew angle up to 10° and is approximately equal to 0.9 for a skew angle equal to 20°; this ratio further decreases to about 0.75 as the skew angle increases to 30° and reaches a minimum of 0.35 at a skew angle of 50°.

Table 4.21: FEA Maximum Longitudinal Bending Moment – Ratio $M1/\alpha\alpha$ / $M1/00$

| Number of Lanes | Span Length (ft) | Maximum Longitudinal Moment - $M1/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M1/00$ (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 13.9 | 1.00 | 13.7 | 0.99 | 13.3 | 0.96 | 12.3 | 0.89 | 11.0 | 0.79 | 9.5 | 0.69 | 13.9 |
| | 36 | 22.9 | 1.00 | 22.4 | 0.98 | 21.2 | 0.93 | 19.3 | 0.84 | 16.8 | 0.73 | 14.4 | 0.63 | 22.9 |
| | 46 | 33.7 | 1.00 | 32.9 | 0.98 | 30.9 | 0.92 | 27.8 | 0.82 | 24.0 | 0.71 | 19.6 | 0.58 | 33.7 |
| | 54 | 43.7 | 1.00 | 42.7 | 0.98 | 39.9 | 0.91 | 35.5 | 0.81 | 30.4 | 0.69 | 24.3 | 0.55 | 43.7 |
| 2 | 24 | 19.2 | 1.00 | 18.9 | 0.98 | 18.0 | 0.93 | 16.0 | 0.83 | 13.8 | 0.72 | 10.6 | 0.55 | 19.2 |
| | 36 | 31.6 | 1.00 | 31.2 | 0.99 | 29.1 | 0.92 | 25.9 | 0.82 | 21.7 | 0.69 | 17.5 | 0.55 | 31.6 |
| | 46 | 45.1 | 1.00 | 44.2 | 0.98 | 41.1 | 0.91 | 36.1 | 0.80 | 30.2 | 0.67 | 23.7 | 0.53 | 45.1 |
| | 54 | 56.8 | 1.00 | 55.6 | 0.98 | 51.5 | 0.91 | 45.0 | 0.79 | 37.2 | 0.65 | 28.0 | 0.49 | 56.8 |
| 3 | 24 | 21.4 | 1.00 | 21.1 | 0.98 | 19.8 | 0.92 | 16.8 | 0.78 | 13.9 | 0.65 | 10.6 | 0.49 | 21.4 |
| | 36 | 36.0 | 1.00 | 35.7 | 0.99 | 33.0 | 0.91 | 28.6 | 0.79 | 22.9 | 0.64 | 17.8 | 0.49 | 36.0 |
| | 46 | 50.5 | 1.00 | 49.6 | 0.98 | 45.8 | 0.91 | 39.5 | 0.78 | 31.9 | 0.63 | 24.6 | 0.49 | 50.5 |
| | 54 | 62.3 | 1.00 | 61.1 | 0.98 | 56.3 | 0.90 | 48.5 | 0.78 | 39.7 | 0.64 | 30.7 | 0.49 | 62.3 |
| 4 | 24 | 22.2 | 1.00 | 21.9 | 0.98 | 20.2 | 0.91 | 16.9 | 0.76 | 13.9 | 0.63 | 10.6 | 0.48 | 22.2 |
| | 36 | 38.6 | 1.00 | 38.2 | 0.99 | 34.9 | 0.90 | 29.4 | 0.76 | 23.1 | 0.60 | 17.8 | 0.46 | 38.6 |
| | 46 | 54.1 | 1.00 | 53.2 | 0.98 | 48.5 | 0.90 | 41.2 | 0.76 | 32.4 | 0.60 | 24.4 | 0.45 | 54.1 |
| | 54 | 66.4 | 1.00 | 65.1 | 0.98 | 59.5 | 0.90 | 50.7 | 0.76 | 40.6 | 0.61 | 30.7 | 0.46 | 66.4 |

Table 4.22: FEA Edge Beam Moment – Ratio $M1/\alpha\alpha$ / $M1/00$

| Number of Lanes | Span Length (ft) | Edge Beam Moment - $M1/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Edge Moment $M1/00$ (Kip-ft/ft) |
|-----------------|------------------|--|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 17.6 | 1.00 | 17.4 | 0.99 | 16.9 | 0.96 | 15.8 | 0.90 | 14.9 | 0.85 | 12.9 | 0.73 | 17.6 |
| | 36 | 26.6 | 1.00 | 26.2 | 0.98 | 24.9 | 0.94 | 23.0 | 0.87 | 20.9 | 0.78 | 17.9 | 0.67 | 26.6 |
| | 46 | 37.4 | 1.00 | 36.8 | 0.98 | 34.7 | 0.93 | 31.5 | 0.84 | 27.7 | 0.74 | 23.0 | 0.62 | 37.4 |
| | 54 | 47.4 | 1.00 | 46.4 | 0.98 | 43.6 | 0.92 | 39.4 | 0.83 | 34.4 | 0.73 | 28.0 | 0.59 | 47.4 |
| 2 | 24 | 22.3 | 1.00 | 21.9 | 0.98 | 21.0 | 0.94 | 19.1 | 0.86 | 17.1 | 0.77 | 14.0 | 0.63 | 22.3 |
| | 36 | 35.3 | 1.00 | 34.9 | 0.99 | 32.9 | 0.93 | 29.7 | 0.84 | 25.8 | 0.73 | 21.0 | 0.60 | 35.3 |
| | 46 | 48.9 | 1.00 | 48.1 | 0.99 | 44.9 | 0.92 | 39.9 | 0.82 | 34.0 | 0.70 | 27.3 | 0.56 | 48.9 |
| | 54 | 60.5 | 1.00 | 59.4 | 0.98 | 55.3 | 0.91 | 49.0 | 0.81 | 41.3 | 0.68 | 31.9 | 0.53 | 60.5 |
| 3 | 24 | 23.9 | 1.00 | 23.5 | 0.98 | 22.4 | 0.94 | 19.8 | 0.83 | 17.4 | 0.73 | 14.0 | 0.59 | 23.9 |
| | 36 | 39.5 | 1.00 | 39.2 | 0.99 | 36.6 | 0.93 | 32.2 | 0.82 | 27.0 | 0.68 | 21.3 | 0.54 | 39.5 |
| | 46 | 54.3 | 1.00 | 53.5 | 0.99 | 49.6 | 0.91 | 43.4 | 0.80 | 36.1 | 0.66 | 28.2 | 0.52 | 54.3 |
| | 54 | 66.2 | 1.00 | 64.9 | 0.98 | 60.1 | 0.91 | 52.6 | 0.79 | 43.9 | 0.66 | 34.3 | 0.52 | 66.2 |
| 4 | 24 | 24.5 | 1.00 | 24.1 | 0.99 | 22.8 | 0.93 | 20.0 | 0.82 | 17.4 | 0.71 | 14.0 | 0.57 | 24.5 |
| | 36 | 41.6 | 1.00 | 41.4 | 0.99 | 38.4 | 0.92 | 32.9 | 0.79 | 27.2 | 0.65 | 21.3 | 0.51 | 41.6 |
| | 46 | 57.8 | 1.00 | 57.0 | 0.99 | 52.3 | 0.91 | 44.9 | 0.78 | 36.6 | 0.63 | 28.0 | 0.48 | 57.8 |
| | 54 | 70.2 | 1.00 | 68.9 | 0.98 | 63.3 | 0.90 | 54.8 | 0.78 | 44.8 | 0.64 | 34.4 | 0.49 | 70.2 |

Table 4.23: FEA Maximum Transverse Moment – Ratio $M1/\alpha\alpha$ / $M1/00$

| Number of Lanes | Span Length (ft) | Maximum Transverse Moment - $M1/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M1/00$ (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 6.4 | 1.00 | 6.4 | 1.00 | 6.5 | 1.01 | 6.5 | 1.03 | 6.8 | 1.07 | 6.7 | 1.05 | 6.4 |
| | 36 | 6.5 | 1.00 | 6.8 | 1.05 | 8.0 | 1.22 | 8.8 | 1.35 | 9.3 | 1.42 | 9.2 | 1.42 | 6.5 |
| | 46 | 6.4 | 1.00 | 6.6 | 1.03 | 7.3 | 1.15 | 8.1 | 1.28 | 8.9 | 1.40 | 9.6 | 1.51 | 6.4 |
| | 54 | 6.2 | 1.00 | 6.4 | 1.03 | 6.8 | 1.09 | 7.3 | 1.17 | 7.8 | 1.25 | 8.1 | 1.31 | 6.2 |
| 2 | 24 | 7.9 | 1.00 | 8.0 | 1.01 | 8.3 | 1.04 | 8.3 | 1.05 | 8.3 | 1.05 | 8.6 | 1.08 | 7.9 |
| | 36 | 9.4 | 1.00 | 9.6 | 1.03 | 10.6 | 1.13 | 12.0 | 1.29 | 12.9 | 1.37 | 12.8 | 1.37 | 9.4 |
| | 46 | 9.7 | 1.00 | 9.9 | 1.02 | 11.5 | 1.18 | 12.9 | 1.34 | 14.2 | 1.46 | 14.6 | 1.50 | 9.7 |
| | 54 | 9.6 | 1.00 | 9.8 | 1.03 | 11.1 | 1.16 | 12.4 | 1.30 | 13.6 | 1.41 | 14.2 | 1.48 | 9.6 |
| 3 | 24 | 8.3 | 1.00 | 8.4 | 1.01 | 8.7 | 1.05 | 9.3 | 1.12 | 9.5 | 1.15 | 8.7 | 1.05 | 8.3 |
| | 36 | 11.2 | 1.00 | 11.7 | 1.04 | 12.6 | 1.12 | 14.2 | 1.26 | 14.2 | 1.26 | 13.4 | 1.19 | 11.2 |
| | 46 | 12.6 | 1.00 | 13.1 | 1.04 | 14.8 | 1.17 | 16.5 | 1.31 | 17.0 | 1.35 | 16.3 | 1.29 | 12.6 |
| | 54 | 13.1 | 1.00 | 13.5 | 1.03 | 15.4 | 1.18 | 17.2 | 1.32 | 18.1 | 1.39 | 17.6 | 1.35 | 13.1 |
| 4 | 24 | 8.2 | 1.00 | 8.3 | 1.02 | 9.1 | 1.11 | 9.2 | 1.13 | 9.5 | 1.16 | 8.7 | 1.06 | 8.2 |
| | 36 | 12.1 | 1.00 | 12.6 | 1.04 | 13.8 | 1.14 | 14.6 | 1.21 | 14.2 | 1.18 | 13.3 | 1.10 | 12.1 |
| | 46 | 14.6 | 1.00 | 15.2 | 1.04 | 16.7 | 1.15 | 18.2 | 1.25 | 17.7 | 1.21 | 16.1 | 1.11 | 14.6 |
| | 54 | 15.7 | 1.00 | 16.3 | 1.04 | 18.3 | 1.17 | 20.0 | 1.27 | 19.8 | 1.26 | 17.7 | 1.13 | 15.7 |

Table 4.24: FEA Maximum Live Load Deflection – Ratio $\Delta 1/\alpha\alpha / \Delta 1/00$

| Number of Lanes | Span Length (ft) | Maximum Live Load Deflection - $\Delta 1/\alpha\alpha$ (in) | | | | | | | | | | | | Maximum Deflection $\Delta 1/00$ (in) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.055 | 1.00 | 0.053 | 0.98 | 0.050 | 0.91 | 0.043 | 0.79 | 0.035 | 0.64 | 0.026 | 0.47 | 0.055 |
| | 36 | 0.139 | 1.00 | 0.134 | 0.96 | 0.122 | 0.88 | 0.104 | 0.75 | 0.082 | 0.60 | 0.061 | 0.44 | 0.139 |
| | 46 | 0.231 | 1.00 | 0.223 | 0.97 | 0.203 | 0.88 | 0.172 | 0.75 | 0.137 | 0.59 | 0.099 | 0.43 | 0.231 |
| | 54 | 0.291 | 1.00 | 0.282 | 0.97 | 0.255 | 0.88 | 0.216 | 0.74 | 0.172 | 0.59 | 0.122 | 0.42 | 0.291 |
| 2 | 24 | 0.076 | 1.00 | 0.074 | 0.97 | 0.068 | 0.89 | 0.057 | 0.75 | 0.044 | 0.57 | 0.029 | 0.38 | 0.076 |
| | 36 | 0.197 | 1.00 | 0.192 | 0.97 | 0.174 | 0.88 | 0.145 | 0.74 | 0.112 | 0.57 | 0.078 | 0.39 | 0.197 |
| | 46 | 0.316 | 1.00 | 0.307 | 0.97 | 0.277 | 0.88 | 0.231 | 0.73 | 0.179 | 0.57 | 0.125 | 0.40 | 0.316 |
| | 54 | 0.385 | 1.00 | 0.373 | 0.97 | 0.337 | 0.87 | 0.281 | 0.73 | 0.218 | 0.57 | 0.148 | 0.38 | 0.385 |
| 3 | 24 | 0.084 | 1.00 | 0.082 | 0.97 | 0.075 | 0.89 | 0.060 | 0.71 | 0.045 | 0.53 | 0.029 | 0.34 | 0.084 |
| | 36 | 0.226 | 1.00 | 0.221 | 0.98 | 0.198 | 0.88 | 0.163 | 0.72 | 0.121 | 0.54 | 0.080 | 0.35 | 0.226 |
| | 46 | 0.357 | 1.00 | 0.348 | 0.97 | 0.311 | 0.87 | 0.256 | 0.72 | 0.193 | 0.54 | 0.131 | 0.37 | 0.357 |
| | 54 | 0.426 | 1.00 | 0.414 | 0.97 | 0.371 | 0.87 | 0.306 | 0.72 | 0.235 | 0.55 | 0.160 | 0.38 | 0.426 |
| 4 | 24 | 0.087 | 1.00 | 0.084 | 0.97 | 0.076 | 0.88 | 0.061 | 0.70 | 0.045 | 0.51 | 0.029 | 0.33 | 0.087 |
| | 36 | 0.240 | 1.00 | 0.236 | 0.98 | 0.210 | 0.87 | 0.168 | 0.70 | 0.122 | 0.51 | 0.079 | 0.33 | 0.240 |
| | 46 | 0.383 | 1.00 | 0.373 | 0.98 | 0.331 | 0.87 | 0.267 | 0.70 | 0.196 | 0.51 | 0.130 | 0.34 | 0.383 |
| | 54 | 0.455 | 1.00 | 0.442 | 0.97 | 0.394 | 0.87 | 0.321 | 0.71 | 0.241 | 0.53 | 0.160 | 0.35 | 0.455 |

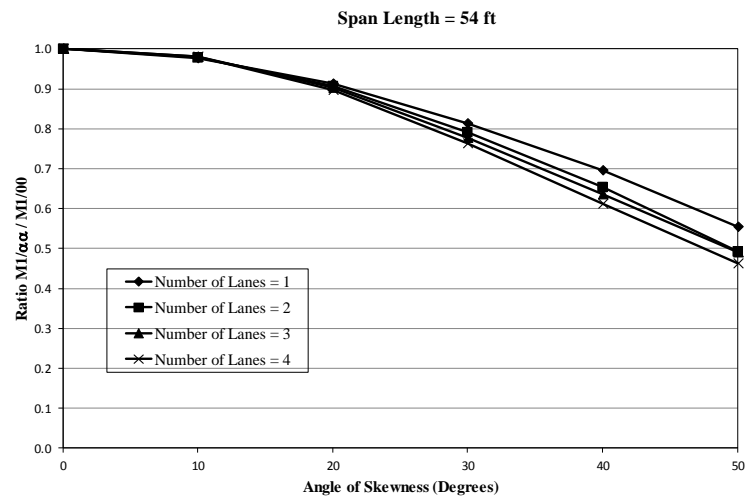
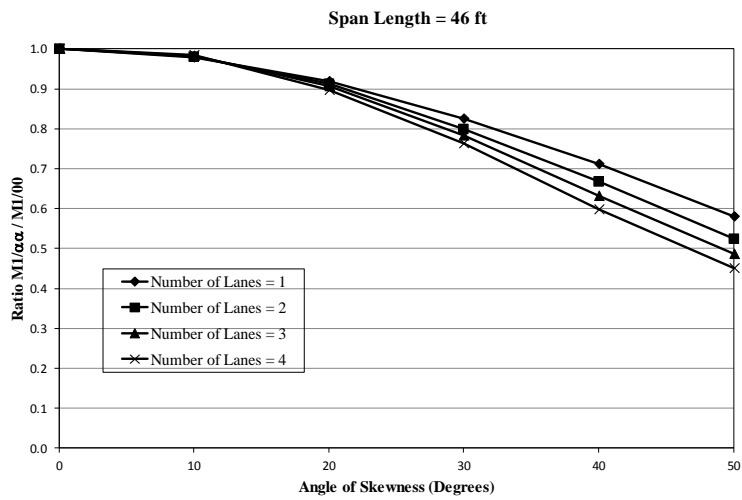
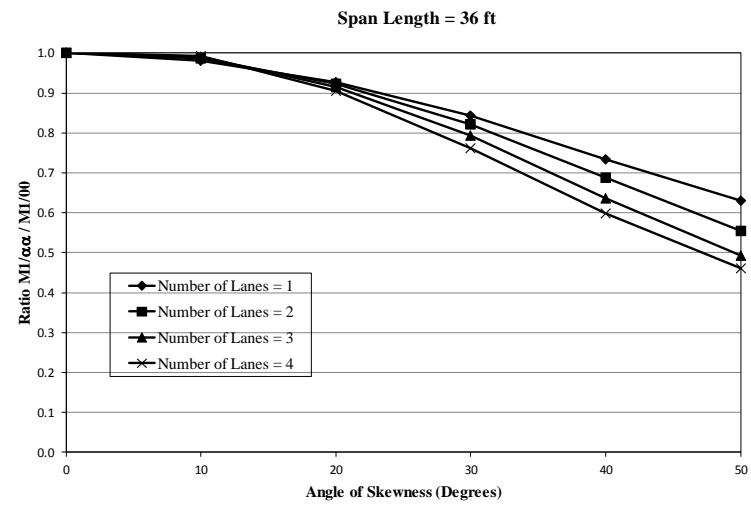
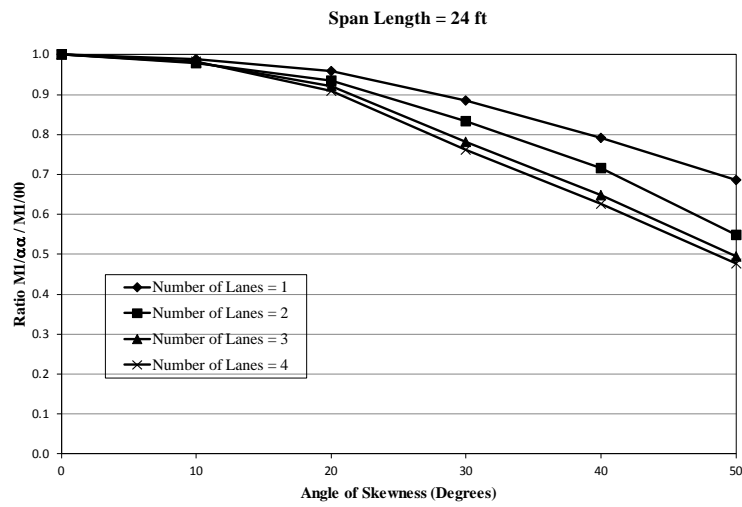


Figure 4.9: FEA Maximum Longitudinal Bending Moment – Ratio $M1/\alpha\alpha / M1/00$

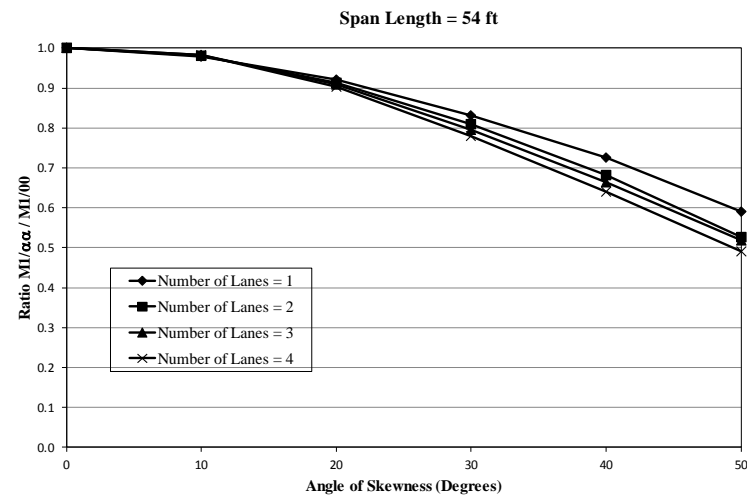
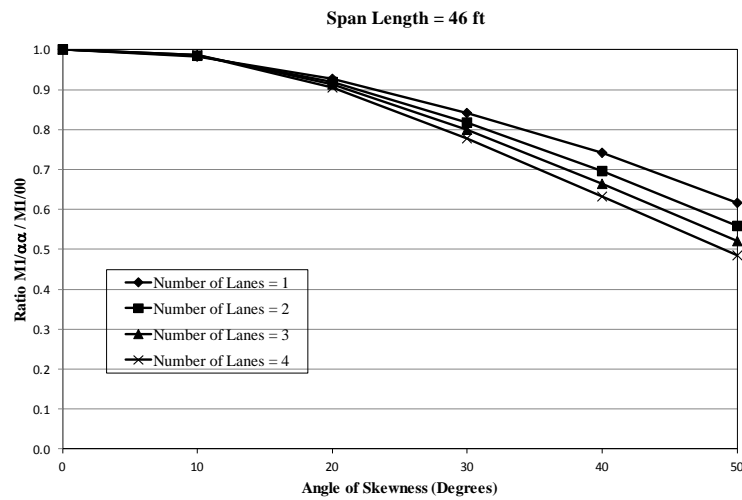
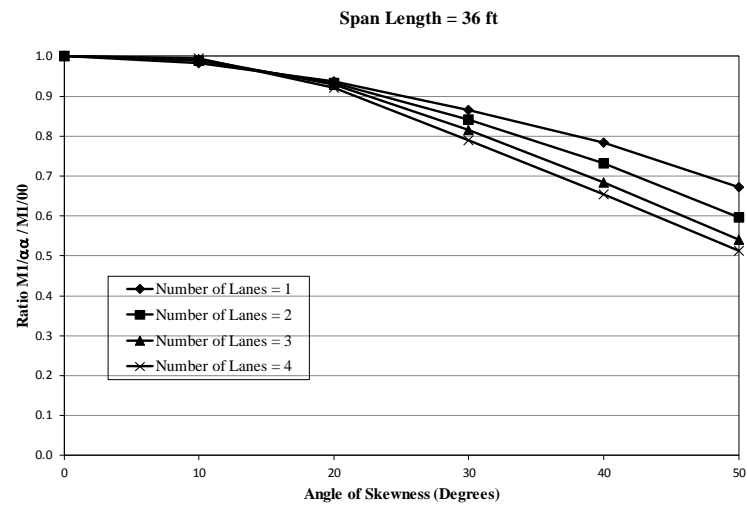
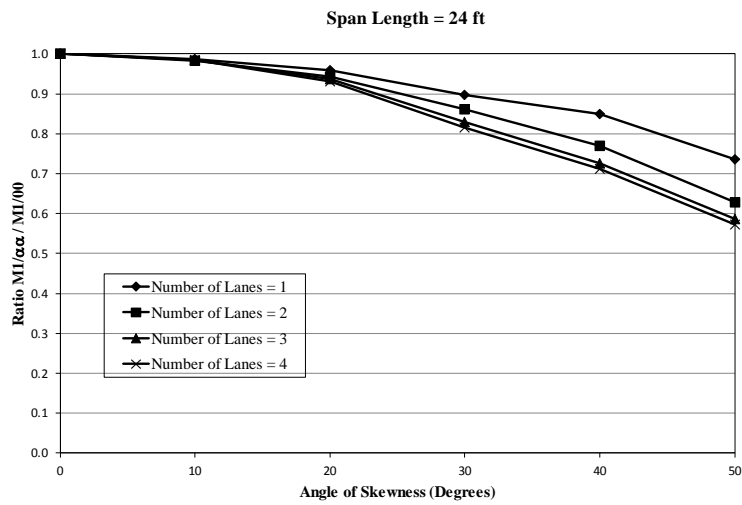


Figure 4.10: FEA Edge Beam Moment – Ratio $M1/\alpha\alpha / M1/00$

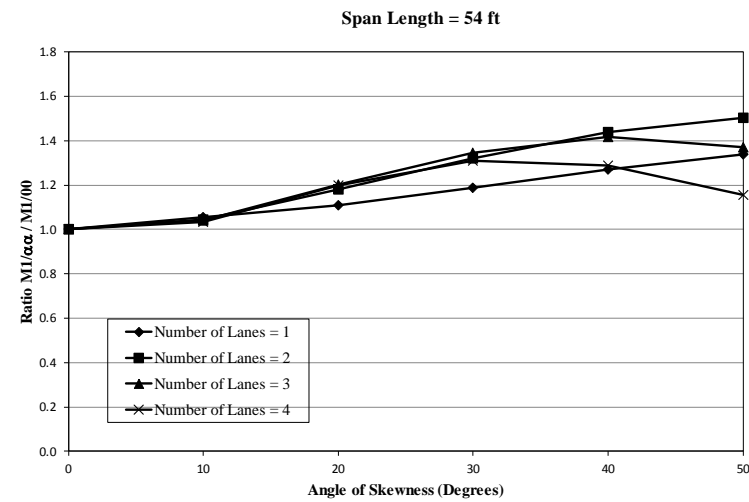
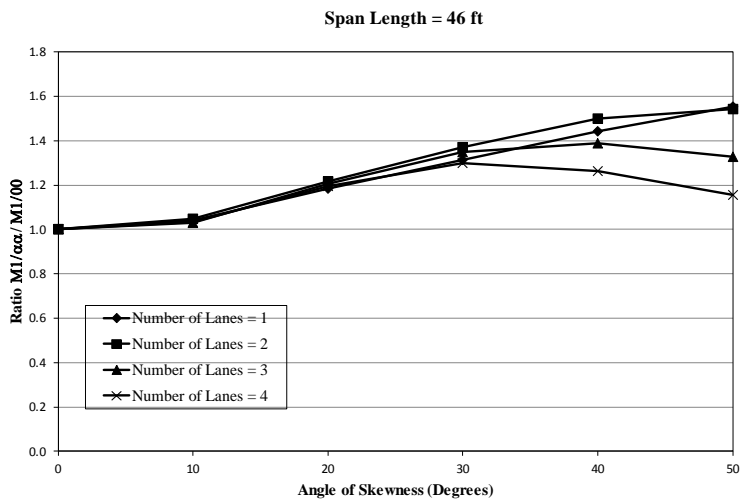
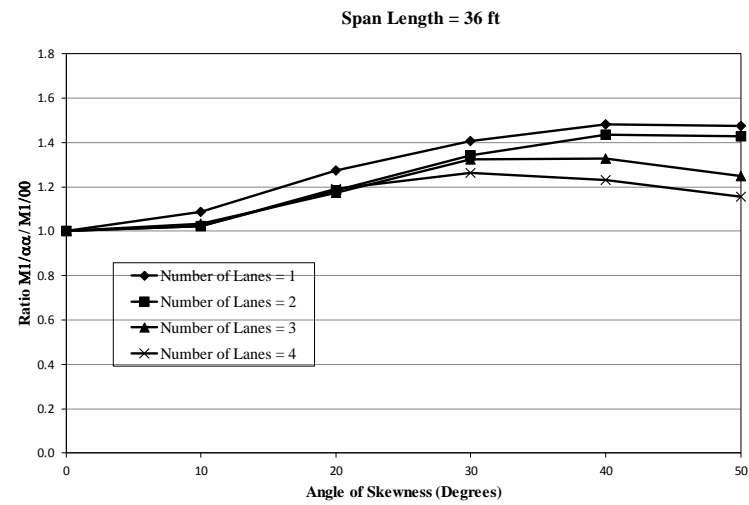
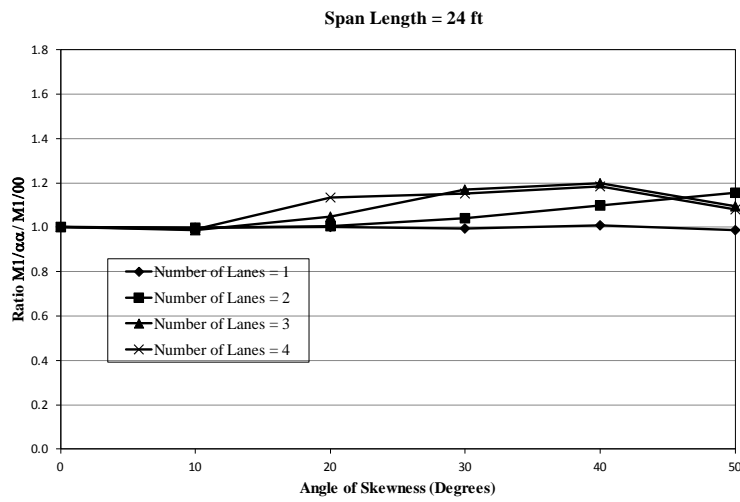


Figure 4.11: FEA Maximum Transverse Moment – Ratio $M1/\alpha\alpha / M1/00$

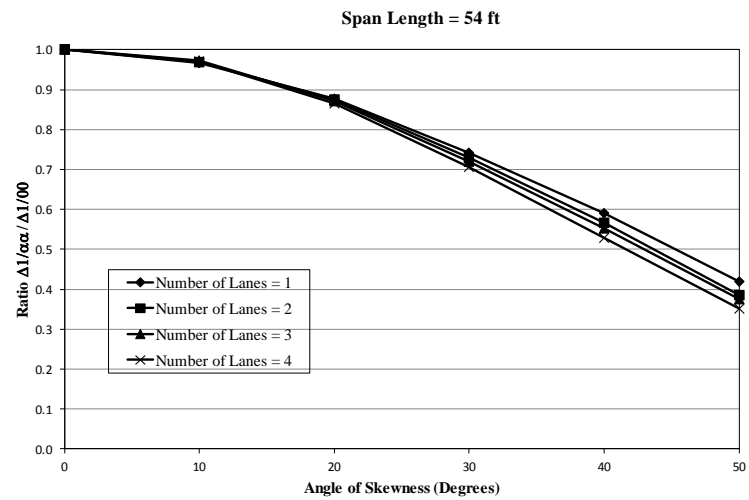
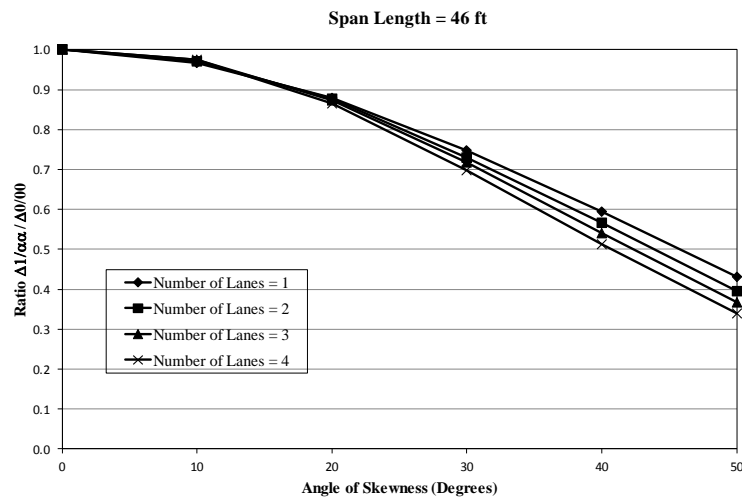
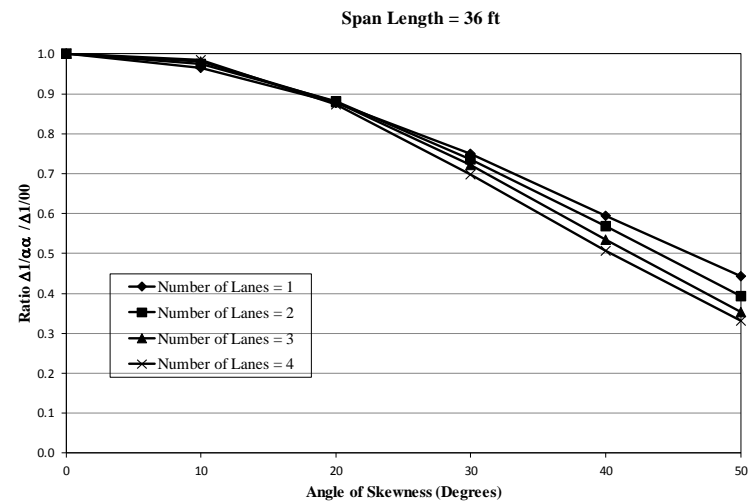
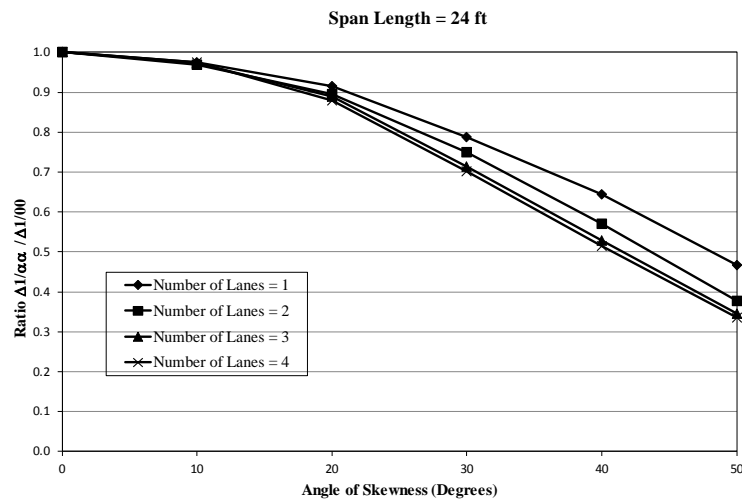


Figure 4.12: FEA Maximum Live Load Deflection – Ratio $\Delta l/\alpha\alpha / \Delta l/00$

4.3.2.3 Summary

The AASHTO Standard Specifications gave similar results to the FEA maximum longitudinal bending moment when the skew angle is less than or equal to 20°. As the skew angle increases, AASHTO Standard Specifications overestimated the maximum moment by about 20% for 30°, 80% for 40°, and 100% for 50°. The procedure presented in AASHTO LRFD Design Specifications overestimated the FEA maximum longitudinal bending moment by up to 65% for skew angles less than 30° and reaching 100% for 50°. The ratio between the FEA longitudinal moments for skewed and straight bridges was almost one for bridges with skew angle less than 20°. This ratio decreased to 0.75 for bridges with skew angles between 30 and 40°, and further decreased to 0.5 as the skew angle of the bridge increased to 50°. This decrease in the longitudinal moment ratio is offset by an increase by up to 65% in the maximum transverse moment ratio as the skew angle increases from 0 to 50°. The ratio between the FEA maximum live load deflection for skewed bridges and straight bridges decreases in a pattern consistent with that of the longitudinal moment. This ratio decreases from one for skew angles less than 10° to 0.6 for skew angles between 40 and 50°.

4.3.3 Skewed Bridges with Two Railings “Case 3”

4.3.3.1 FEA Results versus AASHTO

4.3.3.1.1 Maximum Longitudinal Bending Moment

The maximum slab longitudinal bending moments are summarized in Tables 4.25 and 4.26, for all “Case 3” bridges analyzed along with the corresponding AASHTO bending moments. Note that edge beam moments are excluded from this section because edge beam moments in bridges with two railings are to be considered with railings, which were modeled as frame elements, integral parts of the bridges.

This practice has relatively increased the moment share carried by these stiff elements. As AASHTO do not take these elements in to consideration, a major difference in edge beam moment values is expected when comparing FEA results with AASHTO moments, and thus edge beam moments are not discussed here. Tables/Figures corresponding to edge beam are still presented for the sake of completion.

The AASHTO moments are computed using Eq. (1) for the standard specifications and Eq. (5) for LRFD after applying the necessary reduction for all skew angles Eq. (6).

The FEA maximum longitudinal bending moment for skew angles less than 20° was first compared to the AASHTO standard specifications equations. For one lane bridges, AASHTO overestimates the maximum longitudinal bending moment by about 100% for bridges with span lengths less than 36 ft and 40% for bridges with span lengths greater than 46 ft. For two lane bridges, AASHTO overestimates FEA moment results by about 40% for span lengths less than 46 ft, and gives similar results for bridges with span length greater than 46 ft. For three and four lane bridges, AASHTO recommended moment overestimate FEA maximum longitudinal moment results for bridges with spans less than 24 ft by about 25%, and gives similar results for maximum moments for bridges with span lengths greater than 36 ft. Considering the skew angle between 20 and 30° , and for span lengths between 24 ft and 54 ft, the AASHTO procedure overestimates the maximum longitudinal moment by about 100% for one lane bridges, 40% for two lane bridges, 40% for three and four lane bridges with span length less than 36 ft, and similar results for bridges with span length greater than 46 ft. At relatively high skew angles, between 40 and 50° , AASHTO overestimates the maximum longitudinal moment by about 55% for all

span lengths and slab widths considered in the analysis. It is worth noting here that this overestimation is counter balanced by a significant increase in the maximum transverse moment as detailed later.

The maximum FEA longitudinal bending moments were also compared to the AASHTO LRFD moments. For skew angles less than 30°, LRFD overestimates the maximum longitudinal moment by about 180% for one lane bridges, 80% for two lane bridges, 50% for three lane bridges, and 30% for four lane bridges. The LRFD overestimate of the maximum longitudinal moment increases almost linearly with the skew angle as it varies from 30 to 50°. The LRFD overestimates the bending moment by about 180% for one lane bridges, 150% for two lane bridges, and 120% for three and four lane bridges.

4.3.3.1.2 Maximum Transverse Moment

Table 4.29 summarizes the FEA maximum transverse moments for all “Case 3” bridges. The maximum transverse moment was compared with the corresponding maximum moment value in the longitudinal direction. The ratio of transverse to longitudinal moments is also reported in Table 4.29.

The maximum FEA transverse moments increased with the increase in the skew angle even though the maximum longitudinal moment is decreasing. The ratio of maximum FEA transverse to longitudinal moment increases significantly when the skew angle is increased, from about 40% for straight bridges up to 75% for bridges with 50° skewness. AASHTO accommodates the transverse bending moment by specifying a percentage of the main reinforcement equal to $100/\sqrt{S}$, where S is in ft. For the span lengths considered in this study, the percent decrease of the main reinforcement from 20% for short span bridges of 24 ft to 15% for the long span bridges 54 ft. The results for all skew angles indicated a conformance with AASHTO

requirements whereby the percent difference with the maximum longitudinal moment is decreasing with the increase in span length. Generally, this transverse reinforcement is low so that shrinkage and temperature reinforcement governs. For skew angles equal to 40 and 50°, the percent difference decreases with the span length and is in the range of 60 to 85% for two, three, and four lane bridges.

4.3.3.1.3 Maximum Live Load Deflection

Table 4.30 summarizes the maximum FEA live load deflection as compared to the AASHTO criterion of $(S/800)$. The FEA results are directly related to the assumed slab thickness, which was a reasonable assumption for deflection control. But one can always assume a different thickness and obtain different deflection results.

For any given span length and its corresponding slab thickness, the maximum live load deflection results decrease as the skew angle increases from 0 to 50°. On the other hand, the FEA deflection results range from 1/5 to 1/2 the limiting value $(S/800)$ given by AASHTO, and the percent difference with the AASHTO limiting criteria increases with the skew angle. The percent difference is higher for short spans, and decreases as the span length increases to 54 for a given skew angle. Moreover, the basic assumption of the FEA model is the elastic section behavior, an actual cracked section analysis would yield higher deflections in the slabs. The results will increase to approximately 2/5 to 1 of AASHTO limiting deflection value.

Table 4.25: Comparison of FEA Maximum Longitudinal Bending Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 10.0 | -54% | 9.9 | -54% | 9.7 | -55% | 9.1 | -58% | 8.9 | -59% | 7.7 | -64% | 21.6 |
| | 36 | 16.9 | -48% | 16.7 | -49% | 16.0 | -51% | 14.8 | -54% | 13.4 | -59% | 11.0 | -66% | 32.4 |
| | 46 | 26.5 | -36% | 26.1 | -37% | 24.7 | -40% | 22.5 | -46% | 20.7 | -50% | 15.9 | -62% | 41.4 |
| | 54 | 36.2 | -28% | 35.5 | -29% | 31.0 | -38% | 30.4 | -39% | 26.4 | -47% | 21.0 | -58% | 50.2 |
| 2 | 24 | 14.7 | -32% | 14.4 | -33% | 13.9 | -36% | 12.7 | -41% | 11.2 | -48% | 8.8 | -59% | 21.6 |
| | 36 | 24.8 | -24% | 24.5 | -24% | 23.2 | -28% | 20.8 | -36% | 17.9 | -45% | 13.9 | -57% | 32.4 |
| | 46 | 37.6 | -9% | 37.0 | -11% | 34.5 | -17% | 30.4 | -26% | 25.4 | -39% | 19.6 | -53% | 41.4 |
| | 54 | 49.6 | -1% | 48.6 | -3% | 45.3 | -10% | 39.8 | -21% | 32.9 | -34% | 24.0 | -52% | 50.2 |
| 3 | 24 | 17.4 | -20% | 17.1 | -21% | 15.9 | -27% | 13.2 | -39% | 11.3 | -48% | 8.7 | -60% | 21.6 |
| | 36 | 28.8 | -11% | 28.5 | -12% | 26.5 | -18% | 22.9 | -29% | 18.8 | -42% | 14.1 | -57% | 32.4 |
| | 46 | 42.8 | 3% | 42.2 | 2% | 38.9 | -6% | 33.6 | -19% | 27.3 | -34% | 20.4 | -51% | 41.4 |
| | 54 | 55.3 | 10% | 54.2 | 8% | 49.9 | -1% | 43.1 | -14% | 35.2 | -30% | 26.5 | -47% | 50.2 |
| 4 | 24 | 19.2 | -11% | 18.8 | -13% | 16.3 | -24% | 13.3 | -38% | 11.3 | -48% | 8.7 | -60% | 21.6 |
| | 36 | 31.6 | -2% | 31.3 | -3% | 28.3 | -13% | 23.5 | -27% | 18.9 | -42% | 14.1 | -57% | 32.4 |
| | 46 | 46.1 | 11% | 45.5 | 10% | 41.4 | 0% | 34.9 | -16% | 27.7 | -33% | 20.2 | -51% | 41.4 |
| | 54 | 59.3 | 18% | 58.1 | 16% | 53.0 | 6% | 45.1 | -10% | 36.1 | -28% | 26.6 | -47% | 50.2 |

Table 4.26: Comparison of FEA Maximum Longitudinal Bending Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|--|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 10.0 | 28.1 | -65% | 9.9 | 28.1 | -65% | 9.7 | 27.0 | -64% | 9.1 | 25.3 | -64% | 8.9 | 23.6 | -62% | 7.7 | 21.1 | -63% |
| | 36 | 16.9 | 47.2 | -64% | 16.7 | 47.2 | -65% | 16.0 | 45.3 | -65% | 14.8 | 42.5 | -65% | 13.4 | 39.6 | -66% | 11.0 | 35.4 | -69% |
| | 46 | 26.5 | 62.9 | -58% | 26.1 | 62.9 | -58% | 24.7 | 60.4 | -59% | 22.5 | 56.6 | -60% | 20.7 | 52.8 | -61% | 15.9 | 47.2 | -66% |
| | 54 | 36.2 | 75.3 | -52% | 35.5 | 75.3 | -53% | 31.0 | 72.3 | -57% | 30.4 | 67.8 | -55% | 26.4 | 63.3 | -58% | 21.0 | 56.5 | -63% |
| 2 | 24 | 14.7 | 24.1 | -39% | 14.4 | 24.1 | -40% | 13.9 | 23.2 | -40% | 12.7 | 21.7 | -42% | 11.2 | 20.2 | -44% | 8.8 | 18.1 | -52% |
| | 36 | 24.8 | 45.6 | -46% | 24.5 | 45.6 | -46% | 23.2 | 43.8 | -47% | 20.8 | 41.0 | -49% | 17.9 | 38.3 | -53% | 13.9 | 34.2 | -59% |
| | 46 | 37.6 | 65.3 | -42% | 37.0 | 65.3 | -43% | 34.5 | 62.7 | -45% | 30.4 | 58.8 | -48% | 25.4 | 54.9 | -54% | 19.6 | 49.0 | -60% |
| | 54 | 49.6 | 81.7 | -39% | 48.6 | 81.7 | -40% | 45.3 | 78.4 | -42% | 39.8 | 73.5 | -46% | 32.9 | 68.6 | -52% | 24.0 | 61.3 | -61% |
| 3 | 24 | 17.4 | 22.6 | -23% | 17.1 | 22.6 | -24% | 15.9 | 21.7 | -27% | 13.2 | 20.3 | -35% | 11.3 | 19.0 | -40% | 8.7 | 17.0 | -49% |
| | 36 | 28.8 | 42.3 | -32% | 28.5 | 42.3 | -33% | 26.5 | 40.6 | -35% | 22.9 | 38.1 | -40% | 18.8 | 35.5 | -47% | 14.1 | 31.7 | -56% |
| | 46 | 42.8 | 60.4 | -29% | 42.2 | 60.4 | -30% | 38.9 | 58.0 | -33% | 33.6 | 54.4 | -38% | 27.3 | 50.7 | -46% | 20.4 | 45.3 | -55% |
| | 54 | 55.3 | 77.1 | -28% | 54.2 | 77.1 | -30% | 49.9 | 74.0 | -33% | 43.1 | 69.4 | -38% | 35.2 | 64.8 | -46% | 26.5 | 57.8 | -54% |
| 4 | 24 | 19.2 | 21.5 | -11% | 18.8 | 21.5 | -13% | 16.3 | 20.6 | -21% | 13.3 | 19.4 | -31% | 11.3 | 18.1 | -38% | 8.7 | 16.1 | -46% |
| | 36 | 31.6 | 40.0 | -21% | 31.3 | 40.0 | -22% | 28.3 | 38.4 | -26% | 23.5 | 36.0 | -35% | 18.9 | 33.6 | -44% | 14.1 | 30.0 | -53% |
| | 46 | 46.1 | 59.8 | -23% | 45.5 | 59.8 | -24% | 41.4 | 57.3 | -28% | 34.9 | 53.8 | -35% | 27.7 | 50.2 | -45% | 20.2 | 44.8 | -55% |
| | 54 | 59.3 | 77.1 | -23% | 58.1 | 77.1 | -25% | 53.0 | 74.0 | -28% | 45.1 | 69.4 | -35% | 36.1 | 64.8 | -44% | 26.6 | 57.8 | -54% |

Table 4.27: Comparison of FEA Edge Beam Moment with AASHTO Moment

| Number of Lanes | Span Length (ft) | FEA Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 9.4 | -63% | 9.2 | -64% | 9.1 | -65% | 8.6 | -66% | 8.3 | -67% | 7.2 | -72% | 25.6 |
| | 36 | 17.2 | -55% | 17.0 | -56% | 16.3 | -58% | 15.2 | -61% | 13.9 | -64% | 11.6 | -70% | 38.4 |
| | 46 | 27.3 | -44% | 27.0 | -45% | 25.6 | -48% | 23.4 | -52% | 20.7 | -58% | 17.1 | -65% | 49.1 |
| | 54 | 37.5 | -35% | 36.8 | -36% | 32.2 | -44% | 31.6 | -45% | 27.8 | -52% | 22.5 | -61% | 57.6 |
| 2 | 24 | 11.7 | -54% | 11.5 | -55% | 11.1 | -56% | 10.3 | -60% | 9.5 | -63% | 7.8 | -70% | 25.6 |
| | 36 | 23.4 | -39% | 23.2 | -40% | 22.0 | -43% | 19.9 | -48% | 17.4 | -55% | 13.8 | -64% | 38.4 |
| | 46 | 37.3 | -24% | 36.8 | -25% | 34.5 | -30% | 30.7 | -37% | 26.1 | -47% | 20.7 | -58% | 49.1 |
| | 54 | 50.0 | -13% | 49.1 | -15% | 45.9 | -20% | 40.7 | -29% | 34.3 | -40% | 26.2 | -55% | 57.6 |
| 3 | 24 | 12.5 | -51% | 12.4 | -52% | 11.9 | -54% | 10.7 | -58% | 9.7 | -62% | 7.8 | -70% | 25.6 |
| | 36 | 26.4 | -31% | 26.3 | -32% | 24.7 | -36% | 21.8 | -43% | 18.3 | -52% | 14.1 | -63% | 38.4 |
| | 46 | 42.1 | -14% | 41.6 | -15% | 38.6 | -21% | 33.8 | -31% | 27.9 | -43% | 21.5 | -56% | 49.1 |
| | 54 | 55.6 | -3% | 54.7 | -5% | 50.7 | -12% | 44.2 | -23% | 36.8 | -36% | 28.3 | -51% | 57.6 |
| 4 | 24 | 12.8 | -50% | 12.7 | -51% | 12.1 | -53% | 10.8 | -58% | 9.7 | -62% | 7.8 | -70% | 25.6 |
| | 36 | 28.0 | -27% | 27.9 | -27% | 25.9 | -33% | 22.2 | -42% | 18.4 | -52% | 14.1 | -63% | 38.4 |
| | 46 | 45.1 | -8% | 44.5 | -9% | 40.9 | -17% | 35.0 | -29% | 28.4 | -42% | 21.3 | -57% | 49.1 |
| | 54 | 59.4 | 3% | 58.4 | 1% | 53.7 | -7% | 46.2 | -20% | 37.6 | -35% | 28.4 | -51% | 57.6 |

Table 4.28: Comparison of FEA Edge Beam Moment with LRFD Moment

| Number of Lanes | Span Length (ft) | FEA and LRFD Edge Beam Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | |
|-----------------|------------------|---|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|------------|------|--------|
| | | Angle of Skewness | | | | | | | | | | | | | | | | | |
| | | 0 Degrees | | | 10 Degrees | | | 20 Degrees | | | 30 Degrees | | | 40 Degrees | | | 50 Degrees | | |
| | | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD | FEA | LRFD | % LRFD |
| 1 | 24 | 9.4 | 23.0 | -59% | 9.2 | 23.0 | -60% | 9.1 | 22.1 | -59% | 8.6 | 20.7 | -59% | 8.3 | 19.3 | -57% | 7.2 | 17.3 | -58% |
| | 36 | 17.2 | 39.5 | -56% | 17.0 | 39.5 | -57% | 16.3 | 37.9 | -57% | 15.2 | 35.6 | -57% | 13.9 | 33.2 | -58% | 11.6 | 29.7 | -61% |
| | 46 | 27.3 | 60.9 | -55% | 27.0 | 60.9 | -56% | 25.6 | 58.5 | -56% | 23.4 | 54.9 | -57% | 20.7 | 51.2 | -60% | 17.1 | 45.7 | -63% |
| | 54 | 37.5 | 76.1 | -51% | 36.8 | 76.1 | -52% | 32.2 | 73.1 | -56% | 31.6 | 68.5 | -54% | 27.8 | 64.0 | -57% | 22.5 | 57.1 | -61% |
| 2 | 24 | 11.7 | 21.2 | -45% | 11.5 | 21.2 | -46% | 11.1 | 20.3 | -45% | 10.3 | 19.1 | -46% | 9.5 | 17.8 | -47% | 7.8 | 15.9 | -51% |
| | 36 | 23.4 | 41.4 | -43% | 23.2 | 41.4 | -44% | 22.0 | 39.7 | -45% | 19.9 | 37.3 | -47% | 17.4 | 34.8 | -50% | 13.8 | 31.1 | -55% |
| | 46 | 37.3 | 62.3 | -40% | 36.8 | 62.3 | -41% | 34.5 | 59.8 | -42% | 30.7 | 56.1 | -45% | 26.1 | 52.3 | -50% | 20.7 | 46.7 | -56% |
| | 54 | 50.0 | 79.9 | -37% | 49.1 | 79.9 | -39% | 45.9 | 76.7 | -40% | 40.7 | 72.0 | -43% | 34.3 | 67.2 | -49% | 26.2 | 60.0 | -56% |
| 3 | 24 | 12.5 | 20.5 | -39% | 12.4 | 20.5 | -40% | 11.9 | 19.6 | -40% | 10.7 | 18.4 | -42% | 9.7 | 17.2 | -44% | 7.8 | 15.4 | -49% |
| | 36 | 26.4 | 39.7 | -33% | 26.3 | 39.7 | -34% | 24.7 | 38.1 | -35% | 21.8 | 35.8 | -39% | 18.3 | 33.4 | -45% | 14.1 | 29.8 | -53% |
| | 46 | 42.1 | 59.5 | -29% | 41.6 | 59.5 | -30% | 38.6 | 57.1 | -32% | 33.8 | 53.6 | -37% | 27.9 | 50.0 | -44% | 21.5 | 44.6 | -52% |
| | 54 | 55.6 | 77.3 | -28% | 54.7 | 77.3 | -29% | 50.7 | 74.2 | -32% | 44.2 | 69.6 | -36% | 36.8 | 64.9 | -43% | 28.3 | 58.0 | -51% |
| 4 | 24 | 12.8 | 19.9 | -36% | 12.7 | 19.9 | -36% | 12.1 | 19.1 | -37% | 10.8 | 17.9 | -40% | 9.7 | 16.7 | -42% | 7.8 | 14.9 | -48% |
| | 36 | 28.0 | 38.4 | -27% | 27.9 | 38.4 | -27% | 25.9 | 36.9 | -30% | 22.2 | 34.6 | -36% | 18.4 | 32.3 | -43% | 14.1 | 28.8 | -51% |
| | 46 | 45.1 | 59.1 | -24% | 44.5 | 59.1 | -25% | 40.9 | 56.7 | -28% | 35.0 | 53.2 | -34% | 28.4 | 49.7 | -43% | 21.3 | 44.4 | -52% |
| | 54 | 59.4 | 77.3 | -23% | 58.4 | 77.3 | -24% | 53.7 | 74.2 | -28% | 46.2 | 69.6 | -34% | 37.6 | 64.9 | -42% | 28.4 | 58.0 | -51% |

Table 4.29: Comparison of FEA Maximum Transverse Moment with FEA Maximum Longitudinal Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Transverse Moment (Kip-ft/ft) | | | | | | | | | | | |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|
| | | Angle of Skewness | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | |
| 1 | 24 | 6.7 | 0.67 | 6.7 | 0.68 | 6.7 | 0.69 | 6.6 | 0.73 | 6.7 | 0.75 | 6.6 | 0.85 |
| | 36 | 6.9 | 0.41 | 6.9 | 0.41 | 7.3 | 0.46 | 7.9 | 0.53 | 8.3 | 0.62 | 8.5 | 0.77 |
| | 46 | 6.7 | 0.25 | 6.9 | 0.26 | 7.4 | 0.30 | 8.0 | 0.35 | 8.6 | 0.41 | 9.2 | 0.58 |
| | 54 | 6.5 | 0.18 | 6.7 | 0.19 | 7.0 | 0.23 | 7.4 | 0.24 | 7.9 | 0.30 | 8.2 | 0.39 |
| 2 | 24 | 8.4 | 0.57 | 8.3 | 0.58 | 8.4 | 0.61 | 8.2 | 0.65 | 8.3 | 0.74 | 8.4 | 0.96 |
| | 36 | 10.1 | 0.41 | 10.3 | 0.42 | 10.5 | 0.45 | 11.2 | 0.54 | 12.1 | 0.68 | 12.3 | 0.88 |
| | 46 | 10.4 | 0.28 | 10.6 | 0.29 | 11.4 | 0.33 | 12.6 | 0.41 | 13.7 | 0.54 | 14.2 | 0.72 |
| | 54 | 10.2 | 0.21 | 10.3 | 0.21 | 11.4 | 0.25 | 12.5 | 0.31 | 13.5 | 0.41 | 14.1 | 0.59 |
| 3 | 24 | 8.6 | 0.49 | 8.6 | 0.50 | 8.7 | 0.55 | 9.1 | 0.69 | 9.4 | 0.83 | 8.5 | 0.97 |
| | 36 | 11.9 | 0.41 | 12.3 | 0.43 | 12.5 | 0.47 | 13.9 | 0.61 | 13.8 | 0.74 | 12.9 | 0.92 |
| | 46 | 13.4 | 0.31 | 13.8 | 0.33 | 14.9 | 0.38 | 16.4 | 0.49 | 16.6 | 0.61 | 16.0 | 0.78 |
| | 54 | 13.8 | 0.25 | 14.1 | 0.26 | 15.6 | 0.31 | 17.3 | 0.40 | 18.2 | 0.52 | 17.6 | 0.66 |
| 4 | 24 | 8.4 | 0.44 | 8.4 | 0.45 | 9.1 | 0.56 | 9.3 | 0.69 | 9.4 | 0.83 | 8.5 | 0.97 |
| | 36 | 12.5 | 0.40 | 13.0 | 0.41 | 13.9 | 0.49 | 14.5 | 0.62 | 14.0 | 0.74 | 12.9 | 0.92 |
| | 46 | 15.2 | 0.33 | 15.7 | 0.34 | 16.9 | 0.41 | 18.2 | 0.52 | 17.5 | 0.63 | 15.8 | 0.78 |
| | 54 | 16.3 | 0.28 | 16.8 | 0.29 | 18.6 | 0.35 | 20.2 | 0.45 | 19.9 | 0.55 | 17.7 | 0.67 |

Table 4.30: Comparison of FEA Maximum Live Load Deflection with AASHTO Criterion

| Number of Lanes | Span Length (ft) | FEA Maximum Slab Deflection (in) | | | | | | | | | | | | AASHTO Deflection (in) |
|-----------------|------------------|----------------------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.025 | -93% | 0.025 | -93% | 0.023 | -93% | 0.021 | -94% | 0.017 | -95% | 0.013 | -96% | 0.360 |
| | 36 | 0.088 | -84% | 0.086 | -84% | 0.079 | -85% | 0.070 | -87% | 0.057 | -90% | 0.043 | -92% | 0.540 |
| | 46 | 0.170 | -75% | 0.166 | -76% | 0.153 | -78% | 0.133 | -81% | 0.108 | -84% | 0.080 | -88% | 0.690 |
| | 54 | 0.234 | -71% | 0.227 | -72% | 0.209 | -74% | 0.180 | -78% | 0.146 | -82% | 0.105 | -87% | 0.810 |
| 2 | 24 | 0.039 | -89% | 0.038 | -89% | 0.036 | -90% | 0.029 | -92% | 0.022 | -94% | 0.015 | -96% | 0.360 |
| | 36 | 0.130 | -76% | 0.127 | -76% | 0.117 | -78% | 0.100 | -82% | 0.079 | -85% | 0.056 | -90% | 0.540 |
| | 46 | 0.244 | -65% | 0.238 | -65% | 0.218 | -68% | 0.185 | -73% | 0.145 | -79% | 0.102 | -85% | 0.690 |
| | 54 | 0.323 | -60% | 0.315 | -61% | 0.286 | -65% | 0.242 | -70% | 0.190 | -77% | 0.129 | -84% | 0.810 |
| 3 | 24 | 0.051 | -86% | 0.050 | -86% | 0.044 | -88% | 0.033 | -91% | 0.023 | -94% | 0.015 | -96% | 0.360 |
| | 36 | 0.150 | -72% | 0.147 | -73% | 0.134 | -75% | 0.112 | -79% | 0.084 | -84% | 0.056 | -90% | 0.540 |
| | 46 | 0.280 | -59% | 0.274 | -60% | 0.248 | -64% | 0.206 | -70% | 0.157 | -77% | 0.108 | -84% | 0.690 |
| | 54 | 0.364 | -55% | 0.355 | -56% | 0.321 | -60% | 0.267 | -67% | 0.206 | -75% | 0.140 | -83% | 0.810 |
| 4 | 24 | 0.060 | -83% | 0.058 | -84% | 0.047 | -87% | 0.034 | -91% | 0.023 | -94% | 0.015 | -96% | 0.360 |
| | 36 | 0.164 | -70% | 0.164 | -70% | 0.143 | -73% | 0.116 | -79% | 0.086 | -84% | 0.056 | -90% | 0.540 |
| | 46 | 0.302 | -56% | 0.295 | -57% | 0.265 | -62% | 0.216 | -69% | 0.160 | -77% | 0.106 | -85% | 0.690 |
| | 54 | 0.391 | -52% | 0.381 | -53% | 0.342 | -58% | 0.280 | -65% | 0.211 | -74% | 0.141 | -83% | 0.810 |

4.3.3.2 FEA Results of Skewed versus Straight Bridges

4.3.3.2.1 Maximum Longitudinal Bending Moment

The ratios $M2/\alpha\alpha / M2/00$ for the maximum longitudinal moment are shown in Table 4.31 and Figure 4.13, for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. Such Tables/Figures indicate a uniform pattern of decrease in the maximum longitudinal and edge moment values with the increase in the skew angle, compared to that of straight bridges regardless of the number of lanes and span length. This decrease appears to be significant when the skew angle exceeds 20° . Also, for skew angles greater than 20° , the ratio $M2/\alpha\alpha / M2/00$ decreases with the increase in the number of lanes from one to four. For both the maximum longitudinal moment and edge beam moment, the ratio $M2/\alpha\alpha / M2/00$ is almost one for bridges with skew angles less than 20° , decreases to about 0.75 for bridges with skew angles between 30 and 40° , and further decreases to about 0.5 as the bridge skew angle increases to 50° .

4.3.3.2.2 Maximum Transverse Moment

The ratios $M2/\alpha\alpha / M2/00$ for the maximum transverse moment are shown in Table 4.33 and Figure 4.15 for each of the four span lengths considered (24, 36, 46, and 54 ft) versus the skew angle. The maximum transverse moment increases almost linearly as the skew angle increases from 10 to 40° , where it reaches a peak value. The $M2/\alpha\alpha / M2/00$ ratio decreases slightly again for skew angles between 40 and 50° . The ratio $M2/\alpha\alpha / M2/00$ varies with the variation in the span length and width, thus no general pattern can be deduced as for the results discussed in previous sections. In general, the ratio $M2/\alpha\alpha / M2/00$ is almost 1 for skew angle less than 20° , and it reaches a maximum of 1.3 at a skew angle of 40° .

4.3.3.2.3 Maximum Live Load Deflection

The ratio $\Delta_{2/\alpha} / \Delta_{2/00}$ values obtained are presented in Table 4.34 and Figure 4.16 for each of the four span lengths considered (24, 36, 46, and 54 ft). The maximum live load deflection pattern is consistent and expected to be similar to the maximum longitudinal bending moment. These values indicate that the maximum live load deflection for skewed bridges compared to that of straight bridges decreases with the skew angle for all span lengths and the number of lanes. This decrease is summarized as follows: The ratio is about one for a skew angle up to 10° and is approximately equal to 0.9 for a skew angle equal to 20° ; this ratio further decreases to about 0.75 as the skew angle increases to 30° and reaches a minimum of 0.35 at a skew angle of 50° .

Table 4.31: FEA Maximum Longitudinal Bending Moment – Ratio $M2/\alpha\alpha$ / $M2/00$

| Number of Lanes | Span Length (ft) | Maximum Longitudinal Moment - $M2/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M2/00$ (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 10.0 | 1.00 | 9.9 | 0.99 | 9.7 | 0.97 | 9.1 | 0.91 | 8.9 | 0.89 | 7.7 | 0.77 | 10.0 |
| | 36 | 16.9 | 1.00 | 16.7 | 0.99 | 16.0 | 0.94 | 14.8 | 0.88 | 13.4 | 0.79 | 11.0 | 0.65 | 16.9 |
| | 46 | 26.5 | 1.00 | 26.1 | 0.99 | 24.7 | 0.93 | 22.5 | 0.85 | 20.7 | 0.78 | 15.9 | 0.60 | 26.5 |
| | 54 | 36.2 | 1.00 | 35.5 | 0.98 | 31.0 | 0.86 | 30.4 | 0.84 | 26.4 | 0.73 | 21.0 | 0.58 | 36.2 |
| 2 | 24 | 14.7 | 1.00 | 14.4 | 0.98 | 13.9 | 0.95 | 12.7 | 0.86 | 11.2 | 0.77 | 8.8 | 0.60 | 14.7 |
| | 36 | 24.8 | 1.00 | 24.5 | 0.99 | 23.2 | 0.94 | 20.8 | 0.84 | 17.9 | 0.72 | 13.9 | 0.56 | 24.8 |
| | 46 | 37.6 | 1.00 | 37.0 | 0.99 | 34.5 | 0.92 | 30.4 | 0.81 | 25.4 | 0.68 | 19.6 | 0.52 | 37.6 |
| | 54 | 49.6 | 1.00 | 48.6 | 0.98 | 45.3 | 0.91 | 39.8 | 0.80 | 32.9 | 0.66 | 24.0 | 0.48 | 49.6 |
| 3 | 24 | 17.4 | 1.00 | 17.1 | 0.98 | 15.9 | 0.91 | 13.2 | 0.76 | 11.3 | 0.65 | 8.7 | 0.50 | 17.4 |
| | 36 | 28.8 | 1.00 | 28.5 | 0.99 | 26.5 | 0.92 | 22.9 | 0.80 | 18.8 | 0.65 | 14.1 | 0.49 | 28.8 |
| | 46 | 42.8 | 1.00 | 42.2 | 0.99 | 38.9 | 0.91 | 33.6 | 0.79 | 27.3 | 0.64 | 20.4 | 0.48 | 42.8 |
| | 54 | 55.3 | 1.00 | 54.2 | 0.98 | 49.9 | 0.90 | 43.1 | 0.78 | 35.2 | 0.64 | 26.5 | 0.48 | 55.3 |
| 4 | 24 | 19.2 | 1.00 | 18.8 | 0.98 | 16.3 | 0.85 | 13.3 | 0.70 | 11.3 | 0.59 | 8.7 | 0.46 | 19.2 |
| | 36 | 31.6 | 1.00 | 31.3 | 0.99 | 28.3 | 0.90 | 23.5 | 0.75 | 18.9 | 0.60 | 14.1 | 0.45 | 31.6 |
| | 46 | 46.1 | 1.00 | 45.5 | 0.99 | 41.4 | 0.90 | 34.9 | 0.76 | 27.7 | 0.60 | 20.2 | 0.44 | 46.1 |
| | 54 | 59.3 | 1.00 | 58.1 | 0.98 | 53.0 | 0.89 | 45.1 | 0.76 | 36.1 | 0.61 | 26.6 | 0.45 | 59.3 |

Table 4.32: FEA Edge Beam Moment – Ratio $M2/\alpha\alpha$ / $M2/00$

| Number of Lanes | Span Length (ft) | Edge Beam Moment - $M2/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Edge Moment $M2/00$ (Kip-ft/ft) |
|-----------------|------------------|--|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 9.4 | 1.00 | 9.2 | 0.99 | 9.1 | 0.97 | 8.6 | 0.92 | 8.3 | 0.89 | 7.2 | 0.77 | 9.4 |
| | 36 | 17.2 | 1.00 | 17.0 | 0.99 | 16.3 | 0.95 | 15.2 | 0.88 | 13.9 | 0.80 | 11.6 | 0.68 | 17.2 |
| | 46 | 27.3 | 1.00 | 27.0 | 0.99 | 25.6 | 0.94 | 23.4 | 0.86 | 20.7 | 0.76 | 17.1 | 0.62 | 27.3 |
| | 54 | 37.5 | 1.00 | 36.8 | 0.98 | 32.2 | 0.86 | 31.6 | 0.84 | 27.8 | 0.74 | 22.5 | 0.60 | 37.5 |
| 2 | 24 | 11.7 | 1.00 | 11.5 | 0.98 | 11.1 | 0.95 | 10.3 | 0.88 | 9.5 | 0.81 | 7.8 | 0.66 | 11.7 |
| | 36 | 23.4 | 1.00 | 23.2 | 0.99 | 22.0 | 0.94 | 19.9 | 0.85 | 17.4 | 0.74 | 13.8 | 0.59 | 23.4 |
| | 46 | 37.3 | 1.00 | 36.8 | 0.99 | 34.5 | 0.93 | 30.7 | 0.82 | 26.1 | 0.70 | 20.7 | 0.55 | 37.3 |
| | 54 | 50.0 | 1.00 | 49.1 | 0.98 | 45.9 | 0.92 | 40.7 | 0.81 | 34.3 | 0.69 | 26.2 | 0.52 | 50.0 |
| 3 | 24 | 12.5 | 1.00 | 12.4 | 0.99 | 11.9 | 0.95 | 10.7 | 0.85 | 9.7 | 0.77 | 7.8 | 0.62 | 12.5 |
| | 36 | 26.4 | 1.00 | 26.3 | 1.00 | 24.7 | 0.93 | 21.8 | 0.82 | 18.3 | 0.69 | 14.1 | 0.53 | 26.4 |
| | 46 | 42.1 | 1.00 | 41.6 | 0.99 | 38.6 | 0.92 | 33.8 | 0.80 | 27.9 | 0.66 | 21.5 | 0.51 | 42.1 |
| | 54 | 55.6 | 1.00 | 54.7 | 0.98 | 50.7 | 0.91 | 44.2 | 0.79 | 36.8 | 0.66 | 28.3 | 0.51 | 55.6 |
| 4 | 24 | 12.8 | 1.00 | 12.7 | 0.99 | 12.1 | 0.94 | 10.8 | 0.84 | 9.7 | 0.75 | 7.8 | 0.61 | 12.8 |
| | 36 | 28.0 | 1.00 | 27.9 | 1.00 | 25.9 | 0.93 | 22.2 | 0.80 | 18.4 | 0.66 | 14.1 | 0.50 | 28.0 |
| | 46 | 45.1 | 1.00 | 44.5 | 0.99 | 40.9 | 0.91 | 35.0 | 0.78 | 28.4 | 0.63 | 21.3 | 0.47 | 45.1 |
| | 54 | 59.4 | 1.00 | 58.4 | 0.98 | 53.7 | 0.90 | 46.2 | 0.78 | 37.6 | 0.63 | 28.4 | 0.48 | 59.4 |

Table 4.33: FEA Maximum Transverse Moment – Ratio $M2/\alpha\alpha$ / $M2/00$

| Number of Lanes | Span Length (ft) | Maximum Transverse Moment - $M2/\alpha\alpha$ (Kip-ft/ft) | | | | | | | | | | | | Maximum Moment $M2/00$ (Kip-ft/ft) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 6.7 | 1.00 | 6.7 | 1.00 | 6.7 | 1.00 | 6.6 | 0.99 | 6.7 | 1.01 | 6.6 | 0.98 | 6.7 |
| | 36 | 6.9 | 1.00 | 6.9 | 1.00 | 7.3 | 1.06 | 7.9 | 1.15 | 8.3 | 1.21 | 8.5 | 1.24 | 6.9 |
| | 46 | 6.7 | 1.00 | 6.9 | 1.03 | 7.4 | 1.10 | 8.0 | 1.19 | 8.6 | 1.28 | 9.2 | 1.37 | 6.7 |
| | 54 | 6.5 | 1.00 | 6.7 | 1.03 | 7.0 | 1.07 | 7.4 | 1.13 | 7.9 | 1.21 | 8.2 | 1.26 | 6.5 |
| 2 | 24 | 8.4 | 1.00 | 8.3 | 1.00 | 8.4 | 1.01 | 8.2 | 0.98 | 8.3 | 0.99 | 8.4 | 1.00 | 8.4 |
| | 36 | 10.1 | 1.00 | 10.3 | 1.02 | 10.5 | 1.04 | 11.2 | 1.11 | 12.1 | 1.20 | 12.3 | 1.22 | 10.1 |
| | 46 | 10.4 | 1.00 | 10.6 | 1.02 | 11.4 | 1.10 | 12.6 | 1.21 | 13.7 | 1.32 | 14.2 | 1.36 | 10.4 |
| | 54 | 10.2 | 1.00 | 10.3 | 1.01 | 11.4 | 1.12 | 12.5 | 1.23 | 13.5 | 1.32 | 14.1 | 1.38 | 10.2 |
| 3 | 24 | 8.6 | 1.00 | 8.6 | 1.00 | 8.7 | 1.02 | 9.1 | 1.06 | 9.4 | 1.10 | 8.5 | 0.99 | 8.6 |
| | 36 | 11.9 | 1.00 | 12.3 | 1.03 | 12.5 | 1.05 | 13.9 | 1.17 | 13.8 | 1.16 | 12.9 | 1.08 | 11.9 |
| | 46 | 13.4 | 1.00 | 13.8 | 1.03 | 14.9 | 1.11 | 16.4 | 1.22 | 16.6 | 1.23 | 16.0 | 1.19 | 13.4 |
| | 54 | 13.8 | 1.00 | 14.1 | 1.03 | 15.6 | 1.13 | 17.3 | 1.26 | 18.2 | 1.32 | 17.6 | 1.28 | 13.8 |
| 4 | 24 | 8.4 | 1.00 | 8.4 | 1.01 | 9.1 | 1.09 | 9.3 | 1.11 | 9.4 | 1.13 | 8.5 | 1.01 | 8.4 |
| | 36 | 12.5 | 1.00 | 13.0 | 1.03 | 13.9 | 1.11 | 14.5 | 1.16 | 14.0 | 1.12 | 12.9 | 1.03 | 12.5 |
| | 46 | 15.2 | 1.00 | 15.7 | 1.03 | 16.9 | 1.11 | 18.2 | 1.20 | 17.5 | 1.15 | 15.8 | 1.04 | 15.2 |
| | 54 | 16.3 | 1.00 | 16.8 | 1.03 | 18.6 | 1.14 | 20.2 | 1.24 | 19.9 | 1.22 | 17.7 | 1.08 | 16.3 |

Table 4.34: FEA Maximum Live Load Deflection – Ratio $\Delta_2/\alpha\alpha / \Delta_2/00$

| Number of Lanes | Span Length (ft) | Maximum Live Load Deflection - $\Delta_2/\alpha\alpha$ (in) | | | | | | | | | | | | Maximum Deflection $\Delta_2/00$ (in) |
|-----------------|------------------|---|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------------|
| | | Angle of Skewness | | | | | | | | | | | | |
| | | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| 1 | 24 | 0.025 | 1.00 | 0.025 | 0.98 | 0.023 | 0.94 | 0.021 | 0.84 | 0.017 | 0.70 | 0.013 | 0.53 | 0.025 |
| | 36 | 0.088 | 1.00 | 0.086 | 0.97 | 0.079 | 0.90 | 0.070 | 0.79 | 0.057 | 0.64 | 0.043 | 0.48 | 0.088 |
| | 46 | 0.170 | 1.00 | 0.166 | 0.97 | 0.153 | 0.90 | 0.133 | 0.78 | 0.108 | 0.64 | 0.080 | 0.47 | 0.170 |
| | 54 | 0.234 | 1.00 | 0.227 | 0.97 | 0.209 | 0.89 | 0.180 | 0.77 | 0.146 | 0.62 | 0.105 | 0.45 | 0.234 |
| 2 | 24 | 0.039 | 1.00 | 0.038 | 0.97 | 0.036 | 0.90 | 0.029 | 0.75 | 0.022 | 0.56 | 0.015 | 0.38 | 0.039 |
| | 36 | 0.130 | 1.00 | 0.127 | 0.98 | 0.117 | 0.90 | 0.100 | 0.77 | 0.079 | 0.61 | 0.056 | 0.43 | 0.130 |
| | 46 | 0.244 | 1.00 | 0.238 | 0.98 | 0.218 | 0.89 | 0.185 | 0.76 | 0.145 | 0.59 | 0.102 | 0.42 | 0.244 |
| | 54 | 0.323 | 1.00 | 0.315 | 0.97 | 0.286 | 0.89 | 0.242 | 0.75 | 0.190 | 0.59 | 0.129 | 0.40 | 0.323 |
| 3 | 24 | 0.051 | 1.00 | 0.050 | 0.98 | 0.044 | 0.86 | 0.033 | 0.64 | 0.023 | 0.45 | 0.015 | 0.29 | 0.051 |
| | 36 | 0.150 | 1.00 | 0.147 | 0.99 | 0.134 | 0.90 | 0.112 | 0.75 | 0.084 | 0.56 | 0.056 | 0.38 | 0.150 |
| | 46 | 0.280 | 1.00 | 0.274 | 0.98 | 0.248 | 0.89 | 0.206 | 0.74 | 0.157 | 0.56 | 0.108 | 0.39 | 0.280 |
| | 54 | 0.364 | 1.00 | 0.355 | 0.97 | 0.321 | 0.88 | 0.267 | 0.73 | 0.206 | 0.57 | 0.140 | 0.38 | 0.364 |
| 4 | 24 | 0.060 | 1.00 | 0.058 | 0.96 | 0.047 | 0.79 | 0.034 | 0.56 | 0.023 | 0.39 | 0.015 | 0.25 | 0.060 |
| | 36 | 0.164 | 1.00 | 0.164 | 1.00 | 0.143 | 0.87 | 0.116 | 0.71 | 0.086 | 0.52 | 0.056 | 0.34 | 0.164 |
| | 46 | 0.302 | 1.00 | 0.295 | 0.98 | 0.265 | 0.88 | 0.216 | 0.72 | 0.160 | 0.53 | 0.106 | 0.35 | 0.302 |
| | 54 | 0.391 | 1.00 | 0.381 | 0.97 | 0.342 | 0.87 | 0.280 | 0.72 | 0.211 | 0.54 | 0.141 | 0.36 | 0.391 |

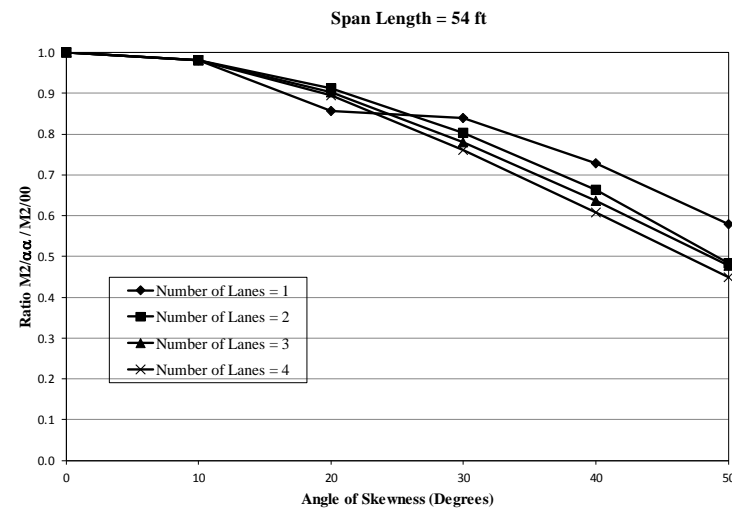
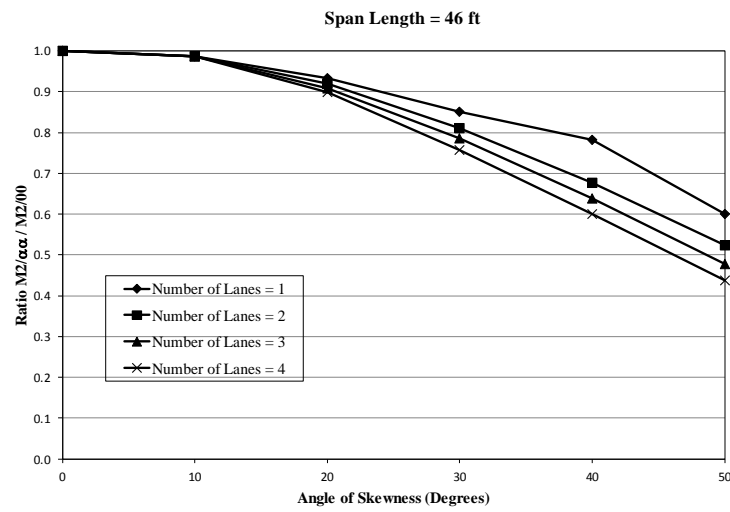
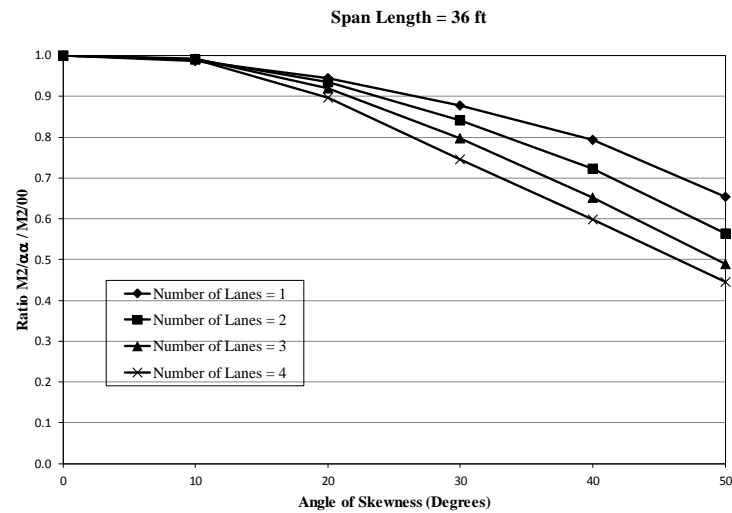
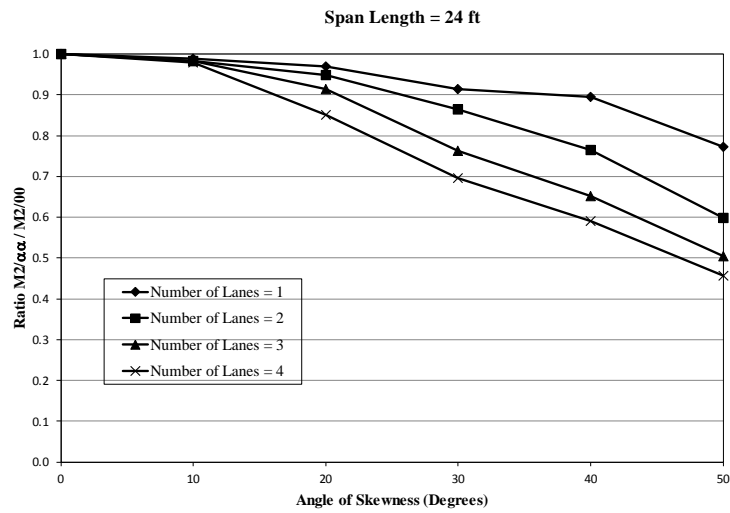


Figure 4.13: FEA Maximum Longitudinal Bending Moment – Ratio $M2/\alpha\alpha / M2/00$

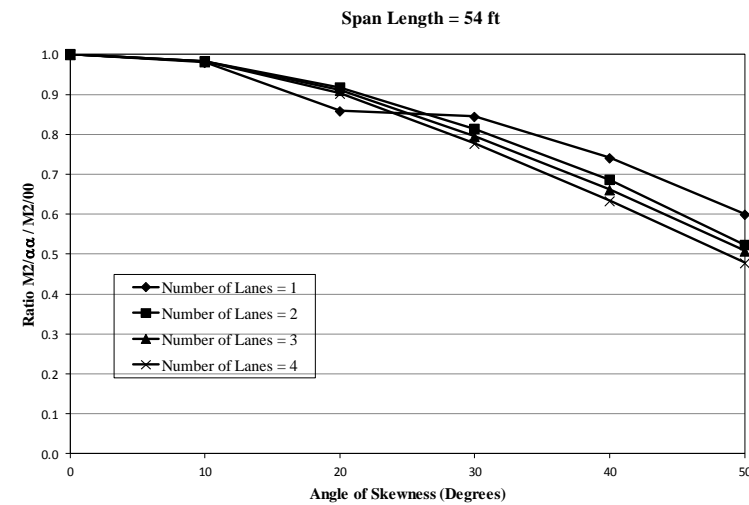
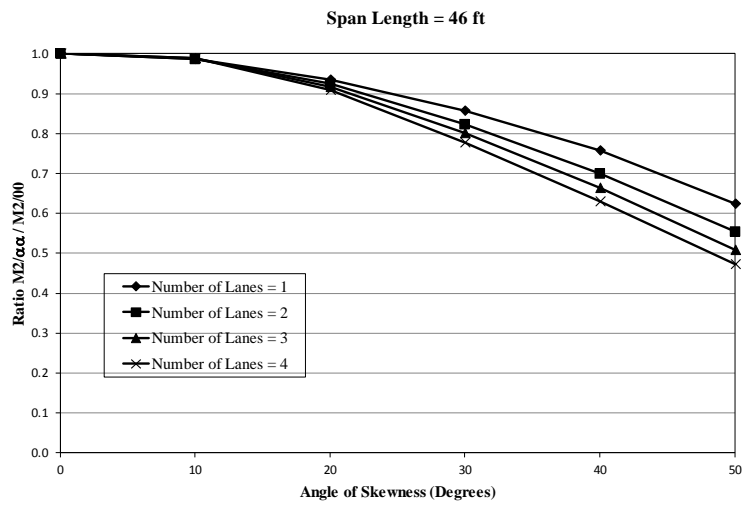
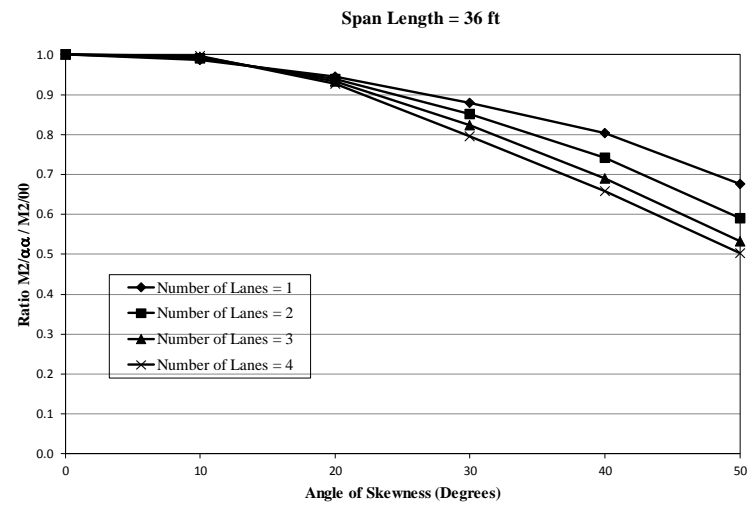
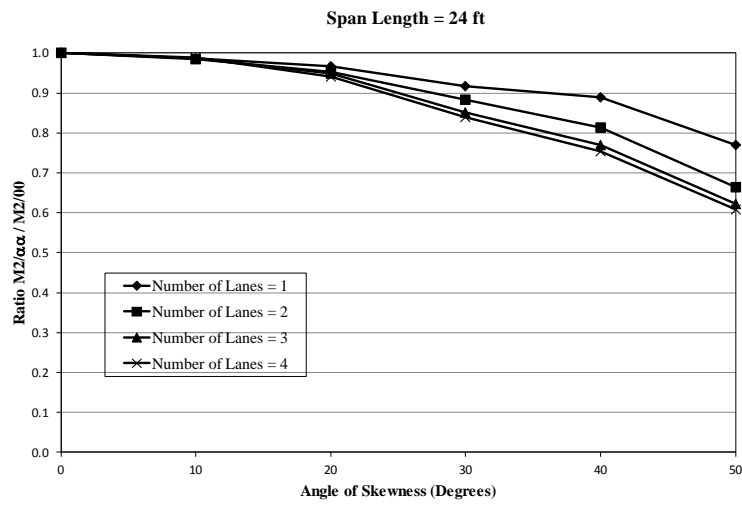


Figure 4.14:FEA Edge Beam Moment – Ratio $M2/\alpha\alpha / M2/00$

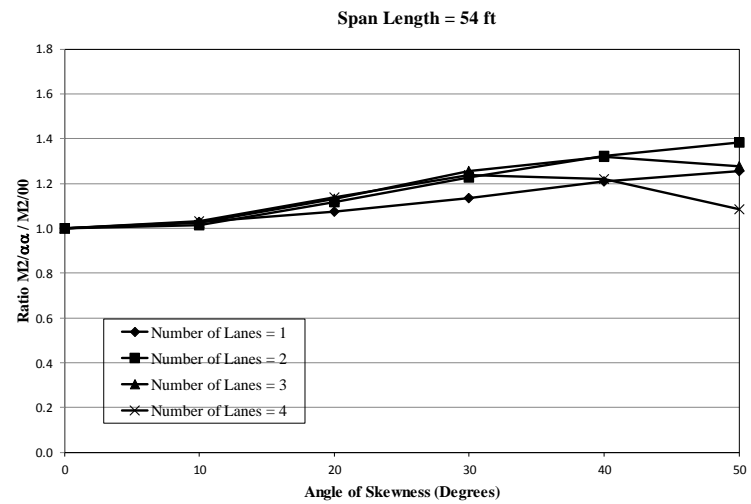
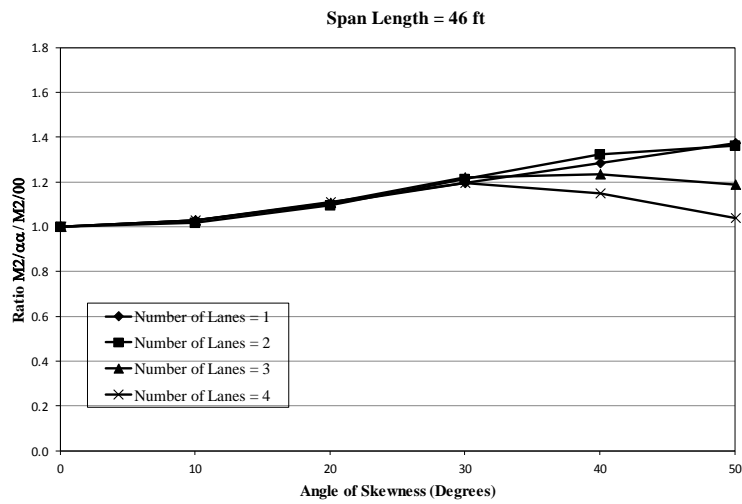
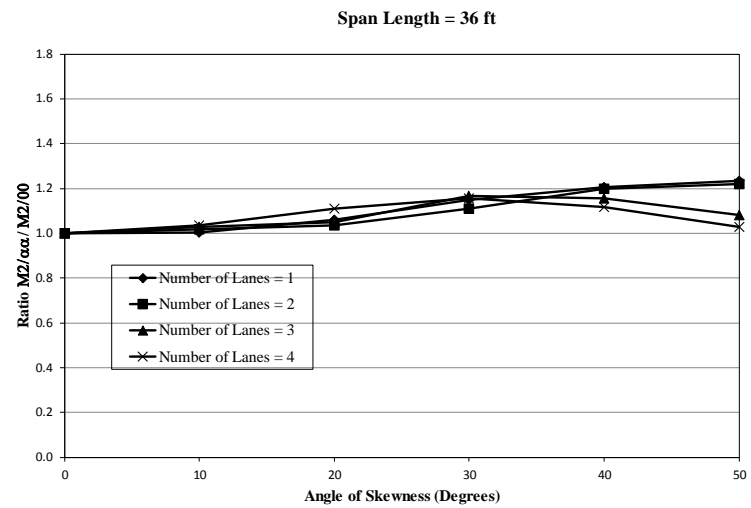
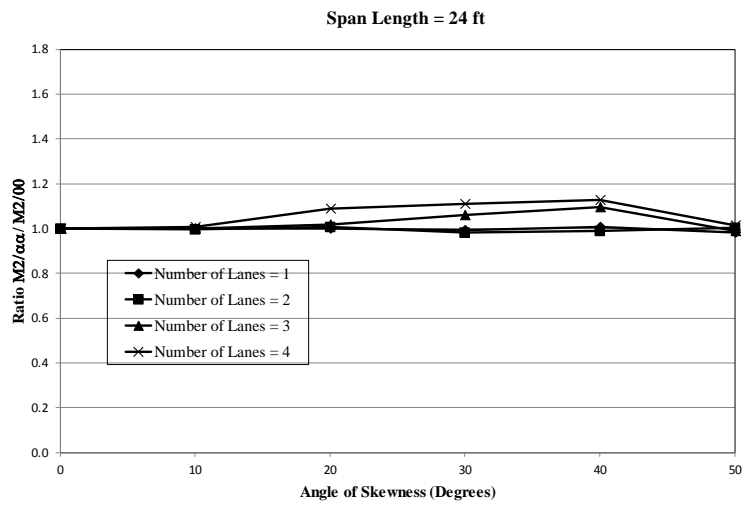


Figure 4.15: FEA Maximum Transverse Moment – Ratio $M2/\alpha\alpha / M2/00$

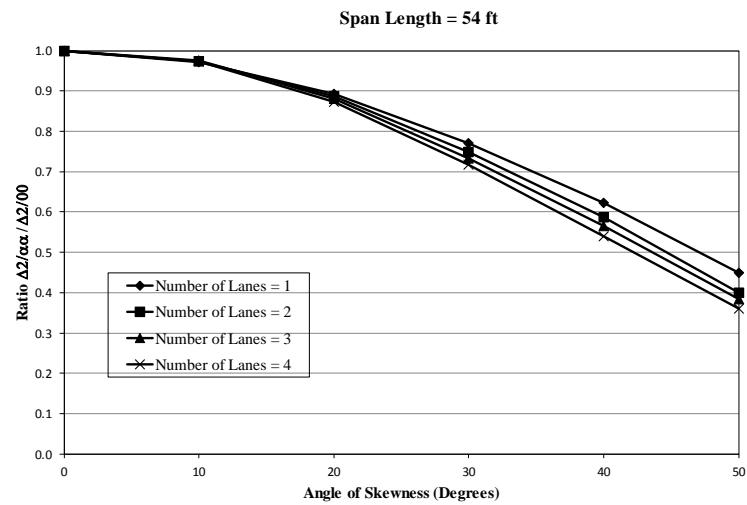
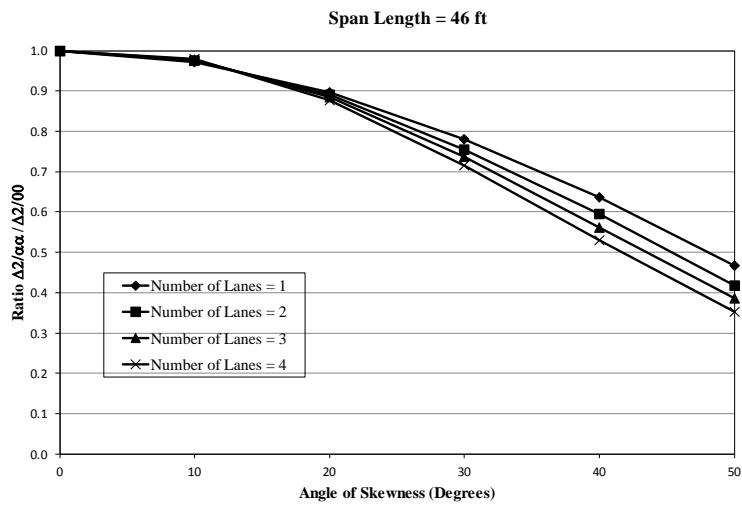
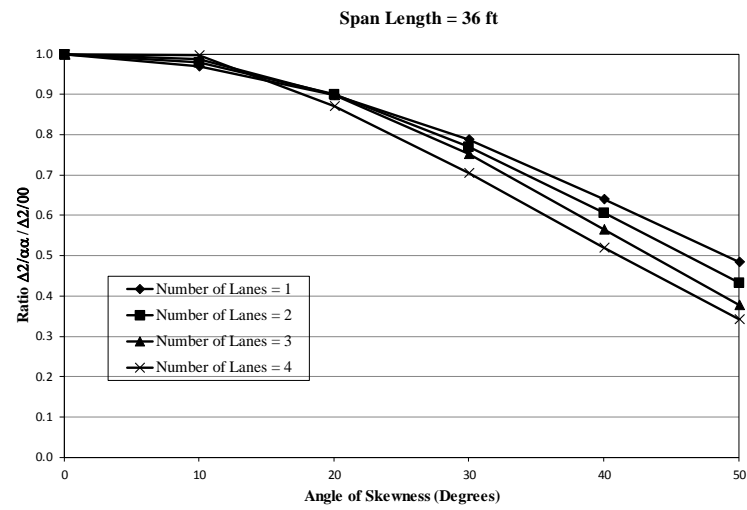
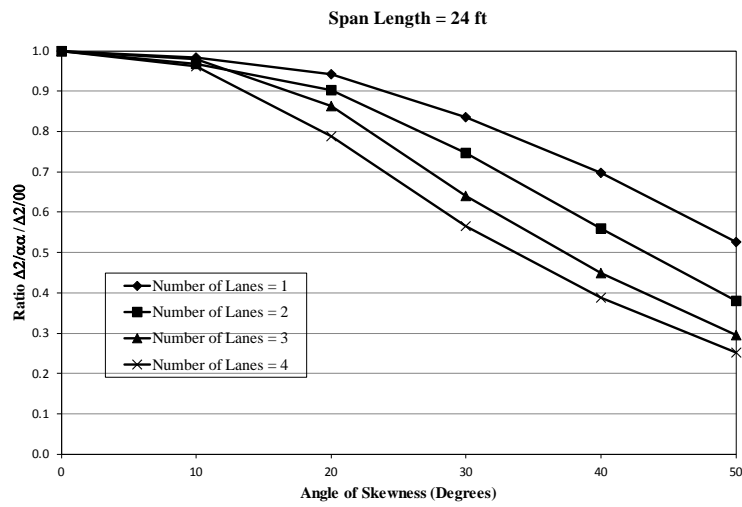


Figure 4.16: FEA Maximum Live Load Deflection – Ratio $\Delta 2/\alpha\alpha / \Delta 2/00$

4.3.3.3 Summary

The AASHTO Standard Specifications gave similar results to the FEA maximum longitudinal bending moment when the skew angle is less than or equal to 10° . As the skew angle increases, AASHTO Standard Specifications overestimated the maximum moment by about 30% for 30° , 80% for 40° , and 120% for 50° . The procedure presented in AASHTO LRFD Design Specifications overestimated the FEA maximum longitudinal bending moment by up to 100% for skew angles less than 30° and reaching 180% for 50° . The ratio between the FEA longitudinal moments for skewed and straight bridges was almost one for bridges with skew angle less than 20° . This ratio decreased to 0.75 for bridges with skew angles between 30° and 40° , and further decreased to 0.5 as the skew angle of the bridge increased to 50° . This decrease in the longitudinal moment ratio is offset by an increase by up to 75% in the maximum transverse moment ratio as the skew angle increases from 0 to 50° . The ratio between the FEA maximum live load deflection for skewed bridges and straight bridges decreases in a pattern consistent with that of the longitudinal moment. This ratio decreases from one for skew angles less than 10° to 0.6 for skew angles between 40° and 50° .

4.4 Summary Results of Maximum Longitudinal Bending Moment for all Skewed Bridges with/without Railings

In this section, the maximum longitudinal moment for all bridges is compared with the reference cases which are straight bridges without railings. Table 4.37 presents the maximum longitudinal moment for all bridges and Table 4.38 show the ratios $M_i/\alpha\alpha / M_0/00$ for all bridges. This ratio shows the influence of the combination of skewness and railings for any bridge as compared to the reference bridge.

For angle of skewness less than 20° , the reduction in the longitudinal moment reaches 40% for bridges with two railings, and about none for bridges with no railings. For angle of skewness equal to 30° , the reduction in the longitudinal moment reaches 45% for bridges with two railings, and about 20% for bridges with no railings.

For angle of skewness equal to 40° , the reduction in the longitudinal moment reaches 50% for bridges with two railings, and about 35% for bridges with no railings. For angle of skewness equal to 50° , the reduction in the longitudinal moment reaches 60% for bridges with two railings, and about 50% for bridges with no railings.

The reduction in the longitudinal moment is not affected by the span length. The reduction in the longitudinal moment is more when the number of lanes decreases, but this effect decreases to none when for high skewness irrespective of the number of railings.

For angle of skewness less than 20° , the reduction in moment reaches 40 to 25% from 1 to 4 lanes for bridges with two railings, to none for bridges with no railings with any number of lanes.

For angle of skewness equal to 30° , the reduction in moment reaches 45 to 35% from 1 to 4 lanes for bridges with two railings, to 25% for bridges with no railings with any number of lanes.

For angle of skewness equal to 40° , the reduction in moment reaches 50% for bridges with two railings, to 40% for bridges with no railings with any number of lanes.

For angle of skewness equal to 50° , the reduction in moment reaches 55% for bridges with and without railings for any number of lanes.

For bridges with no railings, there is no reduction in moment for skew angle less than 20° , but this reduction reaches 25% for skew angle of 30° , 40% for skew angle of 40° and 55% for skew angle of 50° for any number of lanes.

For bridges with one railing, there reduction in moment reaches 20% to none from 1 to 4 lanes for skew angle less than 20° , but this reduction reaches 30% for skew angle of 30° , 40% for skew angle of 40° and 55% for skew angle of 50° for any number of lanes.

For bridges with one railing, there reduction in moment reaches to 30% from 1 to 4 lanes for skew angle less than 20° , but this reduction reaches 40% for skew angle of 30° , 50% for skew angle of 40° and 60% for skew angle of 50° for any number of lanes.

Table 4.35: FEA Maximum Longitudinal Bending Moment

| Number of Lanes | Span Length (ft) | FEA Maximum Longitudinal Moment (Kip-ft/ft) | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|------------------|---|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|
| | | 0 Degrees | | | | 10 Degrees | | | | 20 Degrees | | | | 30 Degrees | | | | 40 Degrees | | | | 50 Degrees | | | |
| | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | |
| 1 | 24 | 16.6 | 16.6 | 13.9 | 10.0 | 16.6 | 16.1 | 13.7 | 9.9 | 16.6 | 15.3 | 13.3 | 9.7 | 16.6 | 13.5 | 12.3 | 9.1 | 16.6 | 11.7 | 11.0 | 8.9 | 16.6 | 9.6 | 9.5 | 7.7 |
| | 36 | 29.1 | 29.1 | 22.9 | 16.9 | 29.1 | 28.3 | 22.4 | 16.7 | 29.1 | 25.9 | 21.2 | 16.0 | 29.1 | 22.6 | 19.3 | 14.8 | 29.1 | 18.8 | 16.8 | 13.4 | 29.1 | 15.2 | 14.4 | 11.0 |
| | 46 | 42.0 | 42.0 | 33.7 | 26.5 | 42.0 | 40.8 | 32.9 | 26.1 | 42.0 | 37.3 | 30.9 | 24.7 | 42.0 | 32.4 | 27.8 | 22.5 | 42.0 | 27.0 | 24.0 | 20.7 | 42.0 | 21.1 | 19.6 | 15.9 |
| | 54 | 52.2 | 52.2 | 43.7 | 36.2 | 52.2 | 50.7 | 42.7 | 35.5 | 52.2 | 46.6 | 39.9 | 31.0 | 52.2 | 40.6 | 35.5 | 30.4 | 52.2 | 33.9 | 30.4 | 26.4 | 52.2 | 26.3 | 24.3 | 21.0 |
| 2 | 24 | 20.5 | 20.5 | 19.2 | 14.7 | 20.5 | 19.9 | 18.9 | 14.4 | 20.5 | 18.7 | 18.0 | 13.9 | 20.5 | 16.3 | 16.0 | 12.7 | 20.5 | 13.8 | 13.8 | 11.2 | 20.5 | 10.6 | 10.6 | 8.8 |
| | 36 | 35.3 | 35.3 | 31.6 | 24.8 | 35.3 | 34.7 | 31.2 | 24.5 | 35.3 | 31.7 | 29.1 | 23.2 | 35.3 | 27.2 | 25.9 | 20.8 | 35.3 | 22.2 | 21.7 | 17.9 | 35.3 | 17.5 | 17.5 | 13.9 |
| | 46 | 50.4 | 50.4 | 45.1 | 37.6 | 50.4 | 49.2 | 44.2 | 37.0 | 50.4 | 44.8 | 41.1 | 34.5 | 50.4 | 38.3 | 36.1 | 30.4 | 50.4 | 31.1 | 30.2 | 25.4 | 50.4 | 23.9 | 23.7 | 19.6 |
| | 54 | 62.3 | 62.3 | 56.8 | 49.6 | 62.3 | 60.8 | 55.6 | 48.6 | 62.3 | 55.5 | 51.5 | 45.3 | 62.3 | 47.6 | 45.0 | 39.8 | 62.3 | 38.5 | 37.2 | 32.9 | 62.3 | 28.3 | 28.0 | 24.0 |
| 3 | 24 | 21.7 | 21.7 | 21.4 | 17.4 | 21.7 | 21.3 | 21.1 | 17.1 | 21.7 | 19.9 | 19.8 | 15.9 | 21.7 | 16.8 | 16.8 | 13.2 | 21.7 | 13.9 | 13.9 | 11.3 | 21.7 | 10.6 | 10.6 | 8.7 |
| | 36 | 37.5 | 37.5 | 36.0 | 28.8 | 37.5 | 37.0 | 35.7 | 28.5 | 37.5 | 33.8 | 33.0 | 26.5 | 37.5 | 28.9 | 28.6 | 22.9 | 37.5 | 22.9 | 22.9 | 18.8 | 37.5 | 17.8 | 17.8 | 14.1 |
| | 46 | 52.9 | 52.9 | 50.5 | 42.8 | 52.9 | 51.9 | 49.6 | 42.2 | 52.9 | 47.2 | 45.8 | 38.9 | 52.9 | 40.2 | 39.5 | 33.6 | 52.9 | 32.1 | 31.9 | 27.3 | 52.9 | 24.6 | 24.6 | 20.4 |
| | 54 | 65.0 | 65.0 | 62.3 | 55.3 | 65.0 | 63.6 | 61.1 | 54.2 | 65.0 | 58.1 | 56.3 | 49.9 | 65.0 | 49.5 | 48.5 | 43.1 | 65.0 | 40.0 | 39.7 | 35.2 | 65.0 | 30.7 | 30.7 | 26.5 |
| 4 | 24 | 22.3 | 22.3 | 22.2 | 19.2 | 22.3 | 21.9 | 21.9 | 18.8 | 22.3 | 20.2 | 20.2 | 16.3 | 22.3 | 16.9 | 16.9 | 13.3 | 22.3 | 13.9 | 13.9 | 11.3 | 22.3 | 10.6 | 10.6 | 8.7 |
| | 36 | 39.1 | 39.1 | 38.6 | 31.6 | 39.1 | 38.7 | 38.2 | 31.3 | 39.1 | 35.1 | 34.9 | 28.3 | 39.1 | 29.4 | 29.4 | 23.5 | 39.1 | 23.1 | 23.1 | 18.9 | 39.1 | 17.8 | 17.8 | 14.1 |
| | 46 | 55.2 | 55.2 | 54.1 | 46.1 | 55.2 | 54.3 | 53.2 | 45.5 | 55.2 | 49.1 | 48.5 | 41.4 | 55.2 | 41.4 | 41.2 | 34.9 | 55.2 | 32.4 | 32.4 | 27.7 | 55.2 | 24.4 | 24.4 | 20.2 |
| | 54 | 67.7 | 67.7 | 66.4 | 59.3 | 67.7 | 66.3 | 65.1 | 58.1 | 67.7 | 60.3 | 59.5 | 53.0 | 67.7 | 51.0 | 50.7 | 45.1 | 67.7 | 40.7 | 40.6 | 36.1 | 67.7 | 30.7 | 30.7 | 26.6 |

Table 4.36: FEA Maximum Longitudinal Bending Moment – Ratio $M_i/\alpha\alpha / M_0/00$

| Number of Lanes | Span Length (ft) | FEA Maximum Longitudinal Moment (Kip-ft/ft) - $M_i/\alpha\alpha / M_0/00$ | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|------------------|---|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|------------|------|------|------|
| | | 0 Degrees | | | | 10 Degrees | | | | 20 Degrees | | | | 30 Degrees | | | | 40 Degrees | | | | 50 Degrees | | | |
| | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | | R0 | R1 | R2 | |
| 1 | 24 | 16.6 | 1.00 | 0.84 | 0.60 | 16.6 | 0.97 | 0.83 | 0.60 | 16.6 | 0.92 | 0.80 | 0.58 | 16.6 | 0.81 | 0.74 | 0.55 | 16.6 | 0.71 | 0.66 | 0.54 | 16.6 | 0.58 | 0.58 | 0.47 |
| | 36 | 29.1 | 1.00 | 0.79 | 0.58 | 29.1 | 0.97 | 0.77 | 0.57 | 29.1 | 0.89 | 0.73 | 0.55 | 29.1 | 0.78 | 0.66 | 0.51 | 29.1 | 0.65 | 0.58 | 0.46 | 29.1 | 0.52 | 0.49 | 0.38 |
| | 46 | 42.0 | 1.00 | 0.80 | 0.63 | 42.0 | 0.97 | 0.78 | 0.62 | 42.0 | 0.89 | 0.74 | 0.59 | 42.0 | 0.77 | 0.66 | 0.54 | 42.0 | 0.64 | 0.57 | 0.49 | 42.0 | 0.50 | 0.47 | 0.38 |
| | 54 | 52.2 | 1.00 | 0.84 | 0.69 | 52.2 | 0.97 | 0.82 | 0.68 | 52.2 | 0.89 | 0.76 | 0.59 | 52.2 | 0.78 | 0.68 | 0.58 | 52.2 | 0.65 | 0.58 | 0.51 | 52.2 | 0.50 | 0.46 | 0.40 |
| 2 | 24 | 20.5 | 1.00 | 0.94 | 0.72 | 20.5 | 0.97 | 0.92 | 0.70 | 20.5 | 0.91 | 0.88 | 0.68 | 20.5 | 0.80 | 0.78 | 0.62 | 20.5 | 0.67 | 0.67 | 0.55 | 20.5 | 0.52 | 0.52 | 0.43 |
| | 36 | 35.3 | 1.00 | 0.89 | 0.70 | 35.3 | 0.98 | 0.88 | 0.69 | 35.3 | 0.90 | 0.83 | 0.66 | 35.3 | 0.77 | 0.73 | 0.59 | 35.3 | 0.63 | 0.61 | 0.51 | 35.3 | 0.50 | 0.50 | 0.39 |
| | 46 | 50.4 | 1.00 | 0.90 | 0.75 | 50.4 | 0.98 | 0.88 | 0.74 | 50.4 | 0.89 | 0.82 | 0.69 | 50.4 | 0.76 | 0.72 | 0.60 | 50.4 | 0.62 | 0.60 | 0.51 | 50.4 | 0.47 | 0.47 | 0.39 |
| | 54 | 62.3 | 1.00 | 0.91 | 0.80 | 62.3 | 0.97 | 0.89 | 0.78 | 62.3 | 0.89 | 0.83 | 0.73 | 62.3 | 0.76 | 0.72 | 0.64 | 62.3 | 0.62 | 0.60 | 0.53 | 62.3 | 0.45 | 0.45 | 0.39 |
| 3 | 24 | 21.7 | 1.00 | 0.99 | 0.80 | 21.7 | 0.98 | 0.97 | 0.79 | 21.7 | 0.92 | 0.91 | 0.73 | 21.7 | 0.77 | 0.77 | 0.61 | 21.7 | 0.64 | 0.64 | 0.52 | 21.7 | 0.49 | 0.49 | 0.40 |
| | 36 | 37.5 | 1.00 | 0.96 | 0.77 | 37.5 | 0.99 | 0.95 | 0.76 | 37.5 | 0.90 | 0.88 | 0.71 | 37.5 | 0.77 | 0.76 | 0.61 | 37.5 | 0.61 | 0.61 | 0.50 | 37.5 | 0.47 | 0.47 | 0.38 |
| | 46 | 52.9 | 1.00 | 0.95 | 0.81 | 52.9 | 0.98 | 0.94 | 0.80 | 52.9 | 0.89 | 0.86 | 0.73 | 52.9 | 0.76 | 0.75 | 0.63 | 52.9 | 0.61 | 0.60 | 0.52 | 52.9 | 0.47 | 0.47 | 0.39 |
| | 54 | 65.0 | 1.00 | 0.96 | 0.85 | 65.0 | 0.98 | 0.94 | 0.83 | 65.0 | 0.89 | 0.87 | 0.77 | 65.0 | 0.76 | 0.75 | 0.66 | 65.0 | 0.62 | 0.61 | 0.54 | 65.0 | 0.47 | 0.47 | 0.41 |
| 4 | 24 | 22.3 | 1.00 | 1.00 | 0.86 | 22.3 | 0.98 | 0.98 | 0.84 | 22.3 | 0.91 | 0.91 | 0.73 | 22.3 | 0.76 | 0.76 | 0.60 | 22.3 | 0.62 | 0.62 | 0.51 | 22.3 | 0.48 | 0.48 | 0.39 |
| | 36 | 39.1 | 1.00 | 0.99 | 0.81 | 39.1 | 0.99 | 0.98 | 0.80 | 39.1 | 0.90 | 0.89 | 0.72 | 39.1 | 0.75 | 0.75 | 0.60 | 39.1 | 0.59 | 0.59 | 0.48 | 39.1 | 0.45 | 0.45 | 0.36 |
| | 46 | 55.2 | 1.00 | 0.98 | 0.84 | 55.2 | 0.98 | 0.96 | 0.82 | 55.2 | 0.89 | 0.88 | 0.75 | 55.2 | 0.75 | 0.75 | 0.63 | 55.2 | 0.59 | 0.59 | 0.50 | 55.2 | 0.44 | 0.44 | 0.37 |
| | 54 | 67.7 | 1.00 | 0.98 | 0.88 | 67.7 | 0.98 | 0.96 | 0.86 | 67.7 | 0.89 | 0.88 | 0.78 | 67.7 | 0.75 | 0.75 | 0.67 | 67.7 | 0.60 | 0.60 | 0.53 | 67.7 | 0.45 | 0.45 | 0.39 |

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

In this research, the significance of the presence of railings in skewed reinforced concrete slab bridges is investigated using the finite element method. The study involved the analysis of geometrically distinct simply supported, one span reinforced concrete slab bridges with variation in span length, number of lanes, skew angle, transverse truck loading positions and the presence railings. The maximum bending moments, edge beam moments, transverse moments, and live load deflections are extracted from the finite element analysis and compared with AASHTO Standard Specifications and AASHTO Load Resistance Factor Design (LRFD) in addition to a direct comparison with the base case bridges, which are straight bridges with no railings.

The FEA method was used to analyze the slab bridges; where by, the slabs were modeled and analyzed using SAP2000 computer program. Rectangular and triangular elements are used to model the effect of skewness keeping the aspect ratio close to one as much as the bridge geometry permits especially at the edges. The size of the typical square element is 1 ft x 1 ft. AASHTO HS20 truck load as concentrated load applied at the node, and the supports assigned as simple supports at each pier. Railings were modeled as integral parts of the slab bridges.

For the purpose of this study, a total number of 384 bridges were modeled divided into four categories: one lane, two lane, three lane, and four lane bridges with lane width of 12 ft. Each category was subdivided further into four other categories according to span length: 24 ft, 36 ft, 46 ft, and 54 ft, with the slab thickness being

18in, 21in, 24in and 27in, respectively, and after that Each category is subdivided in to six other categories representing six distinct skew angles, which are 0, 10, 20, 30, 40 and 50 degrees. Bridges were then split into three major categories:

Case 1: “Skewed bridges with no railings”

Case 2: “Skewed bridges with one railing”

Case 3: “Skewed bridges with two railings”

AASHTO HS20 design trucks were positioned longitudinally on the bridges to produce maximum moments where two different configurations were considered: E1 and E2 edge loading conditions. These loading conditions give maximum longitudinal and edge beam moments.

Based on FEA tabulated results a comparison between the base case bridges and bridges with railings was conducted to assess the presence of these elements on the capacity of the bridges. Bending moments, edge beam moments, transverse and deflections were considered. In addition, a comparison with AASHTO design moments and deflection values was also conducted. Results were presented in plots, graphs, and tables, and summarized in comparative tables which show the relative percentage differences and ratios.

5.2 Conclusions

The results of this research evaluated the effect of railings on the maximum bending moments, edge beam moments, transverse moments and maximum live load deflections for single span bridges. The following conclusions are drawn based on the results of this investigation.

5.2.1 Longitudinal Bending Moments

The AASHTO Standard Specifications gave similar results to the FEA maximum moment when the skew angle is less than 20°. As the skew angle increases till 50°, AASHTO Standard Specifications overestimated the maximum moment till it reaches 100% for bridges with no railings and 150% for bridges with two railings. The procedure presented in AASHTO LRFD Design Specifications overestimated the maximum moment by up to 65% for skew angles less than 30° and reaching 100% when the skew angle reaches 50°. This overestimation increases to 150% when adding two railings.

Based on the comparison of the longitudinal moment of all bridges with base case bridges, the following conclusions can be made:

For angle of skewness less than 20°, the reduction in the longitudinal moment reaches 40% for bridges with two railings, and about none for bridges with no railings. For angle of skewness equal to 30°, the reduction in the longitudinal moment reaches 45% for bridges with two railings, and about 20% for bridges with no railings.

For angle of skewness equal to 40°, the reduction in the longitudinal moment reaches 50% for bridges with two railings, and about 35% for bridges with no railings. For angle of skewness equal to 50°, the reduction in the longitudinal moment reaches 60% for bridges with two railings, and about 50% for bridges with no railings.

The reduction in the longitudinal moment is not affected by the span length. The reduction in the longitudinal moment is more when the number of lanes decreases, but this effect decreases to none when for high skewness irrespective of the number of railings.

For angle of skewness less than 20° , the reduction in moment reaches 40 to 25% from 1 to 4 lanes for bridges with two railings, to none for bridges with no railings with any number of lanes.

For angle of skewness equal to 30° , the reduction in moment reaches 45 to 35% from 1 to 4 lanes for bridges with two railings, to 25% for bridges with no railings with any number of lanes.

For angle of skewness equal to 40° , the reduction in moment reaches 50% for bridges with two railings, to 40% for bridges with no railings with any number of lanes. For angle of skewness equal to 50° , the reduction in moment reaches 55% for bridges with and without railings for any number of lanes.

For bridges with no railings, there is no reduction in moment for skew angle less than 20° , but this reduction reaches 25% for skew angle of 30° , 40% for skew angle of 40° and 55% for skew angle of 50° for any number of lanes. For bridges with one railing, there reduction in moment reaches 20% to none from 1 to 4 lanes for skew angle less than 20° , but this reduction reaches 30% for skew angle of 30° , 40% for skew angle of 40° and 55% for skew angle of 50° for any number of lanes.

For bridges with one railing, there reduction in moment reaches to 30% from 1 to 4 lanes for skew angle less than 20° , but this reduction reaches 40% for skew angle of 30° , 50% for skew angle of 40° and 60% for skew angle of 50° for any number of lanes.

5.2.2 Edge Beam Moments

In general, the edge beam moment for all bridges with one or no railings follow a similar pattern of the maximum longitudinal moment when compared to AASHTO Specifications or when compared to base case bridges. When two railings

are added, and due to the stiffness of the railings, railings will attract more loads and thus they have to be designed accordingly. Both AASHTO Specifications do not consider their presence. For that reason these specifications underestimate the edge beam moments for all bridges with two railings.

5.2.3 *Maximum Transverse Moment*

In general, the maximum transverse moment increases with the increase of the skew angle for all bridges with and without railings. This increase decreases with the increase in the number of lanes. At large skew angles, there is a significant increase in this transversal moment which is not covered by the AASHTO Specifications any more. So, when this increase becomes significant, it is important to check if the percentage transversal reinforcement provided by codes is satisfactory or not.

5.2.4 *Maximum Deflections*

The FEA results are directly related to the assumed slab thickness, which was a reasonable assumption for deflection control. But one can always assume a different thickness and obtain different deflection results.

For any given span length and its corresponding slab thickness, the maximum live load deflection results decrease as the skew angle increases from 0 to 50°. On the other hand, the FEA deflection results range from 1/5 to 1/2 the limiting value ($S/800$) given by AASHTO, and the percent difference with the AASHTO limiting criteria increases with the skew angle. The percent difference is higher for short spans, and decreases as the span length increases to 54 ft for a given skew angle. The presence of railings will result in lower deflections as compared to bridges without railings. Moreover, the basic assumption of the FEA model is the elastic section behavior, an actual cracked section analysis would yield higher deflections in

the slabs. The results will increase to approximately 2/5 to 1 of AASHTO limiting deflection value.

5.3 Recommendations

AASHTO Standard Specifications and AASHTO LRFD empirical equations do not account for the presence of railings as integral parts of a bridge slab, and these elements are neglected during the design stage. Based on the finite element analysis, it is clearly evident that these elements increase the capacity of the bridges if they are modeled as integral parts of the slab. In addition, railings can be used as one alternative strengthening technique to upgrade already existing bridges that require rehabilitation or upgrading, or if heavier loads are foreseen. In skewed bridges, there is already a reduction in the longitudinal moment as compared to straight bridges, but this decrease in the longitudinal moment is accompanied by an increase in the transversal moment. The increase in the transversal moment is even more significant when railings are present. So, it is optional for a designer to consider a reduction in the longitudinal moment for skewed bridges and/or bridges with integral railings, but it is imperative to take into account the increase in transversal moment which the code specifications fail to cover in this case. Therefore, if the bridges designer opts to do, it is safest to design a skewed bridge with railings as a straight bridge without railings for longitudinal reinforcement, but the increase in transversal reinforcement should not be ignored.

This research was limited to single spans, and it is recommended to extend the analysis to continuous bridges. Further, experimental work is recommended to assess and validate the finite element analysis results obtained in this investigation.

BIBLIOGRAPHY

1. Burdette, E. and Good pasture, D. – NCHRP (1988). “Correction of bridge load capacity estimates with test data”, Rep. No. 306, Nat. Cooperative Hwy. Res. Program, Transportation Research Board, Washington, D.C.
2. Frederick, G. R. (1997). “Experimental and analytical investigation of load distribution in concrete slab bridges”, Spring Conf., Society for Experimental Mechanics, Bellevue, Washington, D.C.
3. Jensen, V. P. (1938). “A distribution procedure for the analysis of slabs continuous over flexible beams”, Bulletin No. 304, Univ. of Illinois, Urbana, Illinois.
4. Jensen, V. P. (1939). “Moments in simple span bridge slabs with stiffened edges”, Bulletin No. 315, Univ. of Illinois, Urbana, Illinois.
5. LRFD Bridge Design Specifications (2010). American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C.
6. Mabsout, M., Tarhini, K., Frederick, G. and Kobrosly M. (1997). “Influence of sidewalks and railings on wheel load distribution in steel girder highway bridges”, Journal of Bridge Engineering, ASCE, August, Vol. 2, No. 3, pp. 88--96.
7. Mabsout, M., Tarhini, K., Jabakhanji, R., and Awwad, E. (2004). “Wheel load distribution in concrete slab bridges”, Journal of Bridge Engineering, ASCE, March-April, Vol. 9, No. 2, pp. 147--155.
8. SAP2000 (Version 15, 2012). Computers and Structures Inc., Berkeley, California.
9. Shekar, Y., Azizinamini, A., Barnhill, G., and Boothby T. (1993). “Performance of concrete slab bridges”, Final Rep., NDOR Project No. RESI99, Univ. of Nebraska, Lincoln, Neb.
10. Standard Specifications for Highway Bridges (2003). American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C.
11. Westergaard, H. M. (1926). “Stresses in concrete pavements computed by theoretical analysis”, Public Roads, 7(2), pp. 25--35.
12. Westergaard, H. M. (1930). “Computation of stresses in slabs due to wheel loads”, Public Roads, 11 (1), pp. 1--23.
13. Menassa, C., Mabsout, M., Tarhini, K. and Frederick, G. (2007). “Influence of skew angle in reinforced concrete slab bridges”, Journal of Bridge Engineering, ASCE, March-April, Vol. 2, No. 12, pp. 205--214.
14. Waked, M., Mabsout, M., and Tarhini, K. (2014). “Influence of sidewalks and railings on wheel load distribution in concrete slab bridges”, to be submitted to Journal of Bridge Engineering (Master’s thesis by Waked, AUB, 2010).

APPENDIX 1
LONGITUDINAL BENDING MOMENT TABLES

Table A1. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 14 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 18.7 | 28.1 | 18.3 | 28.1 | 17.6 | 27.0 | 15.9 | 25.3 | 13.9 | 23.6 | 12.1 | 21.1 | 21.6 |
| 1 | 20.1 | 28.1 | 19.6 | 28.1 | 18.8 | 27.0 | 16.9 | 25.3 | 15.5 | 23.6 | 13.1 | 21.1 | 21.6 |
| 2 | 16.4 | 28.1 | 16.1 | 28.1 | 15.3 | 27.0 | 13.5 | 25.3 | 11.5 | 23.6 | 9.6 | 21.1 | 21.6 |
| 3 | 14.9 | 28.1 | 14.5 | 28.1 | 13.7 | 27.0 | 11.8 | 25.3 | 10.0 | 23.6 | 8.0 | 21.1 | 21.6 |
| 4 | 14.1 | 28.1 | 13.8 | 28.1 | 12.9 | 27.0 | 11.1 | 25.3 | 9.2 | 23.6 | 7.2 | 21.1 | 21.6 |
| 5 | 13.9 | 28.1 | 13.5 | 28.1 | 12.6 | 27.0 | 10.8 | 25.3 | 8.9 | 23.6 | 6.9 | 21.1 | 21.6 |
| 6 | 14.3 | 28.1 | 13.9 | 28.1 | 13.1 | 27.0 | 11.2 | 25.3 | 9.3 | 23.6 | 7.3 | 21.1 | 21.6 |
| 7 | 16.6 | 28.1 | 16.1 | 28.1 | 15.2 | 27.0 | 13.2 | 25.3 | 11.7 | 23.6 | 9.2 | 21.1 | 21.6 |
| 8 | 13.4 | 28.1 | 13.0 | 28.1 | 12.2 | 27.0 | 10.3 | 25.3 | 8.3 | 23.6 | 6.3 | 21.1 | 21.6 |
| 9 | 12.0 | 28.1 | 11.6 | 28.1 | 10.8 | 27.0 | 8.9 | 25.3 | 6.9 | 23.6 | 4.8 | 21.1 | 21.6 |
| 10 | 11.2 | 28.1 | 10.8 | 28.1 | 10.0 | 27.0 | 8.1 | 25.3 | 6.1 | 23.6 | 3.8 | 21.1 | 21.6 |
| 11 | 10.6 | 28.1 | 10.3 | 28.1 | 9.4 | 27.0 | 7.5 | 25.3 | 5.5 | 23.6 | 3.0 | 21.1 | 21.6 |
| 12 | 10.2 | 28.1 | 9.9 | 28.1 | 9.1 | 27.0 | 7.2 | 25.3 | 5.1 | 23.6 | 2.1 | 21.1 | 21.6 |
| 13 | 10.0 | 28.1 | 9.6 | 28.1 | 8.8 | 27.0 | 6.9 | 25.3 | 4.8 | 23.6 | 1.2 | 21.1 | 21.6 |
| 14 | 9.8 | 28.1 | 9.5 | 28.1 | 8.7 | 27.0 | 6.8 | 25.3 | 4.7 | 23.6 | 0.0 | 21.1 | 21.6 |

Table A2. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 14 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 31.4 | 47.2 | 30.6 | 47.2 | 28.3 | 45.3 | 25.0 | 42.5 | 21.1 | 39.6 | 17.8 | 35.4 | 32.4 |
| 1 | 32.7 | 47.2 | 31.9 | 47.2 | 29.6 | 45.3 | 26.3 | 42.5 | 22.7 | 39.6 | 18.6 | 35.4 | 32.4 |
| 2 | 29.1 | 47.2 | 28.2 | 47.2 | 25.9 | 45.3 | 22.6 | 42.5 | 18.7 | 39.6 | 15.2 | 35.4 | 32.4 |
| 3 | 27.5 | 47.2 | 26.7 | 47.2 | 24.4 | 45.3 | 21.0 | 42.5 | 17.1 | 39.6 | 13.4 | 35.4 | 32.4 |
| 4 | 26.7 | 47.2 | 25.9 | 47.2 | 23.6 | 45.3 | 20.2 | 42.5 | 16.3 | 39.6 | 12.5 | 35.4 | 32.4 |
| 5 | 26.4 | 47.2 | 25.6 | 47.2 | 23.3 | 45.3 | 19.9 | 42.5 | 16.0 | 39.6 | 12.1 | 35.4 | 32.4 |
| 6 | 26.9 | 47.2 | 26.0 | 47.2 | 23.7 | 45.3 | 20.3 | 42.5 | 16.3 | 39.6 | 12.5 | 35.4 | 32.4 |
| 7 | 29.1 | 47.2 | 28.3 | 47.2 | 25.9 | 45.3 | 22.5 | 42.5 | 18.8 | 39.6 | 14.3 | 35.4 | 32.4 |
| 8 | 25.9 | 47.2 | 25.1 | 47.2 | 22.8 | 45.3 | 19.4 | 42.5 | 15.3 | 39.6 | 11.4 | 35.4 | 32.4 |
| 9 | 24.5 | 47.2 | 23.7 | 47.2 | 21.4 | 45.3 | 18.0 | 42.5 | 14.0 | 39.6 | 9.8 | 35.4 | 32.4 |
| 10 | 23.7 | 47.2 | 22.9 | 47.2 | 20.6 | 45.3 | 17.2 | 42.5 | 13.2 | 39.6 | 8.9 | 35.4 | 32.4 |
| 11 | 23.2 | 47.2 | 22.3 | 47.2 | 20.0 | 45.3 | 16.7 | 42.5 | 12.7 | 39.6 | 8.3 | 35.4 | 32.4 |
| 12 | 22.8 | 47.2 | 22.0 | 47.2 | 19.7 | 45.3 | 16.3 | 42.5 | 12.3 | 39.6 | 8.0 | 35.4 | 32.4 |
| 13 | 22.5 | 47.2 | 21.7 | 47.2 | 19.4 | 45.3 | 16.1 | 42.5 | 12.1 | 39.6 | 7.8 | 35.4 | 32.4 |
| 14 | 22.4 | 47.2 | 21.6 | 47.2 | 19.3 | 45.3 | 16.0 | 42.5 | 12.0 | 39.6 | 7.7 | 35.4 | 32.4 |

Table A3. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 14 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 44.2 | 62.9 | 43.0 | 62.9 | 39.7 | 60.4 | 34.8 | 56.6 | 29.4 | 52.8 | 23.6 | 47.2 | 41.4 |
| 1 | 45.6 | 62.9 | 44.5 | 62.9 | 41.0 | 60.4 | 36.1 | 56.6 | 30.7 | 52.8 | 24.5 | 47.2 | 41.4 |
| 2 | 41.9 | 62.9 | 40.7 | 62.9 | 37.3 | 60.4 | 32.4 | 56.6 | 27.0 | 52.8 | 21.1 | 47.2 | 41.4 |
| 3 | 40.4 | 62.9 | 39.1 | 62.9 | 35.8 | 60.4 | 30.8 | 56.6 | 25.3 | 52.8 | 19.4 | 47.2 | 41.4 |
| 4 | 39.6 | 62.9 | 38.4 | 62.9 | 35.0 | 60.4 | 30.0 | 56.6 | 24.5 | 52.8 | 18.5 | 47.2 | 41.4 |
| 5 | 39.3 | 62.9 | 38.1 | 62.9 | 34.7 | 60.4 | 29.7 | 56.6 | 24.2 | 52.8 | 18.2 | 47.2 | 41.4 |
| 6 | 39.7 | 62.9 | 38.5 | 62.9 | 35.1 | 60.4 | 30.1 | 56.6 | 24.6 | 52.8 | 18.6 | 47.2 | 41.4 |
| 7 | 42.0 | 62.9 | 40.8 | 62.9 | 37.3 | 60.4 | 32.4 | 56.6 | 26.8 | 52.8 | 20.4 | 47.2 | 41.4 |
| 8 | 38.8 | 62.9 | 37.5 | 62.9 | 34.2 | 60.4 | 29.2 | 56.6 | 23.7 | 52.8 | 17.6 | 47.2 | 41.4 |
| 9 | 37.4 | 62.9 | 36.2 | 62.9 | 32.8 | 60.4 | 27.8 | 56.6 | 22.3 | 52.8 | 16.1 | 47.2 | 41.4 |
| 10 | 36.6 | 62.9 | 35.4 | 62.9 | 32.0 | 60.4 | 27.0 | 56.6 | 21.5 | 52.8 | 15.3 | 47.2 | 41.4 |
| 11 | 36.0 | 62.9 | 34.8 | 62.9 | 31.4 | 60.4 | 26.5 | 56.6 | 20.9 | 52.8 | 14.7 | 47.2 | 41.4 |
| 12 | 35.6 | 62.9 | 34.4 | 62.9 | 31.0 | 60.4 | 26.1 | 56.6 | 20.6 | 52.8 | 14.4 | 47.2 | 41.4 |
| 13 | 35.4 | 62.9 | 34.2 | 62.9 | 30.8 | 60.4 | 25.9 | 56.6 | 20.4 | 52.8 | 14.2 | 47.2 | 41.4 |
| 14 | 35.2 | 62.9 | 34.0 | 62.9 | 30.7 | 60.4 | 25.8 | 56.6 | 20.3 | 52.8 | 14.1 | 47.2 | 41.4 |

Table A4. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 54 ft, Deck Width = 14 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 54.5 | 75.3 | 53.0 | 75.3 | 48.9 | 72.3 | 42.8 | 67.8 | 36.0 | 63.3 | 28.7 | 56.5 | 50.2 |
| 1 | 55.9 | 75.3 | 54.4 | 75.3 | 50.2 | 72.3 | 44.3 | 67.8 | 37.7 | 63.3 | 30.0 | 56.5 | 50.2 |
| 2 | 52.2 | 75.3 | 50.7 | 75.3 | 46.6 | 72.3 | 40.5 | 67.8 | 33.7 | 63.3 | 26.3 | 56.5 | 50.2 |
| 3 | 50.6 | 75.3 | 49.1 | 75.3 | 45.0 | 72.3 | 38.9 | 67.8 | 32.2 | 63.3 | 24.6 | 56.5 | 50.2 |
| 4 | 49.9 | 75.3 | 48.4 | 75.3 | 44.2 | 72.3 | 38.1 | 67.8 | 31.4 | 63.3 | 23.7 | 56.5 | 50.2 |
| 5 | 49.6 | 75.3 | 48.1 | 75.3 | 43.9 | 72.3 | 37.8 | 67.8 | 31.1 | 63.3 | 23.3 | 56.5 | 50.2 |
| 6 | 50.0 | 75.3 | 48.5 | 75.3 | 44.3 | 72.3 | 38.2 | 67.8 | 31.4 | 63.3 | 23.2 | 56.5 | 50.2 |
| 7 | 52.2 | 75.3 | 50.7 | 75.3 | 46.6 | 72.3 | 40.6 | 67.8 | 33.9 | 63.3 | 23.8 | 56.5 | 50.2 |
| 8 | 49.1 | 75.3 | 47.6 | 75.3 | 43.4 | 72.3 | 37.3 | 67.8 | 30.5 | 63.3 | 26.1 | 56.5 | 50.2 |
| 9 | 47.7 | 75.3 | 46.2 | 75.3 | 42.0 | 72.3 | 35.9 | 67.8 | 29.2 | 63.3 | 23.1 | 56.5 | 50.2 |
| 10 | 46.9 | 75.3 | 45.4 | 75.3 | 41.2 | 72.3 | 35.1 | 67.8 | 28.4 | 63.3 | 21.9 | 56.5 | 50.2 |
| 11 | 46.3 | 75.3 | 44.8 | 75.3 | 40.6 | 72.3 | 34.6 | 67.8 | 27.8 | 63.3 | 21.2 | 56.5 | 50.2 |
| 12 | 45.9 | 75.3 | 44.4 | 75.3 | 40.3 | 72.3 | 34.2 | 67.8 | 27.5 | 63.3 | 20.8 | 56.5 | 50.2 |
| 13 | 45.7 | 75.3 | 44.2 | 75.3 | 40.0 | 72.3 | 34.0 | 67.8 | 27.3 | 63.3 | 20.6 | 56.5 | 50.2 |
| 14 | 45.5 | 75.3 | 44.0 | 75.3 | 39.9 | 72.3 | 33.9 | 67.8 | 27.2 | 63.3 | 20.5 | 56.5 | 50.2 |

Table A5. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 24 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 21.7 | 24.1 | 21.3 | 24.1 | 20.4 | 23.2 | 18.4 | 21.7 | 15.6 | 20.2 | 13.1 | 18.1 | 21.6 |
| 1 | 23.1 | 24.1 | 22.6 | 24.1 | 21.6 | 23.2 | 19.4 | 21.7 | 17.2 | 20.2 | 14.0 | 18.1 | 21.6 |
| 2 | 19.6 | 24.1 | 19.1 | 24.1 | 18.1 | 23.2 | 16.0 | 21.7 | 13.2 | 20.2 | 10.6 | 18.1 | 21.6 |
| 3 | 18.1 | 24.1 | 17.6 | 24.1 | 16.6 | 23.2 | 14.4 | 21.7 | 11.7 | 20.2 | 8.9 | 18.1 | 21.6 |
| 4 | 17.4 | 24.1 | 17.0 | 24.1 | 15.9 | 23.2 | 13.7 | 21.7 | 11.0 | 20.2 | 8.1 | 18.1 | 21.6 |
| 5 | 17.3 | 24.1 | 16.8 | 24.1 | 15.7 | 23.2 | 13.5 | 21.7 | 10.7 | 20.2 | 7.9 | 18.1 | 21.6 |
| 6 | 18.0 | 24.1 | 17.5 | 24.1 | 16.4 | 23.2 | 14.1 | 21.7 | 11.2 | 20.2 | 8.4 | 18.1 | 21.6 |
| 7 | 20.5 | 24.1 | 19.9 | 24.1 | 18.7 | 23.2 | 16.3 | 21.7 | 13.8 | 20.2 | 10.4 | 18.1 | 21.6 |
| 8 | 17.7 | 24.1 | 17.2 | 24.1 | 16.1 | 23.2 | 13.7 | 21.7 | 10.6 | 20.2 | 7.8 | 18.1 | 21.6 |
| 9 | 16.9 | 24.1 | 16.4 | 24.1 | 15.2 | 23.2 | 12.8 | 21.7 | 9.7 | 20.2 | 6.6 | 18.1 | 21.6 |
| 10 | 17.2 | 24.1 | 16.7 | 24.1 | 15.5 | 23.2 | 13.0 | 21.7 | 9.7 | 20.2 | 6.7 | 18.1 | 21.6 |
| 11 | 19.4 | 24.1 | 18.8 | 24.1 | 17.5 | 23.2 | 14.8 | 21.7 | 11.9 | 20.2 | 8.3 | 18.1 | 21.6 |
| 12 | 16.3 | 24.1 | 15.7 | 24.1 | 14.5 | 23.2 | 11.8 | 21.7 | 8.2 | 20.2 | 5.1 | 18.1 | 21.6 |
| 13 | 15.0 | 24.1 | 14.4 | 24.1 | 13.1 | 23.2 | 10.3 | 21.7 | 6.7 | 20.2 | 3.6 | 18.1 | 21.6 |
| 14 | 14.4 | 24.1 | 13.8 | 24.1 | 12.4 | 23.2 | 9.5 | 21.7 | 5.6 | 20.2 | 2.2 | 18.1 | 21.6 |
| 15 | 14.2 | 24.1 | 13.7 | 24.1 | 12.2 | 23.2 | 9.2 | 21.7 | 5.0 | 20.2 | 0.0 | 18.1 | 21.6 |
| 16 | 14.8 | 24.1 | 14.2 | 24.1 | 12.7 | 23.2 | 9.5 | 21.7 | 4.8 | 20.2 | | 18.1 | 21.6 |
| 17 | 17.0 | 24.1 | 16.4 | 24.1 | 14.7 | 23.2 | 11.3 | 21.7 | 7.0 | 20.2 | | 18.1 | 21.6 |
| 18 | 13.9 | 24.1 | 13.3 | 24.1 | 11.7 | 23.2 | 8.1 | 21.7 | 2.8 | 20.2 | | 18.1 | 21.6 |
| 19 | 12.6 | 24.1 | 11.9 | 24.1 | 10.2 | 23.2 | 6.3 | 21.7 | 0.0 | 20.2 | | 18.1 | 21.6 |
| 20 | 11.8 | 24.1 | 11.1 | 24.1 | 9.3 | 23.2 | 5.1 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 21 | 11.2 | 24.1 | 10.6 | 24.1 | 8.7 | 23.2 | 4.0 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 22 | 10.9 | 24.1 | 10.2 | 24.1 | 8.3 | 23.2 | 2.8 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 23 | 10.6 | 24.1 | 10.0 | 24.1 | 8.0 | 23.2 | 1.6 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 24 | 10.5 | 24.1 | 9.8 | 24.1 | 7.8 | 23.2 | 0.7 | 21.7 | | 20.2 | | 18.1 | 21.6 |

Table A6. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 37.2 | 45.6 | 36.7 | 45.6 | 34.0 | 43.8 | 29.8 | 41.0 | 24.7 | 38.3 | 20.3 | 34.2 | 32.4 |
| 1 | 38.5 | 45.6 | 38.0 | 45.6 | 35.2 | 43.8 | 31.0 | 41.0 | 26.3 | 38.3 | 21.1 | 34.2 | 32.4 |
| 2 | 34.8 | 45.6 | 34.3 | 45.6 | 31.5 | 43.8 | 27.2 | 41.0 | 22.2 | 38.3 | 17.5 | 34.2 | 32.4 |
| 3 | 33.3 | 45.6 | 32.7 | 45.6 | 29.9 | 43.8 | 25.6 | 41.0 | 20.5 | 38.3 | 15.8 | 34.2 | 32.4 |
| 4 | 32.6 | 45.6 | 32.0 | 45.6 | 29.1 | 43.8 | 24.7 | 41.0 | 19.6 | 38.3 | 14.8 | 34.2 | 32.4 |
| 5 | 32.3 | 45.6 | 31.7 | 45.6 | 28.8 | 43.8 | 24.4 | 41.0 | 19.2 | 38.3 | 14.4 | 34.2 | 32.4 |
| 6 | 32.9 | 45.6 | 32.3 | 45.6 | 29.4 | 43.8 | 24.8 | 41.0 | 19.5 | 38.3 | 14.8 | 34.2 | 32.4 |
| 7 | 35.3 | 45.6 | 34.7 | 45.6 | 31.7 | 43.8 | 27.1 | 41.0 | 22.1 | 38.3 | 16.7 | 34.2 | 32.4 |
| 8 | 32.5 | 45.6 | 31.8 | 45.6 | 28.8 | 43.8 | 24.2 | 41.0 | 18.7 | 38.3 | 13.9 | 34.2 | 32.4 |
| 9 | 31.6 | 45.6 | 30.9 | 45.6 | 27.9 | 43.8 | 23.1 | 41.0 | 17.7 | 38.3 | 12.7 | 34.2 | 32.4 |
| 10 | 31.8 | 45.6 | 31.1 | 45.6 | 28.1 | 43.8 | 23.2 | 41.0 | 17.6 | 38.3 | 12.6 | 34.2 | 32.4 |
| 11 | 33.9 | 45.6 | 33.3 | 45.6 | 30.2 | 43.8 | 25.2 | 41.0 | 19.8 | 38.3 | 14.2 | 34.2 | 32.4 |
| 12 | 30.8 | 45.6 | 30.1 | 45.6 | 27.0 | 43.8 | 21.9 | 41.0 | 16.0 | 38.3 | 10.9 | 34.2 | 32.4 |
| 13 | 29.4 | 45.6 | 28.8 | 45.6 | 25.6 | 43.8 | 20.5 | 41.0 | 14.4 | 38.3 | 9.2 | 34.2 | 32.4 |
| 14 | 28.8 | 45.6 | 28.2 | 45.6 | 25.0 | 43.8 | 19.7 | 41.0 | 13.4 | 38.3 | 8.1 | 34.2 | 32.4 |
| 15 | 28.6 | 45.6 | 28.0 | 45.6 | 24.7 | 43.8 | 19.3 | 41.0 | 12.8 | 38.3 | 7.4 | 34.2 | 32.4 |
| 16 | 29.1 | 45.6 | 28.5 | 45.6 | 25.2 | 43.8 | 19.7 | 41.0 | 12.7 | 38.3 | 7.4 | 34.2 | 32.4 |
| 17 | 31.4 | 45.6 | 30.8 | 45.6 | 27.5 | 43.8 | 21.8 | 41.0 | 14.8 | 38.3 | 8.8 | 34.2 | 32.4 |
| 18 | 28.3 | 45.6 | 27.6 | 45.6 | 24.4 | 43.8 | 18.5 | 41.0 | 10.7 | 38.3 | 5.8 | 34.2 | 32.4 |
| 19 | 26.9 | 45.6 | 26.3 | 45.6 | 23.0 | 43.8 | 17.0 | 41.0 | 8.7 | 38.3 | 3.2 | 34.2 | 32.4 |
| 20 | 26.1 | 45.6 | 25.5 | 45.6 | 22.2 | 43.8 | 16.2 | 41.0 | 7.0 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 25.6 | 45.6 | 25.0 | 45.6 | 21.7 | 43.8 | 15.6 | 41.0 | 5.3 | 38.3 | | 34.2 | 32.4 |
| 22 | 25.3 | 45.6 | 24.7 | 45.6 | 21.4 | 43.8 | 15.2 | 41.0 | 3.4 | 38.3 | | 34.2 | 32.4 |
| 23 | 25.1 | 45.6 | 24.5 | 45.6 | 21.2 | 43.8 | 15.0 | 41.0 | 1.9 | 38.3 | | 34.2 | 32.4 |
| 24 | 25.0 | 45.6 | 24.4 | 45.6 | 21.1 | 43.8 | 14.9 | 41.0 | 1.5 | 38.3 | | 34.2 | 32.4 |

Table A7. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 52.5 | 65.3 | 51.3 | 65.3 | 47.3 | 62.7 | 41.0 | 58.8 | 33.9 | 54.9 | 26.7 | 49.0 | 41.4 |
| 1 | 53.7 | 65.3 | 52.7 | 65.3 | 48.5 | 62.7 | 42.1 | 58.8 | 35.0 | 54.9 | 27.5 | 49.0 | 41.4 |
| 2 | 50.0 | 65.3 | 48.9 | 65.3 | 44.8 | 62.7 | 38.3 | 58.8 | 31.1 | 54.9 | 23.9 | 49.0 | 41.4 |
| 3 | 48.4 | 65.3 | 47.3 | 65.3 | 43.1 | 62.7 | 36.6 | 58.8 | 29.4 | 54.9 | 22.0 | 49.0 | 41.4 |
| 4 | 47.7 | 65.3 | 46.5 | 65.3 | 42.3 | 62.7 | 35.7 | 58.8 | 28.4 | 54.9 | 21.0 | 49.0 | 41.4 |
| 5 | 47.4 | 65.3 | 46.2 | 65.3 | 42.0 | 62.7 | 35.3 | 58.8 | 28.0 | 54.9 | 20.5 | 49.0 | 41.4 |
| 6 | 47.9 | 65.3 | 46.7 | 65.3 | 42.5 | 62.7 | 35.8 | 58.8 | 28.3 | 54.9 | 20.9 | 49.0 | 41.4 |
| 7 | 50.4 | 65.3 | 49.2 | 65.3 | 44.8 | 62.7 | 38.0 | 58.8 | 30.4 | 54.9 | 22.7 | 49.0 | 41.4 |
| 8 | 47.5 | 65.3 | 46.2 | 65.3 | 41.9 | 62.7 | 35.1 | 58.8 | 27.3 | 54.9 | 19.8 | 49.0 | 41.4 |
| 9 | 46.5 | 65.3 | 45.3 | 65.3 | 40.9 | 62.7 | 34.0 | 58.8 | 26.2 | 54.9 | 18.5 | 49.0 | 41.4 |
| 10 | 46.7 | 65.3 | 45.5 | 65.3 | 41.1 | 62.7 | 34.1 | 58.8 | 26.1 | 54.9 | 18.4 | 49.0 | 41.4 |
| 11 | 48.9 | 65.3 | 47.7 | 65.3 | 43.2 | 62.7 | 36.1 | 58.8 | 27.9 | 54.9 | 19.8 | 49.0 | 41.4 |
| 12 | 45.7 | 65.3 | 44.4 | 65.3 | 40.0 | 62.7 | 32.8 | 58.8 | 24.5 | 54.9 | 16.5 | 49.0 | 41.4 |
| 13 | 44.3 | 65.3 | 43.1 | 65.3 | 38.6 | 62.7 | 31.4 | 58.8 | 22.9 | 54.9 | 14.6 | 49.0 | 41.4 |
| 14 | 43.7 | 65.3 | 42.5 | 65.3 | 38.0 | 62.7 | 30.7 | 58.8 | 21.9 | 54.9 | 13.4 | 49.0 | 41.4 |
| 15 | 43.5 | 65.3 | 42.3 | 65.3 | 37.8 | 62.7 | 30.4 | 58.8 | 21.4 | 54.9 | 12.6 | 49.0 | 41.4 |
| 16 | 44.0 | 65.3 | 42.8 | 65.3 | 38.3 | 62.7 | 30.9 | 58.8 | 21.6 | 54.9 | 12.5 | 49.0 | 41.4 |
| 17 | 46.3 | 65.3 | 45.2 | 65.3 | 40.6 | 62.7 | 33.1 | 58.8 | 23.5 | 54.9 | 13.7 | 49.0 | 41.4 |
| 18 | 43.2 | 65.3 | 42.0 | 65.3 | 37.5 | 62.7 | 30.0 | 58.8 | 20.1 | 54.9 | 10.0 | 49.0 | 41.4 |
| 19 | 41.8 | 65.3 | 40.7 | 65.3 | 36.2 | 62.7 | 28.6 | 58.8 | 18.4 | 54.9 | 7.5 | 49.0 | 41.4 |
| 20 | 41.1 | 65.3 | 39.9 | 65.3 | 35.4 | 62.7 | 27.9 | 58.8 | 17.4 | 54.9 | 5.6 | 49.0 | 41.4 |
| 21 | 40.6 | 65.3 | 39.4 | 65.3 | 34.9 | 62.7 | 27.4 | 58.8 | 16.8 | 54.9 | 3.6 | 49.0 | 41.4 |
| 22 | 40.2 | 65.3 | 39.1 | 65.3 | 34.6 | 62.7 | 27.1 | 58.8 | 16.3 | 54.9 | 2.1 | 49.0 | 41.4 |
| 23 | 40.0 | 65.3 | 38.9 | 65.3 | 34.5 | 62.7 | 26.9 | 58.8 | 16.1 | 54.9 | 0.0 | 49.0 | 41.4 |
| 24 | 40.0 | 65.3 | 38.8 | 65.3 | 34.4 | 62.7 | 26.9 | 58.8 | 16.1 | 54.9 | | 49.0 | 41.4 |

Table A8. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 64.5 | 81.7 | 63.0 | 81.7 | 58.0 | 78.4 | 50.2 | 73.5 | 41.2 | 68.6 | 31.2 | 61.3 | 50.2 |
| 1 | 65.8 | 81.7 | 64.3 | 81.7 | 59.2 | 78.4 | 51.5 | 73.5 | 42.6 | 68.6 | 32.2 | 61.3 | 50.2 |
| 2 | 62.1 | 81.7 | 60.5 | 81.7 | 55.5 | 78.4 | 47.6 | 73.5 | 38.5 | 68.6 | 28.3 | 61.3 | 50.2 |
| 3 | 60.5 | 81.7 | 58.9 | 81.7 | 53.8 | 78.4 | 45.9 | 73.5 | 36.7 | 68.6 | 26.4 | 61.3 | 50.2 |
| 4 | 59.7 | 81.7 | 58.1 | 81.7 | 53.0 | 78.4 | 45.0 | 73.5 | 35.8 | 68.6 | 25.3 | 61.3 | 50.2 |
| 5 | 59.4 | 81.7 | 57.9 | 81.7 | 52.7 | 78.4 | 44.6 | 73.5 | 35.3 | 68.6 | 24.6 | 61.3 | 50.2 |
| 6 | 60.0 | 81.7 | 58.4 | 81.7 | 53.2 | 78.4 | 45.0 | 73.5 | 35.6 | 68.6 | 24.3 | 61.3 | 50.2 |
| 7 | 62.3 | 81.7 | 60.8 | 81.7 | 55.5 | 78.4 | 47.5 | 73.5 | 38.1 | 68.6 | 24.7 | 61.3 | 50.2 |
| 8 | 59.5 | 81.7 | 57.9 | 81.7 | 52.6 | 78.4 | 44.4 | 73.5 | 34.7 | 68.6 | 26.8 | 61.3 | 50.2 |
| 9 | 58.5 | 81.7 | 56.9 | 81.7 | 51.6 | 78.4 | 43.4 | 73.5 | 33.6 | 68.6 | 23.7 | 61.3 | 50.2 |
| 10 | 58.7 | 81.7 | 57.1 | 81.7 | 51.8 | 78.4 | 43.4 | 73.5 | 33.5 | 68.6 | 22.4 | 61.3 | 50.2 |
| 11 | 60.8 | 81.7 | 59.2 | 81.7 | 53.9 | 78.4 | 45.7 | 73.5 | 35.7 | 68.6 | 22.2 | 61.3 | 50.2 |
| 12 | 57.7 | 81.7 | 56.1 | 81.7 | 50.7 | 78.4 | 42.2 | 73.5 | 32.0 | 68.6 | 23.9 | 61.3 | 50.2 |
| 13 | 56.3 | 81.7 | 54.7 | 81.7 | 49.4 | 78.4 | 40.9 | 73.5 | 30.6 | 68.6 | 20.3 | 61.3 | 50.2 |
| 14 | 55.7 | 81.7 | 54.1 | 81.7 | 48.7 | 78.4 | 40.2 | 73.5 | 29.7 | 68.6 | 18.4 | 61.3 | 50.2 |
| 15 | 55.5 | 81.7 | 53.9 | 81.7 | 48.5 | 78.4 | 40.0 | 73.5 | 29.4 | 68.6 | 17.2 | 61.3 | 50.2 |
| 16 | 56.0 | 81.7 | 54.4 | 81.7 | 49.1 | 78.4 | 40.5 | 73.5 | 29.6 | 68.6 | 16.3 | 61.3 | 50.2 |
| 17 | 58.3 | 81.7 | 56.7 | 81.7 | 51.4 | 78.4 | 42.9 | 73.5 | 32.1 | 68.6 | 16.0 | 61.3 | 50.2 |
| 18 | 55.2 | 81.7 | 53.6 | 81.7 | 48.3 | 78.4 | 39.7 | 73.5 | 28.5 | 68.6 | 17.4 | 61.3 | 50.2 |
| 19 | 53.8 | 81.7 | 52.3 | 81.7 | 46.9 | 78.4 | 38.4 | 73.5 | 27.2 | 68.6 | 13.3 | 61.3 | 50.2 |
| 20 | 53.1 | 81.7 | 51.5 | 81.7 | 46.2 | 78.4 | 37.6 | 73.5 | 26.4 | 68.6 | 10.9 | 61.3 | 50.2 |
| 21 | 52.6 | 81.7 | 51.0 | 81.7 | 45.7 | 78.4 | 37.2 | 73.5 | 25.9 | 68.6 | 9.2 | 61.3 | 50.2 |
| 22 | 52.3 | 81.7 | 50.7 | 81.7 | 45.4 | 78.4 | 36.9 | 73.5 | 25.5 | 68.6 | 8.0 | 61.3 | 50.2 |
| 23 | 52.1 | 81.7 | 50.5 | 81.7 | 45.3 | 78.4 | 36.8 | 73.5 | 25.4 | 68.6 | 7.4 | 61.3 | 50.2 |
| 24 | 52.0 | 81.7 | 50.5 | 81.7 | 45.3 | 78.4 | 36.8 | 73.5 | 25.4 | 68.6 | 7.4 | 61.3 | 50.2 |

Table A9. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 36 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 22.7 | 22.6 | 22.4 | 22.6 | 21.3 | 21.7 | 18.8 | 20.3 | 15.8 | 19.0 | 13.1 | 17.0 | 21.6 |
| 1 | 24.1 | 22.6 | 23.7 | 22.6 | 22.5 | 21.7 | 19.9 | 20.3 | 17.4 | 19.0 | 14.0 | 17.0 | 21.6 |
| 2 | 20.6 | 22.6 | 20.2 | 22.6 | 19.1 | 21.7 | 16.4 | 20.3 | 13.4 | 19.0 | 10.6 | 17.0 | 21.6 |
| 3 | 19.1 | 22.6 | 18.7 | 22.6 | 17.6 | 21.7 | 14.9 | 20.3 | 11.9 | 19.0 | 8.9 | 17.0 | 21.6 |
| 4 | 18.5 | 22.6 | 18.1 | 22.6 | 16.9 | 21.7 | 14.1 | 20.3 | 11.1 | 19.0 | 8.1 | 17.0 | 21.6 |
| 5 | 18.4 | 22.6 | 18.1 | 22.6 | 16.8 | 21.7 | 14.0 | 20.3 | 10.9 | 19.0 | 7.9 | 17.0 | 21.6 |
| 6 | 19.1 | 22.6 | 18.8 | 22.6 | 17.5 | 21.7 | 14.6 | 20.3 | 11.3 | 19.0 | 8.4 | 17.0 | 21.6 |
| 7 | 21.7 | 22.6 | 21.3 | 22.6 | 19.9 | 21.7 | 16.8 | 20.3 | 13.9 | 19.0 | 10.4 | 17.0 | 21.6 |
| 8 | 19.0 | 22.6 | 18.7 | 22.6 | 17.3 | 21.7 | 14.2 | 20.3 | 10.7 | 19.0 | 7.7 | 17.0 | 21.6 |
| 9 | 18.3 | 22.6 | 17.9 | 22.6 | 16.5 | 21.7 | 13.2 | 20.3 | 9.7 | 19.0 | 6.6 | 17.0 | 21.6 |
| 10 | 18.7 | 22.6 | 18.3 | 22.6 | 16.8 | 21.7 | 13.5 | 20.3 | 9.7 | 19.0 | 6.6 | 17.0 | 21.6 |
| 11 | 21.0 | 22.6 | 20.5 | 22.6 | 18.9 | 21.7 | 15.3 | 20.3 | 11.9 | 19.0 | 8.2 | 17.0 | 21.6 |
| 12 | 18.0 | 22.6 | 17.6 | 22.6 | 16.0 | 21.7 | 12.3 | 20.3 | 8.2 | 19.0 | 5.0 | 17.0 | 21.6 |
| 13 | 16.8 | 22.6 | 16.5 | 22.6 | 14.7 | 21.7 | 10.9 | 20.3 | 6.6 | 19.0 | 3.4 | 17.0 | 21.6 |
| 14 | 16.4 | 22.6 | 16.0 | 22.6 | 14.2 | 21.7 | 10.1 | 20.3 | 5.5 | 19.0 | 2.0 | 17.0 | 21.6 |
| 15 | 16.5 | 22.6 | 16.1 | 22.6 | 14.1 | 21.7 | 9.9 | 20.3 | 4.8 | 19.0 | 0.0 | 17.0 | 21.6 |
| 16 | 17.2 | 22.6 | 16.8 | 22.6 | 14.8 | 21.7 | 10.3 | 20.3 | 4.6 | 19.0 | | 17.0 | 21.6 |
| 17 | 19.8 | 22.6 | 19.3 | 22.6 | 17.1 | 21.7 | 12.3 | 20.3 | 6.6 | 19.0 | | 17.0 | 21.6 |
| 18 | 17.1 | 22.6 | 16.7 | 22.6 | 14.4 | 21.7 | 9.4 | 20.3 | 2.4 | 19.0 | | 17.0 | 21.6 |
| 19 | 16.3 | 22.6 | 15.8 | 22.6 | 13.4 | 21.7 | 8.1 | 20.3 | 0.0 | 19.0 | | 17.0 | 21.6 |
| 20 | 16.6 | 22.6 | 16.1 | 22.6 | 13.6 | 21.7 | 8.0 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 21 | 18.8 | 22.6 | 18.2 | 22.6 | 15.5 | 21.7 | 9.5 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 22 | 15.6 | 22.6 | 15.1 | 22.6 | 12.3 | 21.7 | 6.1 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 23 | 14.3 | 22.6 | 13.8 | 22.6 | 10.8 | 21.7 | 4.3 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 24 | 13.7 | 22.6 | 13.1 | 22.6 | 10.0 | 21.7 | 2.8 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 25 | 13.5 | 22.6 | 12.9 | 22.6 | 9.7 | 21.7 | 0.0 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 26 | 14.0 | 22.6 | 13.3 | 22.6 | 9.9 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 27 | 16.2 | 22.6 | 15.4 | 22.6 | 11.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 28 | 13.0 | 22.6 | 12.3 | 22.6 | 8.6 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 29 | 11.5 | 22.6 | 10.8 | 22.6 | 6.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 30 | 10.6 | 22.6 | 9.8 | 22.6 | 5.6 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 31 | 10.0 | 22.6 | 9.1 | 22.6 | 4.7 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 32 | 9.5 | 22.6 | 8.6 | 22.6 | 3.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 33 | 9.1 | 22.6 | 8.2 | 22.6 | 3.0 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 34 | 8.8 | 22.6 | 7.9 | 22.6 | 2.3 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 35 | 8.6 | 22.6 | 7.7 | 22.6 | 1.5 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 36 | 8.5 | 22.6 | 7.5 | 22.6 | 0.9 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |

Table A10. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 36 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 39.3 | 42.3 | 39.0 | 42.3 | 36.2 | 40.6 | 31.6 | 38.1 | 25.6 | 35.5 | 20.5 | 31.7 | 32.4 |
| 1 | 40.6 | 42.3 | 40.3 | 42.3 | 37.4 | 40.6 | 32.5 | 38.1 | 27.1 | 35.5 | 21.3 | 31.7 | 32.4 |
| 2 | 37.0 | 42.3 | 36.6 | 42.3 | 33.7 | 40.6 | 28.9 | 38.1 | 22.9 | 35.5 | 17.8 | 31.7 | 32.4 |
| 3 | 35.4 | 42.3 | 35.0 | 42.3 | 32.0 | 40.6 | 27.2 | 38.1 | 21.3 | 35.5 | 16.0 | 31.7 | 32.4 |
| 4 | 34.7 | 42.3 | 34.3 | 42.3 | 31.2 | 40.6 | 26.3 | 38.1 | 20.4 | 35.5 | 15.0 | 31.7 | 32.4 |
| 5 | 34.5 | 42.3 | 34.1 | 42.3 | 31.0 | 40.6 | 26.0 | 38.1 | 20.0 | 35.5 | 14.6 | 31.7 | 32.4 |
| 6 | 35.0 | 42.3 | 34.6 | 42.3 | 31.5 | 40.6 | 26.4 | 38.1 | 20.3 | 35.5 | 15.0 | 31.7 | 32.4 |
| 7 | 37.5 | 42.3 | 37.0 | 42.3 | 33.8 | 40.6 | 28.5 | 38.1 | 22.8 | 35.5 | 16.9 | 31.7 | 32.4 |
| 8 | 34.7 | 42.3 | 34.2 | 42.3 | 31.0 | 40.6 | 25.8 | 38.1 | 19.4 | 35.5 | 14.1 | 31.7 | 32.4 |
| 9 | 33.8 | 42.3 | 33.3 | 42.3 | 30.0 | 40.6 | 24.7 | 38.1 | 18.4 | 35.5 | 12.9 | 31.7 | 32.4 |
| 10 | 34.0 | 42.3 | 33.5 | 42.3 | 30.2 | 40.6 | 24.8 | 38.1 | 18.3 | 35.5 | 12.8 | 31.7 | 32.4 |
| 11 | 36.2 | 42.3 | 35.7 | 42.3 | 32.3 | 40.6 | 26.6 | 38.1 | 20.5 | 35.5 | 14.3 | 31.7 | 32.4 |
| 12 | 33.1 | 42.3 | 32.6 | 42.3 | 29.1 | 40.6 | 23.5 | 38.1 | 16.8 | 35.5 | 11.0 | 31.7 | 32.4 |
| 13 | 31.8 | 42.3 | 31.3 | 42.3 | 27.8 | 40.6 | 22.1 | 38.1 | 15.2 | 35.5 | 9.3 | 31.7 | 32.4 |
| 14 | 31.3 | 42.3 | 30.7 | 42.3 | 27.1 | 40.6 | 21.3 | 38.1 | 14.4 | 35.5 | 8.2 | 31.7 | 32.4 |
| 15 | 31.2 | 42.3 | 30.6 | 42.3 | 27.0 | 40.6 | 21.0 | 38.1 | 13.9 | 35.5 | 7.5 | 31.7 | 32.4 |
| 16 | 31.8 | 42.3 | 31.2 | 42.3 | 27.5 | 40.6 | 21.5 | 38.1 | 14.1 | 35.5 | 7.4 | 31.7 | 32.4 |
| 17 | 34.3 | 42.3 | 33.7 | 42.3 | 29.9 | 40.6 | 23.5 | 38.1 | 16.4 | 35.5 | 8.8 | 31.7 | 32.4 |
| 18 | 31.5 | 42.3 | 30.9 | 42.3 | 27.0 | 40.6 | 20.7 | 38.1 | 12.8 | 35.5 | 5.8 | 31.7 | 32.4 |
| 19 | 30.6 | 42.3 | 29.9 | 42.3 | 26.0 | 40.6 | 19.5 | 38.1 | 11.5 | 35.5 | 3.2 | 31.7 | 32.4 |
| 20 | 30.7 | 42.3 | 30.1 | 42.3 | 26.1 | 40.6 | 19.4 | 38.1 | 11.1 | 35.5 | 0.0 | 31.7 | 32.4 |
| 21 | 32.9 | 42.3 | 32.2 | 42.3 | 28.1 | 40.6 | 21.0 | 38.1 | 12.9 | 35.5 | | 31.7 | 32.4 |
| 22 | 29.6 | 42.3 | 29.0 | 42.3 | 24.7 | 40.6 | 17.6 | 38.1 | 8.8 | 35.5 | | 31.7 | 32.4 |
| 23 | 28.3 | 42.3 | 27.6 | 42.3 | 23.2 | 40.6 | 15.9 | 38.1 | 6.7 | 35.5 | | 31.7 | 32.4 |
| 24 | 27.6 | 42.3 | 26.9 | 42.3 | 22.4 | 40.6 | 14.8 | 38.1 | 5.4 | 35.5 | | 31.7 | 32.4 |
| 25 | 27.3 | 42.3 | 26.6 | 42.3 | 22.0 | 40.6 | 14.1 | 38.1 | 3.7 | 35.5 | | 31.7 | 32.4 |
| 26 | 27.7 | 42.3 | 27.0 | 42.3 | 22.3 | 40.6 | 14.0 | 38.1 | 0.0 | 35.5 | | 31.7 | 32.4 |
| 27 | 29.9 | 42.3 | 29.2 | 42.3 | 24.3 | 40.6 | 15.5 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 28 | 26.7 | 42.3 | 26.0 | 42.3 | 20.9 | 40.6 | 11.9 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 29 | 25.2 | 42.3 | 24.5 | 42.3 | 19.3 | 40.6 | 9.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 30 | 24.3 | 42.3 | 23.6 | 42.3 | 18.2 | 40.6 | 8.1 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 31 | 23.6 | 42.3 | 22.9 | 42.3 | 17.4 | 40.6 | 6.6 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 32 | 23.1 | 42.3 | 22.4 | 42.3 | 16.8 | 40.6 | 5.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 33 | 22.8 | 42.3 | 22.0 | 42.3 | 16.3 | 40.6 | 3.5 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 34 | 22.5 | 42.3 | 21.7 | 42.3 | 16.0 | 40.6 | 1.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 35 | 22.3 | 42.3 | 21.6 | 42.3 | 15.7 | 40.6 | 0.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 36 | 22.2 | 42.3 | 21.5 | 42.3 | 15.6 | 40.6 | | 38.1 | | 35.5 | | 31.7 | 32.4 |

Table A11. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 55.3 | 60.4 | 54.3 | 60.4 | 49.9 | 58.0 | 43.0 | 54.4 | 34.8 | 50.7 | 27.5 | 45.3 | 41.4 |
| 1 | 56.5 | 60.4 | 55.6 | 60.4 | 51.0 | 58.0 | 44.1 | 54.4 | 36.3 | 50.7 | 28.2 | 45.3 | 41.4 |
| 2 | 52.7 | 60.4 | 51.7 | 60.4 | 47.2 | 58.0 | 40.2 | 54.4 | 32.1 | 50.7 | 24.6 | 45.3 | 41.4 |
| 3 | 51.1 | 60.4 | 50.1 | 60.4 | 45.5 | 58.0 | 38.5 | 54.4 | 30.3 | 50.7 | 22.8 | 45.3 | 41.4 |
| 4 | 50.3 | 60.4 | 49.3 | 60.4 | 44.6 | 58.0 | 37.5 | 54.4 | 29.4 | 50.7 | 21.8 | 45.3 | 41.4 |
| 5 | 50.0 | 60.4 | 49.0 | 60.4 | 44.3 | 58.0 | 37.1 | 54.4 | 28.9 | 50.7 | 21.3 | 45.3 | 41.4 |
| 6 | 50.5 | 60.4 | 49.4 | 60.4 | 44.7 | 58.0 | 37.4 | 54.4 | 29.1 | 50.7 | 21.6 | 45.3 | 41.4 |
| 7 | 52.9 | 60.4 | 51.9 | 60.4 | 47.0 | 58.0 | 39.7 | 54.4 | 31.6 | 50.7 | 23.5 | 45.3 | 41.4 |
| 8 | 50.0 | 60.4 | 48.9 | 60.4 | 44.0 | 58.0 | 36.6 | 54.4 | 28.2 | 50.7 | 20.6 | 45.3 | 41.4 |
| 9 | 49.1 | 60.4 | 47.9 | 60.4 | 43.0 | 58.0 | 35.5 | 54.4 | 27.0 | 50.7 | 19.4 | 45.3 | 41.4 |
| 10 | 49.2 | 60.4 | 48.1 | 60.4 | 43.1 | 58.0 | 35.5 | 54.4 | 26.9 | 50.7 | 19.3 | 45.3 | 41.4 |
| 11 | 51.3 | 60.4 | 50.3 | 60.4 | 45.1 | 58.0 | 37.4 | 54.4 | 29.1 | 50.7 | 20.8 | 45.3 | 41.4 |
| 12 | 48.2 | 60.4 | 47.0 | 60.4 | 41.9 | 58.0 | 34.1 | 54.4 | 25.3 | 50.7 | 17.5 | 45.3 | 41.4 |
| 13 | 46.8 | 60.4 | 45.6 | 60.4 | 40.5 | 58.0 | 32.6 | 54.4 | 23.8 | 50.7 | 15.8 | 45.3 | 41.4 |
| 14 | 46.2 | 60.4 | 45.0 | 60.4 | 39.8 | 58.0 | 31.8 | 54.4 | 22.9 | 50.7 | 14.8 | 45.3 | 41.4 |
| 15 | 46.1 | 60.4 | 44.9 | 60.4 | 39.6 | 58.0 | 31.5 | 54.4 | 22.4 | 50.7 | 14.2 | 45.3 | 41.4 |
| 16 | 46.7 | 60.4 | 45.4 | 60.4 | 40.1 | 58.0 | 31.8 | 54.4 | 22.6 | 50.7 | 14.4 | 45.3 | 41.4 |
| 17 | 49.1 | 60.4 | 48.0 | 60.4 | 42.4 | 58.0 | 34.1 | 54.4 | 24.9 | 50.7 | 16.0 | 45.3 | 41.4 |
| 18 | 46.2 | 60.4 | 45.0 | 60.4 | 39.5 | 58.0 | 31.0 | 54.4 | 21.4 | 50.7 | 12.8 | 45.3 | 41.4 |
| 19 | 45.3 | 60.4 | 44.0 | 60.4 | 38.4 | 58.0 | 29.8 | 54.4 | 20.1 | 50.7 | 11.2 | 45.3 | 41.4 |
| 20 | 45.5 | 60.4 | 44.2 | 60.4 | 38.5 | 58.0 | 29.7 | 54.4 | 19.7 | 50.7 | 10.7 | 45.3 | 41.4 |
| 21 | 47.5 | 60.4 | 46.4 | 60.4 | 40.5 | 58.0 | 31.4 | 54.4 | 21.6 | 50.7 | 11.8 | 45.3 | 41.4 |
| 22 | 44.3 | 60.4 | 43.0 | 60.4 | 37.2 | 58.0 | 27.9 | 54.4 | 17.5 | 50.7 | 8.5 | 45.3 | 41.4 |
| 23 | 42.9 | 60.4 | 41.6 | 60.4 | 35.7 | 58.0 | 26.2 | 54.4 | 15.6 | 50.7 | 5.6 | 45.3 | 41.4 |
| 24 | 42.2 | 60.4 | 40.9 | 60.4 | 34.9 | 58.0 | 25.1 | 54.4 | 14.3 | 50.7 | 0.0 | 45.3 | 41.4 |
| 25 | 42.0 | 60.4 | 40.7 | 60.4 | 34.6 | 58.0 | 24.5 | 54.4 | 13.4 | 50.7 | | 45.3 | 41.4 |
| 26 | 42.4 | 60.4 | 41.0 | 60.4 | 34.9 | 58.0 | 24.5 | 54.4 | 13.0 | 50.7 | | 45.3 | 41.4 |
| 27 | 44.5 | 60.4 | 43.3 | 60.4 | 37.0 | 58.0 | 26.2 | 54.4 | 14.7 | 50.7 | | 45.3 | 41.4 |
| 28 | 41.3 | 60.4 | 40.0 | 60.4 | 33.7 | 58.0 | 22.5 | 54.4 | 10.4 | 50.7 | | 45.3 | 41.4 |
| 29 | 39.8 | 60.4 | 38.6 | 60.4 | 32.2 | 58.0 | 20.6 | 54.4 | 8.1 | 50.7 | | 45.3 | 41.4 |
| 30 | 39.0 | 60.4 | 37.7 | 60.4 | 31.2 | 58.0 | 19.2 | 54.4 | 6.5 | 50.7 | | 45.3 | 41.4 |
| 31 | 38.3 | 60.4 | 37.0 | 60.4 | 30.5 | 58.0 | 18.0 | 54.4 | 4.5 | 50.7 | | 45.3 | 41.4 |
| 32 | 37.8 | 60.4 | 36.6 | 60.4 | 30.0 | 58.0 | 17.1 | 54.4 | 0.0 | 50.7 | | 45.3 | 41.4 |
| 33 | 37.5 | 60.4 | 36.2 | 60.4 | 29.6 | 58.0 | 16.3 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 34 | 37.2 | 60.4 | 36.0 | 60.4 | 29.3 | 58.0 | 15.8 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 35 | 37.1 | 60.4 | 35.8 | 60.4 | 29.2 | 58.0 | 15.4 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 36 | 37.0 | 60.4 | 35.8 | 60.4 | 29.1 | 58.0 | 15.3 | 54.4 | | 50.7 | | 45.3 | 41.4 |

Table A12. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 67.6 | 77.1 | 66.2 | 77.1 | 60.8 | 74.0 | 52.3 | 69.4 | 42.8 | 64.8 | 33.6 | 57.8 | 50.2 |
| 1 | 68.8 | 77.1 | 67.4 | 77.1 | 61.9 | 74.0 | 53.5 | 69.4 | 44.2 | 64.8 | 34.3 | 57.8 | 50.2 |
| 2 | 65.0 | 77.1 | 63.6 | 77.1 | 58.1 | 74.0 | 49.5 | 69.4 | 40.0 | 64.8 | 30.7 | 57.8 | 50.2 |
| 3 | 63.3 | 77.1 | 61.9 | 77.1 | 56.3 | 74.0 | 47.7 | 69.4 | 38.2 | 64.8 | 28.8 | 57.8 | 50.2 |
| 4 | 62.5 | 77.1 | 61.1 | 77.1 | 55.4 | 74.0 | 46.7 | 69.4 | 37.2 | 64.8 | 27.8 | 57.8 | 50.2 |
| 5 | 62.2 | 77.1 | 60.7 | 77.1 | 55.1 | 74.0 | 46.2 | 69.4 | 36.7 | 64.8 | 27.3 | 57.8 | 50.2 |
| 6 | 62.7 | 77.1 | 61.2 | 77.1 | 55.4 | 74.0 | 46.5 | 69.4 | 36.9 | 64.8 | 27.6 | 57.8 | 50.2 |
| 7 | 65.0 | 77.1 | 63.5 | 77.1 | 57.7 | 74.0 | 48.9 | 69.4 | 39.3 | 64.8 | 29.4 | 57.8 | 50.2 |
| 8 | 62.1 | 77.1 | 60.6 | 77.1 | 54.7 | 74.0 | 45.6 | 69.4 | 35.8 | 64.8 | 26.5 | 57.8 | 50.2 |
| 9 | 61.1 | 77.1 | 59.6 | 77.1 | 53.7 | 74.0 | 44.5 | 69.4 | 34.7 | 64.8 | 25.2 | 57.8 | 50.2 |
| 10 | 61.3 | 77.1 | 59.7 | 77.1 | 53.7 | 74.0 | 44.4 | 69.4 | 34.5 | 64.8 | 25.1 | 57.8 | 50.2 |
| 11 | 63.4 | 77.1 | 61.8 | 77.1 | 55.7 | 74.0 | 46.5 | 69.4 | 36.6 | 64.8 | 26.6 | 57.8 | 50.2 |
| 12 | 60.2 | 77.1 | 58.6 | 77.1 | 52.5 | 74.0 | 43.0 | 69.4 | 32.8 | 64.8 | 23.4 | 57.8 | 50.2 |
| 13 | 58.8 | 77.1 | 57.2 | 77.1 | 51.0 | 74.0 | 41.5 | 69.4 | 31.2 | 64.8 | 21.7 | 57.8 | 50.2 |
| 14 | 58.2 | 77.1 | 56.6 | 77.1 | 50.4 | 74.0 | 40.7 | 69.4 | 30.3 | 64.8 | 20.7 | 57.8 | 50.2 |
| 15 | 58.0 | 77.1 | 56.4 | 77.1 | 50.1 | 74.0 | 40.3 | 69.4 | 29.8 | 64.8 | 20.1 | 57.8 | 50.2 |
| 16 | 58.6 | 77.1 | 57.0 | 77.1 | 50.6 | 74.0 | 40.7 | 69.4 | 30.0 | 64.8 | 20.3 | 57.8 | 50.2 |
| 17 | 61.0 | 77.1 | 59.4 | 77.1 | 53.0 | 74.0 | 43.0 | 69.4 | 32.3 | 64.8 | 22.0 | 57.8 | 50.2 |
| 18 | 58.1 | 77.1 | 56.5 | 77.1 | 50.0 | 74.0 | 39.8 | 69.4 | 28.7 | 64.8 | 18.9 | 57.8 | 50.2 |
| 19 | 57.2 | 77.1 | 55.5 | 77.1 | 49.0 | 74.0 | 38.6 | 69.4 | 27.4 | 64.8 | 17.4 | 57.8 | 50.2 |
| 20 | 57.4 | 77.1 | 55.7 | 77.1 | 49.1 | 74.0 | 38.5 | 69.4 | 27.0 | 64.8 | 17.0 | 57.8 | 50.2 |
| 21 | 59.4 | 77.1 | 57.7 | 77.1 | 51.1 | 74.0 | 40.5 | 69.4 | 28.8 | 64.8 | 18.2 | 57.8 | 50.2 |
| 22 | 56.2 | 77.1 | 54.5 | 77.1 | 47.9 | 74.0 | 36.9 | 69.4 | 24.8 | 64.8 | 14.6 | 57.8 | 50.2 |
| 23 | 54.8 | 77.1 | 53.1 | 77.1 | 46.4 | 74.0 | 35.3 | 69.4 | 22.8 | 64.8 | 12.4 | 57.8 | 50.2 |
| 24 | 54.1 | 77.1 | 52.4 | 77.1 | 45.7 | 74.0 | 34.3 | 69.4 | 21.5 | 64.8 | 10.8 | 57.8 | 50.2 |
| 25 | 53.8 | 77.1 | 52.2 | 77.1 | 45.3 | 74.0 | 33.8 | 69.4 | 20.5 | 64.8 | 9.4 | 57.8 | 50.2 |
| 26 | 54.3 | 77.1 | 52.6 | 77.1 | 45.7 | 74.0 | 33.9 | 69.4 | 20.0 | 64.8 | 8.4 | 57.8 | 50.2 |
| 27 | 56.4 | 77.1 | 54.8 | 77.1 | 47.9 | 74.0 | 36.0 | 69.4 | 21.6 | 64.8 | 6.9 | 57.8 | 50.2 |
| 28 | 53.2 | 77.1 | 51.6 | 77.1 | 44.6 | 74.0 | 32.3 | 69.4 | 17.2 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 51.8 | 77.1 | 50.1 | 77.1 | 43.1 | 74.0 | 30.6 | 69.4 | 14.7 | 64.8 | | 57.8 | 50.2 |
| 30 | 50.9 | 77.1 | 49.2 | 77.1 | 42.3 | 74.0 | 29.5 | 69.4 | 12.5 | 64.8 | | 57.8 | 50.2 |
| 31 | 50.3 | 77.1 | 48.6 | 77.1 | 41.6 | 74.0 | 28.7 | 69.4 | 10.4 | 64.8 | | 57.8 | 50.2 |
| 32 | 49.8 | 77.1 | 48.2 | 77.1 | 41.1 | 74.0 | 28.1 | 69.4 | 8.1 | 64.8 | | 57.8 | 50.2 |
| 33 | 49.5 | 77.1 | 47.8 | 77.1 | 40.8 | 74.0 | 27.6 | 69.4 | 5.8 | 64.8 | | 57.8 | 50.2 |
| 34 | 49.2 | 77.1 | 47.6 | 77.1 | 40.6 | 74.0 | 27.3 | 69.4 | 2.0 | 64.8 | | 57.8 | 50.2 |
| 35 | 49.1 | 77.1 | 47.5 | 77.1 | 40.5 | 74.0 | 27.1 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 36 | 49.0 | 77.1 | 47.4 | 77.1 | 40.4 | 74.0 | 27.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |

Table A13. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 48 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 23.1 | 21.5 | 22.8 | 21.5 | 21.6 | 20.6 | 19.0 | 19.4 | 15.8 | 18.1 | 13.1 | 16.1 | 21.6 |
| 1 | 24.5 | 21.5 | 24.1 | 21.5 | 22.8 | 20.6 | 20.0 | 19.4 | 17.4 | 18.1 | 14.0 | 16.1 | 21.6 |
| 2 | 21.0 | 21.5 | 20.7 | 21.5 | 19.3 | 20.6 | 16.6 | 19.4 | 13.4 | 18.1 | 10.6 | 16.1 | 21.6 |
| 3 | 19.5 | 21.5 | 19.2 | 21.5 | 17.8 | 20.6 | 15.0 | 19.4 | 11.9 | 18.1 | 8.9 | 16.1 | 21.6 |
| 4 | 19.0 | 21.5 | 18.7 | 21.5 | 17.2 | 20.6 | 14.3 | 19.4 | 11.1 | 18.1 | 8.1 | 16.1 | 21.6 |
| 5 | 18.9 | 21.5 | 18.6 | 21.5 | 17.1 | 20.6 | 14.1 | 19.4 | 10.9 | 18.1 | 7.9 | 16.1 | 21.6 |
| 6 | 19.7 | 21.5 | 19.4 | 21.5 | 17.8 | 20.6 | 14.7 | 19.4 | 11.3 | 18.1 | 8.4 | 16.1 | 21.6 |
| 7 | 22.3 | 21.5 | 21.9 | 21.5 | 20.2 | 20.6 | 16.9 | 19.4 | 13.9 | 18.1 | 10.4 | 16.1 | 21.6 |
| 8 | 19.6 | 21.5 | 19.3 | 21.5 | 17.6 | 20.6 | 14.3 | 19.4 | 10.7 | 18.1 | 7.7 | 16.1 | 21.6 |
| 9 | 18.9 | 21.5 | 18.6 | 21.5 | 16.8 | 20.6 | 13.4 | 19.4 | 9.7 | 18.1 | 6.6 | 16.1 | 21.6 |
| 10 | 19.4 | 21.5 | 19.1 | 21.5 | 17.2 | 20.6 | 13.6 | 19.4 | 9.7 | 18.1 | 6.6 | 16.1 | 21.6 |
| 11 | 21.7 | 21.5 | 21.3 | 21.5 | 19.3 | 20.6 | 15.4 | 19.4 | 11.9 | 18.1 | 8.2 | 16.1 | 21.6 |
| 12 | 18.8 | 21.5 | 18.5 | 21.5 | 16.4 | 20.6 | 12.4 | 19.4 | 8.1 | 18.1 | 5.0 | 16.1 | 21.6 |
| 13 | 17.7 | 21.5 | 17.4 | 21.5 | 15.1 | 20.6 | 10.9 | 19.4 | 6.5 | 18.1 | 3.4 | 16.1 | 21.6 |
| 14 | 17.4 | 21.5 | 17.1 | 21.5 | 14.6 | 20.6 | 10.2 | 19.4 | 5.5 | 18.1 | 2.0 | 16.1 | 21.6 |
| 15 | 17.5 | 21.5 | 17.2 | 21.5 | 14.6 | 20.6 | 9.9 | 19.4 | 4.7 | 18.1 | 0.0 | 16.1 | 21.6 |
| 16 | 18.4 | 21.5 | 18.0 | 21.5 | 15.3 | 20.6 | 10.3 | 19.4 | 4.5 | 18.1 | | 16.1 | 21.6 |
| 17 | 21.1 | 21.5 | 20.6 | 21.5 | 17.6 | 20.6 | 12.2 | 19.4 | 6.6 | 18.1 | | 16.1 | 21.6 |
| 18 | 18.5 | 21.5 | 18.1 | 21.5 | 14.9 | 20.6 | 9.3 | 19.4 | 2.3 | 18.1 | | 16.1 | 21.6 |
| 19 | 17.8 | 21.5 | 17.4 | 21.5 | 14.0 | 20.6 | 8.0 | 19.4 | 0.0 | 18.1 | | 16.1 | 21.6 |
| 20 | 18.2 | 21.5 | 17.8 | 21.5 | 14.1 | 20.6 | 7.8 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 21 | 20.6 | 21.5 | 20.1 | 21.5 | 16.1 | 20.6 | 9.2 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 22 | 17.6 | 21.5 | 17.1 | 21.5 | 12.9 | 20.6 | 5.7 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 23 | 16.5 | 21.5 | 16.0 | 21.5 | 11.5 | 20.6 | 3.9 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 24 | 16.1 | 21.5 | 15.6 | 21.5 | 10.8 | 20.6 | 2.4 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 25 | 16.2 | 21.5 | 15.6 | 21.5 | 10.5 | 20.6 | 0.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 26 | 16.9 | 21.5 | 16.3 | 21.5 | 10.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 27 | 19.5 | 21.5 | 18.8 | 21.5 | 13.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 28 | 16.8 | 21.5 | 16.1 | 21.5 | 10.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 29 | 16.0 | 21.5 | 15.2 | 21.5 | 8.8 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 30 | 16.2 | 21.5 | 15.5 | 21.5 | 8.8 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 31 | 18.4 | 21.5 | 17.5 | 21.5 | 10.4 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 32 | 15.3 | 21.5 | 14.4 | 21.5 | 7.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 33 | 13.9 | 21.5 | 13.0 | 21.5 | 5.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 34 | 13.3 | 21.5 | 12.3 | 21.5 | 3.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 35 | 13.0 | 21.5 | 12.0 | 21.5 | 2.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 36 | 13.4 | 21.5 | 12.4 | 21.5 | 2.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 37 | 15.6 | 21.5 | 14.4 | 21.5 | 1.5 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 38 | 12.3 | 21.5 | 11.2 | 21.5 | 0.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 39 | 10.8 | 21.5 | 9.6 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 40 | 9.8 | 21.5 | 8.6 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 41 | 9.1 | 21.5 | 7.8 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 42 | 8.5 | 21.5 | 7.1 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 43 | 8.1 | 21.5 | 6.6 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 44 | 7.7 | 21.5 | 6.2 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 45 | 7.4 | 21.5 | 5.8 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 46 | 7.1 | 21.5 | 5.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 47 | 7.0 | 21.5 | 5.3 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 48 | 6.9 | 21.5 | 5.1 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |

Table A14. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 48 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 40.7 | 40.0 | 40.5 | 40.0 | 37.4 | 38.4 | 32.1 | 36.0 | 25.7 | 33.6 | 20.5 | 30.0 | 32.4 |
| 1 | 42.1 | 40.0 | 41.8 | 40.0 | 38.6 | 38.4 | 33.0 | 36.0 | 27.2 | 33.6 | 21.3 | 30.0 | 32.4 |
| 2 | 38.4 | 40.0 | 38.1 | 40.0 | 34.9 | 38.4 | 29.4 | 36.0 | 23.1 | 33.6 | 17.8 | 30.0 | 32.4 |
| 3 | 36.9 | 40.0 | 36.6 | 40.0 | 33.2 | 38.4 | 27.7 | 36.0 | 21.4 | 33.6 | 16.0 | 30.0 | 32.4 |
| 4 | 36.2 | 40.0 | 35.9 | 40.0 | 32.5 | 38.4 | 26.8 | 36.0 | 20.5 | 33.6 | 15.0 | 30.0 | 32.4 |
| 5 | 36.0 | 40.0 | 35.7 | 40.0 | 32.2 | 38.4 | 26.5 | 36.0 | 20.1 | 33.6 | 14.6 | 30.0 | 32.4 |
| 6 | 36.6 | 40.0 | 36.3 | 40.0 | 32.7 | 38.4 | 26.9 | 36.0 | 20.4 | 33.6 | 15.0 | 30.0 | 32.4 |
| 7 | 39.1 | 40.0 | 38.7 | 40.0 | 35.1 | 38.4 | 29.0 | 36.0 | 22.9 | 33.6 | 16.9 | 30.0 | 32.4 |
| 8 | 36.3 | 40.0 | 35.9 | 40.0 | 32.3 | 38.4 | 26.3 | 36.0 | 19.6 | 33.6 | 14.1 | 30.0 | 32.4 |
| 9 | 35.5 | 40.0 | 35.1 | 40.0 | 31.3 | 38.4 | 25.2 | 36.0 | 18.5 | 33.6 | 12.9 | 30.0 | 32.4 |
| 10 | 35.8 | 40.0 | 35.4 | 40.0 | 31.6 | 38.4 | 25.3 | 36.0 | 18.4 | 33.6 | 12.8 | 30.0 | 32.4 |
| 11 | 38.0 | 40.0 | 37.6 | 40.0 | 33.7 | 38.4 | 27.1 | 36.0 | 20.6 | 33.6 | 14.3 | 30.0 | 32.4 |
| 12 | 34.9 | 40.0 | 34.5 | 40.0 | 30.5 | 38.4 | 24.1 | 36.0 | 16.9 | 33.6 | 11.0 | 30.0 | 32.4 |
| 13 | 33.7 | 40.0 | 33.3 | 40.0 | 29.2 | 38.4 | 22.6 | 36.0 | 15.3 | 33.6 | 9.3 | 30.0 | 32.4 |
| 14 | 33.3 | 40.0 | 32.8 | 40.0 | 28.7 | 38.4 | 21.9 | 36.0 | 14.4 | 33.6 | 8.2 | 30.0 | 32.4 |
| 15 | 33.2 | 40.0 | 32.8 | 40.0 | 28.6 | 38.4 | 21.6 | 36.0 | 13.9 | 33.6 | 7.5 | 30.0 | 32.4 |
| 16 | 34.0 | 40.0 | 33.5 | 40.0 | 29.2 | 38.4 | 22.0 | 36.0 | 14.1 | 33.6 | 7.5 | 30.0 | 32.4 |
| 17 | 36.5 | 40.0 | 36.0 | 40.0 | 31.6 | 38.4 | 24.1 | 36.0 | 16.4 | 33.6 | 8.9 | 30.0 | 32.4 |
| 18 | 33.8 | 40.0 | 33.2 | 40.0 | 28.7 | 38.4 | 21.2 | 36.0 | 12.8 | 33.6 | 5.8 | 30.0 | 32.4 |
| 19 | 32.9 | 40.0 | 32.4 | 40.0 | 27.8 | 38.4 | 20.0 | 36.0 | 11.4 | 33.6 | 3.2 | 30.0 | 32.4 |
| 20 | 33.2 | 40.0 | 32.7 | 40.0 | 28.0 | 38.4 | 20.0 | 36.0 | 11.0 | 33.6 | 0.0 | 30.0 | 32.4 |
| 21 | 35.4 | 40.0 | 34.8 | 40.0 | 30.0 | 38.4 | 21.6 | 36.0 | 12.7 | 33.6 | | 30.0 | 32.4 |
| 22 | 32.4 | 40.0 | 31.7 | 40.0 | 26.8 | 38.4 | 18.3 | 36.0 | 8.6 | 33.6 | | 30.0 | 32.4 |
| 23 | 31.1 | 40.0 | 30.4 | 40.0 | 25.4 | 38.4 | 16.6 | 36.0 | 6.5 | 33.6 | | 30.0 | 32.4 |
| 24 | 30.6 | 40.0 | 29.9 | 40.0 | 24.7 | 38.4 | 15.6 | 36.0 | 5.1 | 33.6 | | 30.0 | 32.4 |
| 25 | 30.5 | 40.0 | 29.7 | 40.0 | 24.4 | 38.4 | 15.0 | 36.0 | 3.4 | 33.6 | | 30.0 | 32.4 |
| 26 | 31.1 | 40.0 | 30.3 | 40.0 | 24.9 | 38.4 | 15.2 | 36.0 | 0.0 | 33.6 | | 30.0 | 32.4 |
| 27 | 33.5 | 40.0 | 32.8 | 40.0 | 27.2 | 38.4 | 16.9 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 28 | 30.7 | 40.0 | 29.9 | 40.0 | 24.1 | 38.4 | 13.7 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 29 | 29.7 | 40.0 | 28.9 | 40.0 | 23.0 | 38.4 | 12.2 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 30 | 29.9 | 40.0 | 29.0 | 40.0 | 22.9 | 38.4 | 11.8 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 31 | 31.9 | 40.0 | 31.0 | 40.0 | 24.8 | 38.4 | 13.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 32 | 28.7 | 40.0 | 27.7 | 40.0 | 21.3 | 38.4 | 9.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 33 | 27.2 | 40.0 | 26.2 | 40.0 | 19.6 | 38.4 | 7.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 34 | 26.5 | 40.0 | 25.5 | 40.0 | 18.6 | 38.4 | 5.5 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 35 | 26.1 | 40.0 | 25.1 | 40.0 | 18.0 | 38.4 | 3.8 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 36 | 26.5 | 40.0 | 25.4 | 40.0 | 18.1 | 38.4 | 0.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 37 | 28.6 | 40.0 | 27.4 | 40.0 | 19.9 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 38 | 25.2 | 40.0 | 24.1 | 40.0 | 16.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 39 | 23.7 | 40.0 | 22.5 | 40.0 | 14.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 40 | 22.7 | 40.0 | 21.4 | 40.0 | 13.0 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 41 | 21.9 | 40.0 | 20.6 | 40.0 | 11.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 42 | 21.3 | 40.0 | 20.0 | 40.0 | 10.7 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 43 | 20.8 | 40.0 | 19.4 | 40.0 | 9.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 44 | 20.4 | 40.0 | 19.0 | 40.0 | 8.9 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 45 | 20.1 | 40.0 | 18.7 | 40.0 | 8.1 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 46 | 19.8 | 40.0 | 18.4 | 40.0 | 7.4 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 47 | 19.6 | 40.0 | 18.2 | 40.0 | 6.9 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 48 | 19.5 | 40.0 | 18.1 | 40.0 | 6.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |

Table A15. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 48 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 57.5 | 59.8 | 56.6 | 59.8 | 51.7 | 57.4 | 44.3 | 53.8 | 35.2 | 50.2 | 27.2 | 44.8 | 41.4 |
| 1 | 58.8 | 59.8 | 57.9 | 59.8 | 52.9 | 57.4 | 45.1 | 53.8 | 36.6 | 50.2 | 28.0 | 44.8 | 41.4 |
| 2 | 55.0 | 59.8 | 54.0 | 59.8 | 49.1 | 57.4 | 41.4 | 53.8 | 32.4 | 50.2 | 24.4 | 44.8 | 41.4 |
| 3 | 53.4 | 59.8 | 52.4 | 59.8 | 47.3 | 57.4 | 39.6 | 53.8 | 30.6 | 50.2 | 22.5 | 44.8 | 41.4 |
| 4 | 52.6 | 59.8 | 51.6 | 59.8 | 46.5 | 57.4 | 38.7 | 53.8 | 29.7 | 50.2 | 21.5 | 44.8 | 41.4 |
| 5 | 52.3 | 59.8 | 51.3 | 59.8 | 46.1 | 57.4 | 38.2 | 53.8 | 29.2 | 50.2 | 21.0 | 44.8 | 41.4 |
| 6 | 52.8 | 59.8 | 51.8 | 59.8 | 46.5 | 57.4 | 38.6 | 53.8 | 29.4 | 50.2 | 21.3 | 44.8 | 41.4 |
| 7 | 55.2 | 59.8 | 54.3 | 59.8 | 48.8 | 57.4 | 40.6 | 53.8 | 31.9 | 50.2 | 23.2 | 44.8 | 41.4 |
| 8 | 52.4 | 59.8 | 51.2 | 59.8 | 45.9 | 57.4 | 37.8 | 53.8 | 28.5 | 50.2 | 20.3 | 44.8 | 41.4 |
| 9 | 51.4 | 59.8 | 50.3 | 59.8 | 44.8 | 57.4 | 36.7 | 53.8 | 27.3 | 50.2 | 19.0 | 44.8 | 41.4 |
| 10 | 51.6 | 59.8 | 50.5 | 59.8 | 45.0 | 57.4 | 36.7 | 53.8 | 27.2 | 50.2 | 18.9 | 44.8 | 41.4 |
| 11 | 53.8 | 59.8 | 52.7 | 59.8 | 47.0 | 57.4 | 38.5 | 53.8 | 29.3 | 50.2 | 20.4 | 44.8 | 41.4 |
| 12 | 50.6 | 59.8 | 49.4 | 59.8 | 43.7 | 57.4 | 35.4 | 53.8 | 25.6 | 50.2 | 17.1 | 44.8 | 41.4 |
| 13 | 49.3 | 59.8 | 48.1 | 59.8 | 42.4 | 57.4 | 33.8 | 53.8 | 24.1 | 50.2 | 15.3 | 44.8 | 41.4 |
| 14 | 48.8 | 59.8 | 47.5 | 59.8 | 41.7 | 57.4 | 33.1 | 53.8 | 23.2 | 50.2 | 14.2 | 44.8 | 41.4 |
| 15 | 48.6 | 59.8 | 47.4 | 59.8 | 41.5 | 57.4 | 32.8 | 53.8 | 22.7 | 50.2 | 13.6 | 44.8 | 41.4 |
| 16 | 49.3 | 59.8 | 48.0 | 59.8 | 42.0 | 57.4 | 33.2 | 53.8 | 22.9 | 50.2 | 13.6 | 44.8 | 41.4 |
| 17 | 51.7 | 59.8 | 50.5 | 59.8 | 44.4 | 57.4 | 35.2 | 53.8 | 25.3 | 50.2 | 15.1 | 44.8 | 41.4 |
| 18 | 48.9 | 59.8 | 47.6 | 59.8 | 41.4 | 57.4 | 32.4 | 53.8 | 21.7 | 50.2 | 11.7 | 44.8 | 41.4 |
| 19 | 48.0 | 59.8 | 46.7 | 59.8 | 40.4 | 57.4 | 31.2 | 53.8 | 20.4 | 50.2 | 9.6 | 44.8 | 41.4 |
| 20 | 48.2 | 59.8 | 46.8 | 59.8 | 40.5 | 57.4 | 31.2 | 53.8 | 20.1 | 50.2 | 8.2 | 44.8 | 41.4 |
| 21 | 50.3 | 59.8 | 49.1 | 59.8 | 42.5 | 57.4 | 32.8 | 53.8 | 21.9 | 50.2 | 7.0 | 44.8 | 41.4 |
| 22 | 47.2 | 59.8 | 45.8 | 59.8 | 39.2 | 57.4 | 29.6 | 53.8 | 17.9 | 50.2 | 6.1 | 44.8 | 41.4 |
| 23 | 45.8 | 59.8 | 44.4 | 59.8 | 37.8 | 57.4 | 28.0 | 53.8 | 16.0 | 50.2 | 4.8 | 44.8 | 41.4 |
| 24 | 45.2 | 59.8 | 43.8 | 59.8 | 37.0 | 57.4 | 27.0 | 53.8 | 14.8 | 50.2 | 0.0 | 44.8 | 41.4 |
| 25 | 45.1 | 59.8 | 43.6 | 59.8 | 36.7 | 57.4 | 26.6 | 53.8 | 13.9 | 50.2 | | 44.8 | 41.4 |
| 26 | 45.6 | 59.8 | 44.1 | 59.8 | 37.1 | 57.4 | 26.8 | 53.8 | 13.6 | 50.2 | | 44.8 | 41.4 |
| 27 | 48.0 | 59.8 | 46.6 | 59.8 | 39.4 | 57.4 | 28.6 | 53.8 | 15.4 | 50.2 | | 44.8 | 41.4 |
| 28 | 45.1 | 59.8 | 43.6 | 59.8 | 36.3 | 57.4 | 25.5 | 53.8 | 11.2 | 50.2 | | 44.8 | 41.4 |
| 29 | 44.1 | 59.8 | 42.5 | 59.8 | 35.1 | 57.4 | 24.1 | 53.8 | 9.0 | 50.2 | | 44.8 | 41.4 |
| 30 | 44.2 | 59.8 | 42.6 | 59.8 | 35.0 | 57.4 | 23.8 | 53.8 | 7.6 | 50.2 | | 44.8 | 41.4 |
| 31 | 46.3 | 59.8 | 44.7 | 59.8 | 36.9 | 57.4 | 25.1 | 53.8 | 5.8 | 50.2 | | 44.8 | 41.4 |
| 32 | 43.0 | 59.8 | 41.3 | 59.8 | 33.4 | 57.4 | 21.6 | 53.8 | 0.0 | 50.2 | | 44.8 | 41.4 |
| 33 | 41.5 | 59.8 | 39.8 | 59.8 | 31.7 | 57.4 | 19.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 34 | 40.7 | 59.8 | 39.0 | 59.8 | 30.7 | 57.4 | 18.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 35 | 40.3 | 59.8 | 38.6 | 59.8 | 30.1 | 57.4 | 17.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 36 | 40.7 | 59.8 | 38.9 | 59.8 | 30.2 | 57.4 | 17.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 37 | 42.8 | 59.8 | 41.1 | 59.8 | 32.0 | 57.4 | 18.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 38 | 39.4 | 59.8 | 37.6 | 59.8 | 28.5 | 57.4 | 14.4 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 39 | 37.8 | 59.8 | 36.0 | 59.8 | 26.6 | 57.4 | 12.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 40 | 36.8 | 59.8 | 35.0 | 59.8 | 25.4 | 57.4 | 10.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 41 | 36.1 | 59.8 | 34.2 | 59.8 | 24.4 | 57.4 | 8.4 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 42 | 35.5 | 59.8 | 33.6 | 59.8 | 23.5 | 57.4 | 6.9 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 43 | 35.0 | 59.8 | 33.1 | 59.8 | 22.8 | 57.4 | 5.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 44 | 34.6 | 59.8 | 32.7 | 59.8 | 22.2 | 57.4 | 3.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 45 | 34.3 | 59.8 | 32.4 | 59.8 | 21.8 | 57.4 | 0.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 46 | 34.1 | 59.8 | 32.1 | 59.8 | 21.4 | 57.4 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 47 | 33.9 | 59.8 | 32.0 | 59.8 | 21.1 | 57.4 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 48 | 33.8 | 59.8 | 31.9 | 59.8 | 20.9 | 57.4 | | 53.8 | | 50.2 | | 44.8 | 41.4 |

Table A16. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 54 ft, No Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 70.3 | 77.1 | 69.0 | 77.1 | 63.0 | 74.0 | 53.8 | 69.4 | 43.5 | 64.8 | 33.7 | 57.8 | 50.2 |
| 1 | 71.5 | 77.1 | 70.1 | 77.1 | 64.1 | 74.0 | 55.1 | 69.4 | 44.9 | 64.8 | 34.4 | 57.8 | 50.2 |
| 2 | 67.7 | 77.1 | 66.3 | 77.1 | 60.3 | 74.0 | 51.0 | 69.4 | 40.7 | 64.8 | 30.7 | 57.8 | 50.2 |
| 3 | 66.0 | 77.1 | 64.6 | 77.1 | 58.5 | 74.0 | 49.2 | 69.4 | 38.9 | 64.8 | 28.9 | 57.8 | 50.2 |
| 4 | 65.2 | 77.1 | 63.8 | 77.1 | 57.6 | 74.0 | 48.2 | 69.4 | 37.9 | 64.8 | 27.8 | 57.8 | 50.2 |
| 5 | 64.9 | 77.1 | 63.4 | 77.1 | 57.2 | 74.0 | 47.7 | 69.4 | 37.3 | 64.8 | 27.3 | 57.8 | 50.2 |
| 6 | 65.3 | 77.1 | 63.9 | 77.1 | 57.6 | 74.0 | 48.0 | 69.4 | 37.5 | 64.8 | 27.6 | 57.8 | 50.2 |
| 7 | 67.7 | 77.1 | 66.2 | 77.1 | 59.8 | 74.0 | 50.3 | 69.4 | 39.9 | 64.8 | 29.5 | 57.8 | 50.2 |
| 8 | 64.8 | 77.1 | 63.2 | 77.1 | 56.8 | 74.0 | 47.1 | 69.4 | 36.5 | 64.8 | 26.6 | 57.8 | 50.2 |
| 9 | 63.8 | 77.1 | 62.2 | 77.1 | 55.7 | 74.0 | 46.0 | 69.4 | 35.3 | 64.8 | 25.3 | 57.8 | 50.2 |
| 10 | 63.9 | 77.1 | 62.4 | 77.1 | 55.8 | 74.0 | 45.9 | 69.4 | 35.2 | 64.8 | 25.2 | 57.8 | 50.2 |
| 11 | 66.0 | 77.1 | 64.4 | 77.1 | 57.8 | 74.0 | 48.0 | 69.4 | 37.3 | 64.8 | 26.7 | 57.8 | 50.2 |
| 12 | 62.8 | 77.1 | 61.2 | 77.1 | 54.5 | 74.0 | 44.4 | 69.4 | 33.6 | 64.8 | 23.5 | 57.8 | 50.2 |
| 13 | 61.5 | 77.1 | 59.9 | 77.1 | 53.0 | 74.0 | 42.9 | 69.4 | 32.0 | 64.8 | 21.8 | 57.8 | 50.2 |
| 14 | 60.9 | 77.1 | 59.2 | 77.1 | 52.3 | 74.0 | 42.1 | 69.4 | 31.1 | 64.8 | 20.8 | 57.8 | 50.2 |
| 15 | 60.7 | 77.1 | 59.1 | 77.1 | 52.1 | 74.0 | 41.8 | 69.4 | 30.6 | 64.8 | 20.3 | 57.8 | 50.2 |
| 16 | 61.3 | 77.1 | 59.6 | 77.1 | 52.6 | 74.0 | 42.1 | 69.4 | 30.8 | 64.8 | 20.5 | 57.8 | 50.2 |
| 17 | 63.8 | 77.1 | 62.0 | 77.1 | 54.9 | 74.0 | 44.5 | 69.4 | 33.2 | 64.8 | 22.2 | 57.8 | 50.2 |
| 18 | 60.9 | 77.1 | 59.1 | 77.1 | 51.9 | 74.0 | 41.2 | 69.4 | 29.7 | 64.8 | 19.1 | 57.8 | 50.2 |
| 19 | 60.0 | 77.1 | 58.2 | 77.1 | 50.9 | 74.0 | 40.1 | 69.4 | 28.4 | 64.8 | 17.6 | 57.8 | 50.2 |
| 20 | 60.1 | 77.1 | 58.3 | 77.1 | 51.0 | 74.0 | 40.0 | 69.4 | 28.2 | 64.8 | 17.3 | 57.8 | 50.2 |
| 21 | 62.2 | 77.1 | 60.4 | 77.1 | 52.9 | 74.0 | 42.0 | 69.4 | 30.1 | 64.8 | 18.4 | 57.8 | 50.2 |
| 22 | 59.0 | 77.1 | 57.2 | 77.1 | 49.6 | 74.0 | 38.4 | 69.4 | 26.2 | 64.8 | 14.8 | 57.8 | 50.2 |
| 23 | 57.7 | 77.1 | 55.8 | 77.1 | 48.2 | 74.0 | 36.8 | 69.4 | 24.4 | 64.8 | 12.6 | 57.8 | 50.2 |
| 24 | 57.0 | 77.1 | 55.2 | 77.1 | 47.4 | 74.0 | 35.9 | 69.4 | 23.3 | 64.8 | 11.0 | 57.8 | 50.2 |
| 25 | 56.9 | 77.1 | 55.0 | 77.1 | 47.1 | 74.0 | 35.3 | 69.4 | 22.5 | 64.8 | 9.7 | 57.8 | 50.2 |
| 26 | 57.4 | 77.1 | 55.5 | 77.1 | 47.5 | 74.0 | 35.5 | 69.4 | 22.4 | 64.8 | 8.7 | 57.8 | 50.2 |
| 27 | 59.8 | 77.1 | 57.8 | 77.1 | 49.7 | 74.0 | 37.7 | 69.4 | 24.5 | 64.8 | 7.2 | 57.8 | 50.2 |
| 28 | 56.9 | 77.1 | 54.9 | 77.1 | 46.7 | 74.0 | 34.2 | 69.4 | 20.6 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 55.8 | 77.1 | 53.9 | 77.1 | 45.5 | 74.0 | 32.9 | 69.4 | 19.0 | 64.8 | | 57.8 | 50.2 |
| 30 | 55.9 | 77.1 | 54.0 | 77.1 | 45.5 | 74.0 | 32.5 | 69.4 | 18.3 | 64.8 | | 57.8 | 50.2 |
| 31 | 58.0 | 77.1 | 55.9 | 77.1 | 47.3 | 74.0 | 34.2 | 69.4 | 19.9 | 64.8 | | 57.8 | 50.2 |
| 32 | 54.7 | 77.1 | 52.6 | 77.1 | 43.9 | 74.0 | 30.3 | 69.4 | 15.5 | 64.8 | | 57.8 | 50.2 |
| 33 | 53.2 | 77.1 | 51.1 | 77.1 | 42.2 | 74.0 | 28.3 | 69.4 | 13.2 | 64.8 | | 57.8 | 50.2 |
| 34 | 52.4 | 77.1 | 50.3 | 77.1 | 41.3 | 74.0 | 27.0 | 69.4 | 11.3 | 64.8 | | 57.8 | 50.2 |
| 35 | 52.0 | 77.1 | 50.0 | 77.1 | 40.7 | 74.0 | 26.1 | 69.4 | 9.9 | 64.8 | | 57.8 | 50.2 |
| 36 | 52.4 | 77.1 | 50.3 | 77.1 | 40.9 | 74.0 | 25.7 | 69.4 | 8.0 | 64.8 | | 57.8 | 50.2 |
| 37 | 54.5 | 77.1 | 52.4 | 77.1 | 42.8 | 74.0 | 27.3 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 38 | 51.1 | 77.1 | 49.0 | 77.1 | 39.3 | 74.0 | 23.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 39 | 49.6 | 77.1 | 47.4 | 77.1 | 37.6 | 74.0 | 20.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 40 | 48.6 | 77.1 | 46.4 | 77.1 | 36.5 | 74.0 | 18.9 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 41 | 47.8 | 77.1 | 45.7 | 77.1 | 35.6 | 74.0 | 17.2 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 42 | 47.2 | 77.1 | 45.1 | 77.1 | 34.8 | 74.0 | 15.6 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 43 | 46.8 | 77.1 | 44.6 | 77.1 | 34.2 | 74.0 | 14.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 44 | 46.4 | 77.1 | 44.2 | 77.1 | 33.8 | 74.0 | 12.4 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 45 | 46.1 | 77.1 | 43.9 | 77.1 | 33.4 | 74.0 | 10.7 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 46 | 45.9 | 77.1 | 43.7 | 77.1 | 33.1 | 74.0 | 9.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 47 | 45.8 | 77.1 | 43.6 | 77.1 | 32.9 | 74.0 | 7.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 48 | 45.7 | 77.1 | 43.5 | 77.1 | 32.8 | 74.0 | 7.3 | 69.4 | | 64.8 | | 57.8 | 50.2 |

Table A17. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 14 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 8.9 | 28.1 | 8.9 | 28.1 | 8.7 | 27.0 | 8.1 | 25.3 | 6.5 | 23.6 | 6.6 | 21.1 | 21.6 |
| 1 | 10.2 | 28.1 | 10.0 | 28.1 | 9.7 | 27.0 | 9.0 | 25.3 | 8.6 | 23.6 | 7.3 | 21.1 | 21.6 |
| 2 | 8.5 | 28.1 | 8.4 | 28.1 | 8.1 | 27.0 | 7.4 | 25.3 | 6.4 | 23.6 | 5.7 | 21.1 | 21.6 |
| 3 | 7.7 | 28.1 | 7.6 | 28.1 | 7.4 | 27.0 | 6.6 | 25.3 | 5.7 | 23.6 | 4.7 | 21.1 | 21.6 |
| 4 | 7.8 | 28.1 | 7.6 | 28.1 | 7.4 | 27.0 | 6.5 | 25.3 | 5.6 | 23.6 | 4.6 | 21.1 | 21.6 |
| 5 | 8.1 | 28.1 | 7.9 | 28.1 | 7.7 | 27.0 | 6.8 | 25.3 | 5.8 | 23.6 | 4.7 | 21.1 | 21.6 |
| 6 | 9.0 | 28.1 | 8.9 | 28.1 | 8.6 | 27.0 | 7.7 | 25.3 | 6.6 | 23.6 | 5.5 | 21.1 | 21.6 |
| 7 | 11.7 | 28.1 | 11.5 | 28.1 | 11.1 | 27.0 | 10.1 | 25.3 | 9.4 | 23.6 | 7.7 | 21.1 | 21.6 |
| 8 | 8.9 | 28.1 | 8.7 | 28.1 | 8.4 | 27.0 | 7.4 | 25.3 | 6.2 | 23.6 | 5.0 | 21.1 | 21.6 |
| 9 | 7.7 | 28.1 | 7.6 | 28.1 | 7.3 | 27.0 | 6.2 | 25.3 | 5.0 | 23.6 | 3.6 | 21.1 | 21.6 |
| 10 | 7.2 | 28.1 | 7.0 | 28.1 | 6.7 | 27.0 | 5.6 | 25.3 | 4.3 | 23.6 | 2.7 | 21.1 | 21.6 |
| 11 | 6.8 | 28.1 | 6.6 | 28.1 | 6.3 | 27.0 | 5.2 | 25.3 | 3.9 | 23.6 | 2.0 | 21.1 | 21.6 |
| 12 | 6.6 | 28.1 | 6.4 | 28.1 | 6.1 | 27.0 | 5.0 | 25.3 | 3.6 | 23.6 | 1.1 | 21.1 | 21.6 |
| 13 | 6.5 | 28.1 | 6.3 | 28.1 | 6.0 | 27.0 | 4.9 | 25.3 | 3.4 | 23.6 | 0.2 | 21.1 | 21.6 |
| 14 | 6.4 | 28.1 | 6.3 | 28.1 | 5.9 | 27.0 | 4.8 | 25.3 | 3.4 | 23.6 | 0.0 | 21.1 | 21.6 |

Table A18. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 14 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 18.9 | 47.2 | 18.6 | 47.2 | 17.5 | 45.3 | 15.8 | 42.5 | 12.9 | 39.6 | 11.8 | 35.4 | 32.4 |
| 1 | 19.9 | 47.2 | 19.6 | 47.2 | 18.5 | 45.3 | 16.8 | 42.5 | 14.8 | 39.6 | 12.1 | 35.4 | 32.4 |
| 2 | 18.0 | 47.2 | 17.6 | 47.2 | 16.5 | 45.3 | 14.8 | 42.5 | 12.4 | 39.6 | 10.3 | 35.4 | 32.4 |
| 3 | 17.1 | 47.2 | 16.7 | 47.2 | 15.6 | 45.3 | 13.9 | 42.5 | 11.5 | 39.6 | 9.1 | 35.4 | 32.4 |
| 4 | 17.0 | 47.2 | 16.6 | 47.2 | 15.5 | 45.3 | 13.7 | 42.5 | 11.3 | 39.6 | 8.8 | 35.4 | 32.4 |
| 5 | 17.2 | 47.2 | 16.8 | 47.2 | 15.7 | 45.3 | 13.9 | 42.5 | 11.5 | 39.6 | 8.9 | 35.4 | 32.4 |
| 6 | 18.0 | 47.2 | 17.7 | 47.2 | 16.5 | 45.3 | 14.7 | 42.5 | 12.2 | 39.6 | 9.6 | 35.4 | 32.4 |
| 7 | 20.6 | 47.2 | 20.2 | 47.2 | 19.1 | 45.3 | 17.2 | 42.5 | 15.0 | 39.6 | 11.7 | 35.4 | 32.4 |
| 8 | 17.8 | 47.2 | 17.4 | 47.2 | 16.2 | 45.3 | 14.4 | 42.5 | 11.8 | 39.6 | 8.9 | 35.4 | 32.4 |
| 9 | 16.6 | 47.2 | 16.2 | 47.2 | 15.0 | 45.3 | 13.2 | 42.5 | 10.6 | 39.6 | 7.6 | 35.4 | 32.4 |
| 10 | 16.0 | 47.2 | 15.6 | 47.2 | 14.5 | 45.3 | 12.6 | 42.5 | 10.0 | 39.6 | 6.9 | 35.4 | 32.4 |
| 11 | 15.6 | 47.2 | 15.2 | 47.2 | 14.1 | 45.3 | 12.2 | 42.5 | 9.6 | 39.6 | 6.4 | 35.4 | 32.4 |
| 12 | 15.4 | 47.2 | 15.0 | 47.2 | 13.9 | 45.3 | 12.0 | 42.5 | 9.4 | 39.6 | 6.1 | 35.4 | 32.4 |
| 13 | 15.3 | 47.2 | 14.9 | 47.2 | 13.7 | 45.3 | 11.9 | 42.5 | 9.3 | 39.6 | 6.0 | 35.4 | 32.4 |
| 14 | 15.2 | 47.2 | 14.9 | 47.2 | 13.7 | 45.3 | 11.9 | 42.5 | 9.3 | 39.6 | 6.0 | 35.4 | 32.4 |

Table A19. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 14 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 31.0 | 62.9 | 30.1 | 62.9 | 28.4 | 60.4 | 25.4 | 56.6 | 21.7 | 52.8 | 17.9 | 47.2 | 41.4 |
| 1 | 31.9 | 62.9 | 31.3 | 62.9 | 29.3 | 60.4 | 26.2 | 56.6 | 22.6 | 52.8 | 18.0 | 47.2 | 41.4 |
| 2 | 29.7 | 62.9 | 29.0 | 62.9 | 27.1 | 60.4 | 24.1 | 56.6 | 20.4 | 52.8 | 16.1 | 47.2 | 41.4 |
| 3 | 28.7 | 62.9 | 28.0 | 62.9 | 26.1 | 60.4 | 23.0 | 56.6 | 19.3 | 52.8 | 14.9 | 47.2 | 41.4 |
| 4 | 28.5 | 62.9 | 27.8 | 62.9 | 25.8 | 60.4 | 22.8 | 56.6 | 19.0 | 52.8 | 14.5 | 47.2 | 41.4 |
| 5 | 28.6 | 62.9 | 27.9 | 62.9 | 25.9 | 60.4 | 22.8 | 56.6 | 19.1 | 52.8 | 14.5 | 47.2 | 41.4 |
| 6 | 29.4 | 62.9 | 28.6 | 62.9 | 26.7 | 60.4 | 23.6 | 56.6 | 19.8 | 52.8 | 15.2 | 47.2 | 41.4 |
| 7 | 31.9 | 62.9 | 31.3 | 62.9 | 29.2 | 60.4 | 26.1 | 56.6 | 22.3 | 52.8 | 17.3 | 47.2 | 41.4 |
| 8 | 28.9 | 62.9 | 28.2 | 62.9 | 26.3 | 60.4 | 23.1 | 56.6 | 19.3 | 52.8 | 14.6 | 47.2 | 41.4 |
| 9 | 27.7 | 62.9 | 27.0 | 62.9 | 25.0 | 60.4 | 21.9 | 56.6 | 18.1 | 52.8 | 13.3 | 47.2 | 41.4 |
| 10 | 27.1 | 62.9 | 26.4 | 62.9 | 24.4 | 60.4 | 21.3 | 56.6 | 17.4 | 52.8 | 12.7 | 47.2 | 41.4 |
| 11 | 26.7 | 62.9 | 26.0 | 62.9 | 24.0 | 60.4 | 20.9 | 56.6 | 17.0 | 52.8 | 12.2 | 47.2 | 41.4 |
| 12 | 26.4 | 62.9 | 25.7 | 62.9 | 23.8 | 60.4 | 20.6 | 56.6 | 16.8 | 52.8 | 12.0 | 47.2 | 41.4 |
| 13 | 26.3 | 62.9 | 25.6 | 62.9 | 23.6 | 60.4 | 20.5 | 56.6 | 16.7 | 52.8 | 11.8 | 47.2 | 41.4 |
| 14 | 26.2 | 62.9 | 25.5 | 62.9 | 23.6 | 60.4 | 20.5 | 56.6 | 16.6 | 52.8 | 11.8 | 47.2 | 41.4 |

Table A20. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 54 ft, Deck Width = 14 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 42.0 | 75.3 | 41.1 | 75.3 | 38.3 | 72.3 | 33.7 | 67.8 | 28.5 | 63.3 | 23.1 | 56.5 | 50.2 |
| 1 | 42.9 | 75.3 | 41.9 | 75.3 | 39.2 | 72.3 | 35.0 | 67.8 | 30.1 | 63.3 | 23.9 | 56.5 | 50.2 |
| 2 | 40.6 | 75.3 | 39.6 | 75.3 | 36.8 | 72.3 | 32.5 | 67.8 | 27.4 | 63.3 | 21.5 | 56.5 | 50.2 |
| 3 | 39.4 | 75.3 | 38.5 | 75.3 | 35.7 | 72.3 | 31.4 | 67.8 | 26.3 | 63.3 | 20.2 | 56.5 | 50.2 |
| 4 | 39.1 | 75.3 | 38.1 | 75.3 | 35.4 | 72.3 | 31.1 | 67.8 | 26.0 | 63.3 | 19.8 | 56.5 | 50.2 |
| 5 | 39.2 | 75.3 | 38.2 | 75.3 | 35.4 | 72.3 | 31.1 | 67.8 | 26.0 | 63.3 | 19.6 | 56.5 | 50.2 |
| 6 | 39.8 | 75.3 | 38.9 | 75.3 | 36.1 | 72.3 | 31.8 | 67.8 | 26.6 | 63.3 | 19.8 | 56.5 | 50.2 |
| 7 | 42.3 | 75.3 | 41.3 | 75.3 | 38.5 | 72.3 | 34.4 | 67.8 | 29.3 | 63.3 | 20.6 | 56.5 | 50.2 |
| 8 | 39.3 | 75.3 | 38.3 | 75.3 | 35.6 | 72.3 | 31.2 | 67.8 | 26.1 | 63.3 | 23.1 | 56.5 | 50.2 |
| 9 | 38.1 | 75.3 | 37.1 | 75.3 | 34.3 | 72.3 | 30.0 | 67.8 | 24.9 | 63.3 | 20.2 | 56.5 | 50.2 |
| 10 | 37.4 | 75.3 | 36.4 | 75.3 | 33.6 | 72.3 | 29.4 | 67.8 | 24.2 | 63.3 | 19.1 | 56.5 | 50.2 |
| 11 | 36.9 | 75.3 | 36.0 | 75.3 | 33.2 | 72.3 | 28.9 | 67.8 | 23.8 | 63.3 | 18.5 | 56.5 | 50.2 |
| 12 | 36.7 | 75.3 | 35.7 | 75.3 | 32.9 | 72.3 | 28.6 | 67.8 | 23.5 | 63.3 | 18.2 | 56.5 | 50.2 |
| 13 | 36.5 | 75.3 | 35.5 | 75.3 | 32.8 | 72.3 | 28.5 | 67.8 | 23.4 | 63.3 | 18.0 | 56.5 | 50.2 |
| 14 | 36.4 | 75.3 | 35.4 | 75.3 | 32.7 | 72.3 | 28.4 | 67.8 | 23.3 | 63.3 | 18.0 | 56.5 | 50.2 |

Table A21. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 24 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 10.7 | 24.1 | 10.7 | 24.1 | 10.4 | 23.2 | 9.6 | 21.7 | 7.5 | 20.2 | 7.2 | 18.1 | 21.6 |
| 1 | 12.1 | 24.1 | 11.8 | 24.1 | 11.4 | 23.2 | 10.4 | 21.7 | 9.5 | 20.2 | 7.8 | 18.1 | 21.6 |
| 2 | 10.6 | 24.1 | 10.5 | 24.1 | 10.1 | 23.2 | 9.1 | 21.7 | 7.5 | 20.2 | 6.3 | 18.1 | 21.6 |
| 3 | 10.2 | 24.1 | 9.9 | 24.1 | 9.5 | 23.2 | 8.4 | 21.7 | 6.9 | 20.2 | 5.4 | 18.1 | 21.6 |
| 4 | 10.5 | 24.1 | 10.2 | 24.1 | 9.7 | 23.2 | 8.6 | 21.7 | 6.9 | 20.2 | 5.3 | 18.1 | 21.6 |
| 5 | 11.1 | 24.1 | 10.9 | 24.1 | 10.3 | 23.2 | 9.0 | 21.7 | 7.3 | 20.2 | 5.5 | 18.1 | 21.6 |
| 6 | 12.4 | 24.1 | 12.2 | 24.1 | 11.6 | 23.2 | 10.2 | 21.7 | 8.2 | 20.2 | 6.4 | 18.1 | 21.6 |
| 7 | 15.5 | 24.1 | 15.1 | 24.1 | 14.4 | 23.2 | 12.9 | 21.7 | 11.2 | 20.2 | 8.8 | 18.1 | 21.6 |
| 8 | 13.2 | 24.1 | 12.9 | 24.1 | 12.2 | 23.2 | 10.6 | 21.7 | 8.4 | 20.2 | 6.3 | 18.1 | 21.6 |
| 9 | 12.8 | 24.1 | 12.5 | 24.1 | 11.7 | 23.2 | 10.0 | 21.7 | 7.7 | 20.2 | 5.4 | 18.1 | 21.6 |
| 10 | 13.5 | 24.1 | 13.1 | 24.1 | 12.3 | 23.2 | 10.5 | 21.7 | 7.9 | 20.2 | 5.5 | 18.1 | 21.6 |
| 11 | 16.0 | 24.1 | 15.6 | 24.1 | 14.7 | 23.2 | 12.6 | 21.7 | 10.3 | 20.2 | 7.2 | 18.1 | 21.6 |
| 12 | 13.2 | 24.1 | 12.8 | 24.1 | 11.9 | 23.2 | 9.8 | 21.7 | 6.8 | 20.2 | 4.1 | 18.1 | 21.6 |
| 13 | 12.2 | 24.1 | 11.8 | 24.1 | 10.8 | 23.2 | 8.5 | 21.7 | 5.4 | 20.2 | 2.7 | 18.1 | 21.6 |
| 14 | 11.8 | 24.1 | 11.4 | 24.1 | 10.3 | 23.2 | 7.9 | 21.7 | 4.5 | 20.2 | 1.4 | 18.1 | 21.6 |
| 15 | 11.9 | 24.1 | 11.4 | 24.1 | 10.3 | 23.2 | 7.7 | 21.7 | 3.9 | 20.2 | 0.0 | 18.1 | 21.6 |
| 16 | 12.6 | 24.1 | 12.1 | 24.1 | 10.9 | 23.2 | 8.2 | 21.7 | 3.9 | 20.2 | | 18.1 | 21.6 |
| 17 | 15.0 | 24.1 | 14.5 | 24.1 | 13.2 | 23.2 | 10.1 | 21.7 | 6.2 | 20.2 | | 18.1 | 21.6 |
| 18 | 12.0 | 24.1 | 11.6 | 24.1 | 10.2 | 23.2 | 7.1 | 21.7 | 2.1 | 20.2 | | 18.1 | 21.6 |
| 19 | 10.8 | 24.1 | 10.3 | 24.1 | 8.9 | 23.2 | 5.4 | 21.7 | 0.0 | 20.2 | | 18.1 | 21.6 |
| 20 | 10.1 | 24.1 | 9.6 | 24.1 | 8.1 | 23.2 | 4.3 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 21 | 9.7 | 24.1 | 9.1 | 24.1 | 7.6 | 23.2 | 3.3 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 22 | 9.4 | 24.1 | 8.8 | 24.1 | 7.2 | 23.2 | 2.2 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 23 | 9.2 | 24.1 | 8.7 | 24.1 | 7.0 | 23.2 | 1.0 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 24 | 9.1 | 24.1 | 8.6 | 24.1 | 6.9 | 23.2 | 0.3 | 21.7 | | 20.2 | | 18.1 | 21.6 |

Table A22. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 24.3 | 45.6 | 24.0 | 45.6 | 22.5 | 43.8 | 19.9 | 41.0 | 15.9 | 38.3 | 13.8 | 34.2 | 32.4 |
| 1 | 25.3 | 45.6 | 25.0 | 45.6 | 23.4 | 43.8 | 20.8 | 41.0 | 17.7 | 38.3 | 13.9 | 34.2 | 32.4 |
| 2 | 23.5 | 45.6 | 23.2 | 45.6 | 21.6 | 43.8 | 18.9 | 41.0 | 15.3 | 38.3 | 12.1 | 34.2 | 32.4 |
| 3 | 22.8 | 45.6 | 22.5 | 45.6 | 20.8 | 43.8 | 18.0 | 41.0 | 14.5 | 38.3 | 11.0 | 34.2 | 32.4 |
| 4 | 22.9 | 45.6 | 22.6 | 45.6 | 20.8 | 43.8 | 17.9 | 41.0 | 14.3 | 38.3 | 10.8 | 34.2 | 32.4 |
| 5 | 23.3 | 45.6 | 23.0 | 45.6 | 21.2 | 43.8 | 18.2 | 41.0 | 14.5 | 38.3 | 10.9 | 34.2 | 32.4 |
| 6 | 24.4 | 45.6 | 24.1 | 45.6 | 22.2 | 43.8 | 19.1 | 41.0 | 15.2 | 38.3 | 11.7 | 34.2 | 32.4 |
| 7 | 27.4 | 45.6 | 27.0 | 45.6 | 25.1 | 43.8 | 21.9 | 41.0 | 18.2 | 38.3 | 13.9 | 34.2 | 32.4 |
| 8 | 25.0 | 45.6 | 24.6 | 45.6 | 22.6 | 43.8 | 19.3 | 41.0 | 15.2 | 38.3 | 11.4 | 34.2 | 32.4 |
| 9 | 24.4 | 45.6 | 24.1 | 45.6 | 22.0 | 43.8 | 18.6 | 41.0 | 14.4 | 38.3 | 10.5 | 34.2 | 32.4 |
| 10 | 25.0 | 45.6 | 24.6 | 45.6 | 22.5 | 43.8 | 19.0 | 41.0 | 14.6 | 38.3 | 10.6 | 34.2 | 32.4 |
| 11 | 27.5 | 45.6 | 27.1 | 45.6 | 25.0 | 43.8 | 21.3 | 41.0 | 17.0 | 38.3 | 12.3 | 34.2 | 32.4 |
| 12 | 24.6 | 45.6 | 24.2 | 45.6 | 22.0 | 43.8 | 18.2 | 41.0 | 13.4 | 38.3 | 9.2 | 34.2 | 32.4 |
| 13 | 23.6 | 45.6 | 23.2 | 45.6 | 20.9 | 43.8 | 17.0 | 41.0 | 12.0 | 38.3 | 7.6 | 34.2 | 32.4 |
| 14 | 23.2 | 45.6 | 22.8 | 45.6 | 20.5 | 43.8 | 16.4 | 41.0 | 11.2 | 38.3 | 6.6 | 34.2 | 32.4 |
| 15 | 23.3 | 45.6 | 22.9 | 45.6 | 20.5 | 43.8 | 16.2 | 41.0 | 10.7 | 38.3 | 6.0 | 34.2 | 32.4 |
| 16 | 24.0 | 45.6 | 23.6 | 45.6 | 21.2 | 43.8 | 16.7 | 41.0 | 10.8 | 38.3 | 6.1 | 34.2 | 32.4 |
| 17 | 26.4 | 45.6 | 26.0 | 45.6 | 23.6 | 43.8 | 19.0 | 41.0 | 13.0 | 38.3 | 7.6 | 34.2 | 32.4 |
| 18 | 23.5 | 45.6 | 23.1 | 45.6 | 20.6 | 43.8 | 15.9 | 41.0 | 9.0 | 38.3 | 4.6 | 34.2 | 32.4 |
| 19 | 22.3 | 45.6 | 21.9 | 45.6 | 19.4 | 43.8 | 14.5 | 41.0 | 7.1 | 38.3 | 2.1 | 34.2 | 32.4 |
| 20 | 21.6 | 45.6 | 21.3 | 45.6 | 18.7 | 43.8 | 13.7 | 41.0 | 5.5 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 21.2 | 45.6 | 20.9 | 45.6 | 18.3 | 43.8 | 13.2 | 41.0 | 3.8 | 38.3 | | 34.2 | 32.4 |
| 22 | 21.0 | 45.6 | 20.6 | 45.6 | 18.1 | 43.8 | 12.9 | 41.0 | 2.0 | 38.3 | | 34.2 | 32.4 |
| 23 | 20.9 | 45.6 | 20.5 | 45.6 | 18.0 | 43.8 | 12.8 | 41.0 | 0.6 | 38.3 | | 34.2 | 32.4 |
| 24 | 20.9 | 45.6 | 20.5 | 45.6 | 18.0 | 43.8 | 12.8 | 41.0 | 0.4 | 38.3 | | 34.2 | 32.4 |

Table A23. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 39.8 | 65.3 | 38.8 | 65.3 | 36.2 | 62.7 | 31.6 | 58.8 | 26.2 | 54.9 | 20.8 | 49.0 | 41.4 |
| 1 | 40.6 | 65.3 | 39.9 | 65.3 | 37.0 | 62.7 | 32.3 | 58.8 | 26.9 | 54.9 | 20.8 | 49.0 | 41.4 |
| 2 | 38.5 | 65.3 | 37.7 | 65.3 | 34.9 | 62.7 | 30.1 | 58.8 | 24.6 | 54.9 | 18.7 | 49.0 | 41.4 |
| 3 | 37.6 | 65.3 | 36.8 | 65.3 | 33.9 | 62.7 | 29.0 | 58.8 | 23.4 | 54.9 | 17.4 | 49.0 | 41.4 |
| 4 | 37.5 | 65.3 | 36.7 | 65.3 | 33.7 | 62.7 | 28.8 | 58.8 | 23.0 | 54.9 | 17.0 | 49.0 | 41.4 |
| 5 | 37.7 | 65.3 | 37.0 | 65.3 | 33.9 | 62.7 | 28.9 | 58.8 | 23.0 | 54.9 | 16.9 | 49.0 | 41.4 |
| 6 | 38.7 | 65.3 | 37.9 | 65.3 | 34.8 | 62.7 | 29.7 | 58.8 | 23.7 | 54.9 | 17.6 | 49.0 | 41.4 |
| 7 | 41.5 | 65.3 | 40.8 | 65.3 | 37.6 | 62.7 | 32.4 | 58.8 | 26.2 | 54.9 | 19.7 | 49.0 | 41.4 |
| 8 | 39.0 | 65.3 | 38.1 | 65.3 | 35.0 | 62.7 | 29.7 | 58.8 | 23.4 | 54.9 | 17.1 | 49.0 | 41.4 |
| 9 | 38.4 | 65.3 | 37.5 | 65.3 | 34.3 | 62.7 | 28.9 | 58.8 | 22.5 | 54.9 | 16.0 | 49.0 | 41.4 |
| 10 | 38.8 | 65.3 | 38.0 | 65.3 | 34.7 | 62.7 | 29.3 | 58.8 | 22.7 | 54.9 | 16.0 | 49.0 | 41.4 |
| 11 | 41.2 | 65.3 | 40.5 | 65.3 | 37.1 | 62.7 | 31.5 | 58.8 | 24.7 | 54.9 | 17.6 | 49.0 | 41.4 |
| 12 | 38.3 | 65.3 | 37.4 | 65.3 | 34.1 | 62.7 | 28.4 | 58.8 | 21.4 | 54.9 | 14.4 | 49.0 | 41.4 |
| 13 | 37.2 | 65.3 | 36.3 | 65.3 | 32.9 | 62.7 | 27.2 | 58.8 | 19.9 | 54.9 | 12.7 | 49.0 | 41.4 |
| 14 | 36.7 | 65.3 | 35.9 | 65.3 | 32.5 | 62.7 | 26.7 | 58.8 | 19.2 | 54.9 | 11.6 | 49.0 | 41.4 |
| 15 | 36.7 | 65.3 | 35.9 | 65.3 | 32.5 | 62.7 | 26.5 | 58.8 | 18.8 | 54.9 | 10.9 | 49.0 | 41.4 |
| 16 | 37.4 | 65.3 | 36.5 | 65.3 | 33.1 | 62.7 | 27.1 | 58.8 | 19.1 | 54.9 | 10.9 | 49.0 | 41.4 |
| 17 | 39.8 | 65.3 | 39.1 | 65.3 | 35.6 | 62.7 | 29.5 | 58.8 | 21.1 | 54.9 | 12.2 | 49.0 | 41.4 |
| 18 | 36.9 | 65.3 | 36.0 | 65.3 | 32.6 | 62.7 | 26.5 | 58.8 | 17.8 | 54.9 | 8.5 | 49.0 | 41.4 |
| 19 | 35.7 | 65.3 | 34.8 | 65.3 | 31.4 | 62.7 | 25.2 | 58.8 | 16.2 | 54.9 | 6.2 | 49.0 | 41.4 |
| 20 | 35.0 | 65.3 | 34.2 | 65.3 | 30.7 | 62.7 | 24.5 | 58.8 | 15.3 | 54.9 | 4.2 | 49.0 | 41.4 |
| 21 | 34.6 | 65.3 | 33.8 | 65.3 | 30.3 | 62.7 | 24.1 | 58.8 | 14.7 | 54.9 | 2.3 | 49.0 | 41.4 |
| 22 | 34.4 | 65.3 | 33.6 | 65.3 | 30.1 | 62.7 | 23.9 | 58.8 | 14.3 | 54.9 | 0.9 | 49.0 | 41.4 |
| 23 | 34.3 | 65.3 | 33.5 | 65.3 | 30.0 | 62.7 | 23.8 | 58.8 | 14.2 | 54.9 | 0.0 | 49.0 | 41.4 |
| 24 | 34.3 | 65.3 | 33.5 | 65.3 | 30.1 | 62.7 | 23.9 | 58.8 | 14.2 | 54.9 | | 49.0 | 41.4 |

Table A24. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 53.2 | 81.7 | 52.1 | 81.7 | 48.2 | 78.4 | 41.5 | 73.5 | 34.0 | 68.6 | 25.9 | 61.3 | 50.2 |
| 1 | 53.9 | 81.7 | 52.8 | 81.7 | 48.9 | 78.4 | 42.7 | 73.5 | 35.4 | 68.6 | 26.5 | 61.3 | 50.2 |
| 2 | 51.6 | 81.7 | 50.5 | 81.7 | 46.6 | 78.4 | 40.2 | 73.5 | 32.5 | 68.6 | 23.8 | 61.3 | 50.2 |
| 3 | 50.6 | 81.7 | 49.4 | 81.7 | 45.4 | 78.4 | 39.0 | 73.5 | 31.3 | 68.6 | 22.4 | 61.3 | 50.2 |
| 4 | 50.3 | 81.7 | 49.2 | 81.7 | 45.1 | 78.4 | 38.7 | 73.5 | 30.9 | 68.6 | 21.7 | 61.3 | 50.2 |
| 5 | 50.5 | 81.7 | 49.3 | 81.7 | 45.2 | 78.4 | 38.7 | 73.5 | 30.8 | 68.6 | 21.3 | 61.3 | 50.2 |
| 6 | 51.3 | 81.7 | 50.2 | 81.7 | 46.1 | 78.4 | 39.4 | 73.5 | 31.4 | 68.6 | 21.3 | 61.3 | 50.2 |
| 7 | 54.0 | 81.7 | 52.8 | 81.7 | 48.7 | 78.4 | 42.2 | 73.5 | 34.1 | 68.6 | 21.9 | 61.3 | 50.2 |
| 8 | 51.4 | 81.7 | 50.2 | 81.7 | 46.1 | 78.4 | 39.3 | 73.5 | 31.0 | 68.6 | 24.2 | 61.3 | 50.2 |
| 9 | 50.7 | 81.7 | 49.5 | 81.7 | 45.3 | 78.4 | 38.5 | 73.5 | 30.1 | 68.6 | 21.3 | 61.3 | 50.2 |
| 10 | 51.1 | 81.7 | 49.9 | 81.7 | 45.7 | 78.4 | 38.8 | 73.5 | 30.2 | 68.6 | 20.2 | 61.3 | 50.2 |
| 11 | 53.4 | 81.7 | 52.2 | 81.7 | 48.0 | 78.4 | 41.2 | 73.5 | 32.5 | 68.6 | 20.1 | 61.3 | 50.2 |
| 12 | 50.4 | 81.7 | 49.2 | 81.7 | 45.0 | 78.4 | 37.9 | 73.5 | 29.0 | 68.6 | 21.9 | 61.3 | 50.2 |
| 13 | 49.3 | 81.7 | 48.1 | 81.7 | 43.8 | 78.4 | 36.7 | 73.5 | 27.6 | 68.6 | 18.4 | 61.3 | 50.2 |
| 14 | 48.8 | 81.7 | 47.6 | 81.7 | 43.3 | 78.4 | 36.2 | 73.5 | 26.9 | 68.6 | 16.6 | 61.3 | 50.2 |
| 15 | 48.8 | 81.7 | 47.5 | 81.7 | 43.2 | 78.4 | 36.1 | 73.5 | 26.7 | 68.6 | 15.4 | 61.3 | 50.2 |
| 16 | 49.4 | 81.7 | 48.2 | 81.7 | 43.9 | 78.4 | 36.6 | 73.5 | 27.0 | 68.6 | 14.6 | 61.3 | 50.2 |
| 17 | 51.8 | 81.7 | 50.6 | 81.7 | 46.3 | 78.4 | 39.2 | 73.5 | 29.5 | 68.6 | 14.4 | 61.3 | 50.2 |
| 18 | 48.8 | 81.7 | 47.6 | 81.7 | 43.3 | 78.4 | 36.0 | 73.5 | 26.1 | 68.6 | 15.8 | 61.3 | 50.2 |
| 19 | 47.6 | 81.7 | 46.4 | 81.7 | 42.1 | 78.4 | 34.8 | 73.5 | 24.8 | 68.6 | 11.8 | 61.3 | 50.2 |
| 20 | 46.9 | 81.7 | 45.7 | 81.7 | 41.4 | 78.4 | 34.2 | 73.5 | 24.1 | 68.6 | 9.4 | 61.3 | 50.2 |
| 21 | 46.5 | 81.7 | 45.3 | 81.7 | 41.0 | 78.4 | 33.8 | 73.5 | 23.6 | 68.6 | 7.7 | 61.3 | 50.2 |
| 22 | 46.2 | 81.7 | 45.0 | 81.7 | 40.8 | 78.4 | 33.6 | 73.5 | 23.4 | 68.6 | 6.6 | 61.3 | 50.2 |
| 23 | 46.1 | 81.7 | 44.9 | 81.7 | 40.7 | 78.4 | 33.5 | 73.5 | 23.3 | 68.6 | 6.0 | 61.3 | 50.2 |
| 24 | 46.1 | 81.7 | 44.9 | 81.7 | 40.7 | 78.4 | 33.5 | 73.5 | 23.3 | 68.6 | 6.0 | 61.3 | 50.2 |

Table A25. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 36 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 11.3 | 22.6 | 11.3 | 22.6 | 11.0 | 21.7 | 9.9 | 20.3 | 0.9 | 19.0 | 1.1 | 17.0 | 21.6 |
| 1 | 12.6 | 22.6 | 12.4 | 22.6 | 11.9 | 21.7 | 10.7 | 20.3 | 6.3 | 19.0 | 3.4 | 17.0 | 21.6 |
| 2 | 11.3 | 22.6 | 11.2 | 22.6 | 10.7 | 21.7 | 9.4 | 20.3 | 4.0 | 19.0 | 6.3 | 17.0 | 21.6 |
| 3 | 10.9 | 22.6 | 10.7 | 22.6 | 10.2 | 21.7 | 8.7 | 20.3 | 4.5 | 19.0 | 4.8 | 17.0 | 21.6 |
| 4 | 11.3 | 22.6 | 11.1 | 22.6 | 10.5 | 21.7 | 8.9 | 20.3 | 5.8 | 19.0 | 4.8 | 17.0 | 21.6 |
| 5 | 12.0 | 22.6 | 11.8 | 22.6 | 11.1 | 21.7 | 9.4 | 20.3 | 9.3 | 19.0 | 5.9 | 17.0 | 21.6 |
| 6 | 13.4 | 22.6 | 13.2 | 22.6 | 12.5 | 21.7 | 10.6 | 20.3 | 6.8 | 19.0 | 8.5 | 17.0 | 21.6 |
| 7 | 16.6 | 22.6 | 16.3 | 22.6 | 15.4 | 21.7 | 13.3 | 20.3 | 6.5 | 19.0 | 6.4 | 17.0 | 21.6 |
| 8 | 14.4 | 22.6 | 14.2 | 22.6 | 13.3 | 21.7 | 11.1 | 20.3 | 6.7 | 19.0 | 5.6 | 17.0 | 21.6 |
| 9 | 14.1 | 22.6 | 13.9 | 22.6 | 12.9 | 21.7 | 10.5 | 20.3 | 7.3 | 19.0 | 5.6 | 17.0 | 21.6 |
| 10 | 14.9 | 22.6 | 14.7 | 22.6 | 13.6 | 21.7 | 11.0 | 20.3 | 8.5 | 19.0 | 6.0 | 17.0 | 21.6 |
| 11 | 17.6 | 22.6 | 17.3 | 22.6 | 16.0 | 21.7 | 13.1 | 20.3 | 11.8 | 19.0 | 7.0 | 17.0 | 21.6 |
| 12 | 15.0 | 22.6 | 14.7 | 22.6 | 13.4 | 21.7 | 10.3 | 20.3 | 9.3 | 19.0 | 9.5 | 17.0 | 21.6 |
| 13 | 14.1 | 22.6 | 13.8 | 22.6 | 12.4 | 21.7 | 9.1 | 20.3 | 8.9 | 19.0 | 7.2 | 17.0 | 21.6 |
| 14 | 14.0 | 22.6 | 13.7 | 22.6 | 12.1 | 21.7 | 8.5 | 20.3 | 9.4 | 19.0 | 6.4 | 17.0 | 21.6 |
| 15 | 14.2 | 22.6 | 13.9 | 22.6 | 12.3 | 21.7 | 8.4 | 20.3 | 12.2 | 19.0 | 6.7 | 17.0 | 21.6 |
| 16 | 15.2 | 22.6 | 14.9 | 22.6 | 13.1 | 21.7 | 9.0 | 20.3 | 9.0 | 19.0 | 8.6 | 17.0 | 21.6 |
| 17 | 18.0 | 22.6 | 17.6 | 22.6 | 15.6 | 21.7 | 11.1 | 20.3 | 7.9 | 19.0 | 5.6 | 17.0 | 21.6 |
| 18 | 15.5 | 22.6 | 15.1 | 22.6 | 13.1 | 21.7 | 8.3 | 20.3 | 7.5 | 19.0 | 4.0 | 17.0 | 21.6 |
| 19 | 14.8 | 22.6 | 14.4 | 22.6 | 12.2 | 21.7 | 7.2 | 20.3 | 7.4 | 19.0 | 3.3 | 17.0 | 21.6 |
| 20 | 15.3 | 22.6 | 14.8 | 22.6 | 12.5 | 21.7 | 7.2 | 20.3 | 7.9 | 19.0 | 0.0 | 17.0 | 21.6 |
| 21 | 17.6 | 22.6 | 17.1 | 22.6 | 14.5 | 21.7 | 8.8 | 20.3 | 10.4 | 19.0 | | 17.0 | 21.6 |
| 22 | 14.6 | 22.6 | 14.1 | 22.6 | 11.5 | 21.7 | 5.5 | 20.3 | 7.0 | 19.0 | | 17.0 | 21.6 |
| 23 | 13.4 | 22.6 | 12.8 | 22.6 | 10.1 | 21.7 | 3.8 | 20.3 | 5.6 | 19.0 | | 17.0 | 21.6 |
| 24 | 12.8 | 22.6 | 12.3 | 22.6 | 9.4 | 21.7 | 2.4 | 20.3 | 4.6 | 19.0 | | 17.0 | 21.6 |
| 25 | 12.7 | 22.6 | 12.1 | 22.6 | 9.1 | 21.7 | 0.0 | 20.3 | 3.9 | 19.0 | | 17.0 | 21.6 |
| 26 | 13.2 | 22.6 | 12.6 | 22.6 | 9.4 | 21.7 | | 20.3 | 3.2 | 19.0 | | 17.0 | 21.6 |
| 27 | 15.5 | 22.6 | 14.8 | 22.6 | 11.4 | 21.7 | | 20.3 | 2.6 | 19.0 | | 17.0 | 21.6 |
| 28 | 12.4 | 22.6 | 11.7 | 22.6 | 8.2 | 21.7 | | 20.3 | 2.0 | 19.0 | | 17.0 | 21.6 |
| 29 | 10.9 | 22.6 | 10.2 | 22.6 | 6.5 | 21.7 | | 20.3 | 0.0 | 19.0 | | 17.0 | 21.6 |
| 30 | 10.1 | 22.6 | 9.4 | 22.6 | 5.3 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 31 | 9.5 | 22.6 | 8.7 | 22.6 | 4.4 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 32 | 9.0 | 22.6 | 8.2 | 22.6 | 3.6 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 33 | 8.7 | 22.6 | 7.8 | 22.6 | 2.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 34 | 8.4 | 22.6 | 7.6 | 22.6 | 2.1 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 35 | 8.2 | 22.6 | 7.4 | 22.6 | 1.4 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 36 | 8.1 | 22.6 | 7.2 | 22.6 | 0.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |

Table A26. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 36 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 26.2 | 42.3 | 26.1 | 42.3 | 24.3 | 40.6 | 21.6 | 38.1 | 16.7 | 35.5 | 13.9 | 31.7 | 32.4 |
| 1 | 27.2 | 42.3 | 27.0 | 42.3 | 25.2 | 40.6 | 22.0 | 38.1 | 18.3 | 35.5 | 14.1 | 31.7 | 32.4 |
| 2 | 25.5 | 42.3 | 25.3 | 42.3 | 23.4 | 40.6 | 20.3 | 38.1 | 15.9 | 35.5 | 12.3 | 31.7 | 32.4 |
| 3 | 24.8 | 42.3 | 24.6 | 42.3 | 22.7 | 40.6 | 19.4 | 38.1 | 15.1 | 35.5 | 11.2 | 31.7 | 32.4 |
| 4 | 25.0 | 42.3 | 24.8 | 42.3 | 22.7 | 40.6 | 19.3 | 38.1 | 14.9 | 35.5 | 10.9 | 31.7 | 32.4 |
| 5 | 25.5 | 42.3 | 25.3 | 42.3 | 23.1 | 40.6 | 19.6 | 38.1 | 15.1 | 35.5 | 11.0 | 31.7 | 32.4 |
| 6 | 26.7 | 42.3 | 26.4 | 42.3 | 24.3 | 40.6 | 20.6 | 38.1 | 15.9 | 35.5 | 11.8 | 31.7 | 32.4 |
| 7 | 29.7 | 42.3 | 29.4 | 42.3 | 27.2 | 40.6 | 23.2 | 38.1 | 18.8 | 35.5 | 14.1 | 31.7 | 32.4 |
| 8 | 27.4 | 42.3 | 27.1 | 42.3 | 24.8 | 40.6 | 20.8 | 38.1 | 15.8 | 35.5 | 11.6 | 31.7 | 32.4 |
| 9 | 26.9 | 42.3 | 26.7 | 42.3 | 24.2 | 40.6 | 20.2 | 38.1 | 15.0 | 35.5 | 10.6 | 31.7 | 32.4 |
| 10 | 27.6 | 42.3 | 27.3 | 42.3 | 24.8 | 40.6 | 20.6 | 38.1 | 15.2 | 35.5 | 10.7 | 31.7 | 32.4 |
| 11 | 30.2 | 42.3 | 29.9 | 42.3 | 27.3 | 40.6 | 22.7 | 38.1 | 17.7 | 35.5 | 12.4 | 31.7 | 32.4 |
| 12 | 27.4 | 42.3 | 27.1 | 42.3 | 24.4 | 40.6 | 19.9 | 38.1 | 14.2 | 35.5 | 9.3 | 31.7 | 32.4 |
| 13 | 26.5 | 42.3 | 26.1 | 42.3 | 23.4 | 40.6 | 18.7 | 38.1 | 12.9 | 35.5 | 7.6 | 31.7 | 32.4 |
| 14 | 26.3 | 42.3 | 25.9 | 42.3 | 23.0 | 40.6 | 18.2 | 38.1 | 12.1 | 35.5 | 6.7 | 31.7 | 32.4 |
| 15 | 26.5 | 42.3 | 26.1 | 42.3 | 23.1 | 40.6 | 18.1 | 38.1 | 11.8 | 35.5 | 6.1 | 31.7 | 32.4 |
| 16 | 27.4 | 42.3 | 27.0 | 42.3 | 23.9 | 40.6 | 18.8 | 38.1 | 12.1 | 35.5 | 6.1 | 31.7 | 32.4 |
| 17 | 30.1 | 42.3 | 29.7 | 42.3 | 26.5 | 40.6 | 21.0 | 38.1 | 14.6 | 35.5 | 7.6 | 31.7 | 32.4 |
| 18 | 27.5 | 42.3 | 27.1 | 42.3 | 23.8 | 40.6 | 18.3 | 38.1 | 11.1 | 35.5 | 4.6 | 31.7 | 32.4 |
| 19 | 26.8 | 42.3 | 26.4 | 42.3 | 23.0 | 40.6 | 17.2 | 38.1 | 9.9 | 35.5 | 2.1 | 31.7 | 32.4 |
| 20 | 27.2 | 42.3 | 26.8 | 42.3 | 23.3 | 40.6 | 17.3 | 38.1 | 9.6 | 35.5 | 0.0 | 31.7 | 32.4 |
| 21 | 29.5 | 42.3 | 29.0 | 42.3 | 25.4 | 40.6 | 19.1 | 38.1 | 11.5 | 35.5 | | 31.7 | 32.4 |
| 22 | 26.5 | 42.3 | 26.0 | 42.3 | 22.3 | 40.6 | 15.8 | 38.1 | 7.5 | 35.5 | | 31.7 | 32.4 |
| 23 | 25.3 | 42.3 | 24.8 | 42.3 | 20.9 | 40.6 | 14.2 | 38.1 | 5.6 | 35.5 | | 31.7 | 32.4 |
| 24 | 24.8 | 42.3 | 24.2 | 42.3 | 20.2 | 40.6 | 13.2 | 38.1 | 4.4 | 35.5 | | 31.7 | 32.4 |
| 25 | 24.6 | 42.3 | 24.1 | 42.3 | 20.0 | 40.6 | 12.7 | 38.1 | 2.8 | 35.5 | | 31.7 | 32.4 |
| 26 | 25.2 | 42.3 | 24.6 | 42.3 | 20.3 | 40.6 | 12.7 | 38.1 | 0.0 | 35.5 | | 31.7 | 32.4 |
| 27 | 27.5 | 42.3 | 26.9 | 42.3 | 22.5 | 40.6 | 14.3 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 28 | 24.3 | 42.3 | 23.7 | 42.3 | 19.2 | 40.6 | 10.8 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 29 | 23.0 | 42.3 | 22.3 | 42.3 | 17.6 | 40.6 | 8.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 30 | 22.1 | 42.3 | 21.5 | 42.3 | 16.7 | 40.6 | 7.2 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 31 | 21.6 | 42.3 | 20.9 | 42.3 | 16.0 | 40.6 | 5.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 32 | 21.1 | 42.3 | 20.5 | 42.3 | 15.4 | 40.6 | 4.3 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 33 | 20.8 | 42.3 | 20.2 | 42.3 | 15.0 | 40.6 | 2.8 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 34 | 20.6 | 42.3 | 20.0 | 42.3 | 14.7 | 40.6 | 1.1 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 35 | 20.5 | 42.3 | 19.9 | 42.3 | 14.5 | 40.6 | 0.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 36 | 20.4 | 42.3 | 19.8 | 42.3 | 14.4 | 40.6 | | 38.1 | | 35.5 | | 31.7 | 32.4 |

Table A27. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 43.0 | 60.4 | 42.1 | 60.4 | 39.0 | 58.0 | 33.7 | 54.4 | 26.7 | 50.7 | 21.5 | 45.3 | 41.4 |
| 1 | 43.7 | 60.4 | 43.2 | 60.4 | 39.7 | 58.0 | 34.3 | 54.4 | 28.1 | 50.7 | 21.4 | 45.3 | 41.4 |
| 2 | 41.7 | 60.4 | 41.0 | 60.4 | 37.6 | 58.0 | 32.1 | 54.4 | 25.4 | 50.7 | 19.4 | 45.3 | 41.4 |
| 3 | 40.8 | 60.4 | 40.0 | 60.4 | 36.6 | 58.0 | 31.0 | 54.4 | 24.4 | 50.7 | 18.1 | 45.3 | 41.4 |
| 4 | 40.7 | 60.4 | 39.9 | 60.4 | 36.4 | 58.0 | 30.7 | 54.4 | 24.0 | 50.7 | 17.7 | 45.3 | 41.4 |
| 5 | 41.0 | 60.4 | 40.2 | 60.4 | 36.6 | 58.0 | 30.8 | 54.4 | 24.0 | 50.7 | 17.6 | 45.3 | 41.4 |
| 6 | 42.0 | 60.4 | 41.1 | 60.4 | 37.5 | 58.0 | 31.6 | 54.4 | 24.6 | 50.7 | 18.3 | 45.3 | 41.4 |
| 7 | 44.8 | 60.4 | 44.1 | 60.4 | 40.2 | 58.0 | 34.2 | 54.4 | 27.4 | 50.7 | 20.4 | 45.3 | 41.4 |
| 8 | 42.3 | 60.4 | 41.4 | 60.4 | 37.6 | 58.0 | 31.5 | 54.4 | 24.3 | 50.7 | 17.9 | 45.3 | 41.4 |
| 9 | 41.7 | 60.4 | 40.8 | 60.4 | 36.9 | 58.0 | 30.7 | 54.4 | 23.5 | 50.7 | 16.8 | 45.3 | 41.4 |
| 10 | 42.2 | 60.4 | 41.3 | 60.4 | 37.3 | 58.0 | 31.0 | 54.4 | 23.6 | 50.7 | 16.9 | 45.3 | 41.4 |
| 11 | 44.6 | 60.4 | 43.8 | 60.4 | 39.6 | 58.0 | 33.2 | 54.4 | 25.9 | 50.7 | 18.6 | 45.3 | 41.4 |
| 12 | 41.7 | 60.4 | 40.8 | 60.4 | 36.6 | 58.0 | 30.1 | 54.4 | 22.4 | 50.7 | 15.5 | 45.3 | 41.4 |
| 13 | 40.7 | 60.4 | 39.8 | 60.4 | 35.5 | 58.0 | 28.8 | 54.4 | 21.1 | 50.7 | 13.9 | 45.3 | 41.4 |
| 14 | 40.4 | 60.4 | 39.4 | 60.4 | 35.0 | 58.0 | 28.2 | 54.4 | 20.3 | 50.7 | 13.0 | 45.3 | 41.4 |
| 15 | 40.5 | 60.4 | 39.5 | 60.4 | 35.0 | 58.0 | 28.1 | 54.4 | 20.0 | 50.7 | 12.6 | 45.3 | 41.4 |
| 16 | 41.3 | 60.4 | 40.3 | 60.4 | 35.7 | 58.0 | 28.6 | 54.4 | 20.3 | 50.7 | 12.8 | 45.3 | 41.4 |
| 17 | 43.9 | 60.4 | 43.0 | 60.4 | 38.3 | 58.0 | 31.0 | 54.4 | 22.8 | 50.7 | 14.5 | 45.3 | 41.4 |
| 18 | 41.3 | 60.4 | 40.2 | 60.4 | 35.5 | 58.0 | 28.0 | 54.4 | 19.4 | 50.7 | 11.4 | 45.3 | 41.4 |
| 19 | 40.5 | 60.4 | 39.5 | 60.4 | 34.7 | 58.0 | 27.0 | 54.4 | 18.2 | 50.7 | 9.9 | 45.3 | 41.4 |
| 20 | 40.9 | 60.4 | 39.8 | 60.4 | 34.9 | 58.0 | 27.0 | 54.4 | 17.9 | 50.7 | 9.4 | 45.3 | 41.4 |
| 21 | 43.1 | 60.4 | 42.1 | 60.4 | 37.0 | 58.0 | 28.9 | 54.4 | 19.9 | 50.7 | 10.6 | 45.3 | 41.4 |
| 22 | 40.0 | 60.4 | 38.9 | 60.4 | 33.9 | 58.0 | 25.5 | 54.4 | 15.9 | 50.7 | 7.3 | 45.3 | 41.4 |
| 23 | 38.8 | 60.4 | 37.7 | 60.4 | 32.5 | 58.0 | 23.9 | 54.4 | 14.1 | 50.7 | 4.4 | 45.3 | 41.4 |
| 24 | 38.2 | 60.4 | 37.1 | 60.4 | 31.9 | 58.0 | 22.9 | 54.4 | 12.9 | 50.7 | 0.0 | 45.3 | 41.4 |
| 25 | 38.1 | 60.4 | 37.0 | 60.4 | 31.6 | 58.0 | 22.4 | 54.4 | 12.0 | 50.7 | | 45.3 | 41.4 |
| 26 | 38.6 | 60.4 | 37.5 | 60.4 | 32.0 | 58.0 | 22.5 | 54.4 | 11.7 | 50.7 | | 45.3 | 41.4 |
| 27 | 40.9 | 60.4 | 39.9 | 60.4 | 34.2 | 58.0 | 24.3 | 54.4 | 13.5 | 50.7 | | 45.3 | 41.4 |
| 28 | 37.8 | 60.4 | 36.7 | 60.4 | 31.0 | 58.0 | 20.7 | 54.4 | 9.3 | 50.7 | | 45.3 | 41.4 |
| 29 | 36.4 | 60.4 | 35.3 | 60.4 | 29.6 | 58.0 | 18.8 | 54.4 | 7.1 | 50.7 | | 45.3 | 41.4 |
| 30 | 35.6 | 60.4 | 34.5 | 60.4 | 28.7 | 58.0 | 17.5 | 54.4 | 5.5 | 50.7 | | 45.3 | 41.4 |
| 31 | 35.1 | 60.4 | 34.0 | 60.4 | 28.1 | 58.0 | 16.4 | 54.4 | 3.6 | 50.7 | | 45.3 | 41.4 |
| 32 | 34.7 | 60.4 | 33.6 | 60.4 | 27.6 | 58.0 | 15.6 | 54.4 | 0.0 | 50.7 | | 45.3 | 41.4 |
| 33 | 34.4 | 60.4 | 33.3 | 60.4 | 27.3 | 58.0 | 14.9 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 34 | 34.2 | 60.4 | 33.1 | 60.4 | 27.1 | 58.0 | 14.4 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 35 | 34.1 | 60.4 | 33.0 | 60.4 | 27.0 | 58.0 | 14.1 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 36 | 34.1 | 60.4 | 33.0 | 60.4 | 27.0 | 58.0 | 14.0 | 54.4 | | 50.7 | | 45.3 | 41.4 |

Table A28. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 57.0 | 77.1 | 56.0 | 77.1 | 51.5 | 74.0 | 43.9 | 69.4 | 35.8 | 64.8 | 28.4 | 57.8 | 50.2 |
| 1 | 57.7 | 77.1 | 56.6 | 77.1 | 52.1 | 74.0 | 45.0 | 69.4 | 37.0 | 64.8 | 28.2 | 57.8 | 50.2 |
| 2 | 55.4 | 77.1 | 54.3 | 77.1 | 49.8 | 74.0 | 42.4 | 69.4 | 34.2 | 64.8 | 26.0 | 57.8 | 50.2 |
| 3 | 54.3 | 77.1 | 53.2 | 77.1 | 48.6 | 74.0 | 41.2 | 69.4 | 32.9 | 64.8 | 24.5 | 57.8 | 50.2 |
| 4 | 54.1 | 77.1 | 52.9 | 77.1 | 48.2 | 74.0 | 40.8 | 69.4 | 32.4 | 64.8 | 24.0 | 57.8 | 50.2 |
| 5 | 54.2 | 77.1 | 53.0 | 77.1 | 48.3 | 74.0 | 40.7 | 69.4 | 32.3 | 64.8 | 23.8 | 57.8 | 50.2 |
| 6 | 55.0 | 77.1 | 53.8 | 77.1 | 49.0 | 74.0 | 41.3 | 69.4 | 32.8 | 64.8 | 24.4 | 57.8 | 50.2 |
| 7 | 57.7 | 77.1 | 56.5 | 77.1 | 51.6 | 74.0 | 44.0 | 69.4 | 35.4 | 64.8 | 26.5 | 57.8 | 50.2 |
| 8 | 55.1 | 77.1 | 53.9 | 77.1 | 48.9 | 74.0 | 41.0 | 69.4 | 32.3 | 64.8 | 23.8 | 57.8 | 50.2 |
| 9 | 54.4 | 77.1 | 53.1 | 77.1 | 48.1 | 74.0 | 40.1 | 69.4 | 31.3 | 64.8 | 22.7 | 57.8 | 50.2 |
| 10 | 54.8 | 77.1 | 53.5 | 77.1 | 48.4 | 74.0 | 40.3 | 69.4 | 31.3 | 64.8 | 22.8 | 57.8 | 50.2 |
| 11 | 57.1 | 77.1 | 55.8 | 77.1 | 50.7 | 74.0 | 42.6 | 69.4 | 33.6 | 64.8 | 24.5 | 57.8 | 50.2 |
| 12 | 54.2 | 77.1 | 52.8 | 77.1 | 47.6 | 74.0 | 39.2 | 69.4 | 30.0 | 64.8 | 21.4 | 57.8 | 50.2 |
| 13 | 53.0 | 77.1 | 51.7 | 77.1 | 46.4 | 74.0 | 37.9 | 69.4 | 28.6 | 64.8 | 19.8 | 57.8 | 50.2 |
| 14 | 52.6 | 77.1 | 51.2 | 77.1 | 45.9 | 74.0 | 37.3 | 69.4 | 27.8 | 64.8 | 18.9 | 57.8 | 50.2 |
| 15 | 52.6 | 77.1 | 51.3 | 77.1 | 45.8 | 74.0 | 37.0 | 69.4 | 27.4 | 64.8 | 18.5 | 57.8 | 50.2 |
| 16 | 53.4 | 77.1 | 52.0 | 77.1 | 46.5 | 74.0 | 37.5 | 69.4 | 27.7 | 64.8 | 18.8 | 57.8 | 50.2 |
| 17 | 56.0 | 77.1 | 54.6 | 77.1 | 49.0 | 74.0 | 40.0 | 69.4 | 30.1 | 64.8 | 20.5 | 57.8 | 50.2 |
| 18 | 53.2 | 77.1 | 51.8 | 77.1 | 46.2 | 74.0 | 36.9 | 69.4 | 26.7 | 64.8 | 17.5 | 57.8 | 50.2 |
| 19 | 52.4 | 77.1 | 51.0 | 77.1 | 45.3 | 74.0 | 35.9 | 69.4 | 25.4 | 64.8 | 16.1 | 57.8 | 50.2 |
| 20 | 52.7 | 77.1 | 51.3 | 77.1 | 45.5 | 74.0 | 35.9 | 69.4 | 25.1 | 64.8 | 15.8 | 57.8 | 50.2 |
| 21 | 54.9 | 77.1 | 53.5 | 77.1 | 47.6 | 74.0 | 38.0 | 69.4 | 27.1 | 64.8 | 17.0 | 57.8 | 50.2 |
| 22 | 51.8 | 77.1 | 50.4 | 77.1 | 44.5 | 74.0 | 34.4 | 69.4 | 23.1 | 64.8 | 13.4 | 57.8 | 50.2 |
| 23 | 50.6 | 77.1 | 49.1 | 77.1 | 43.1 | 74.0 | 32.9 | 69.4 | 21.2 | 64.8 | 11.2 | 57.8 | 50.2 |
| 24 | 50.0 | 77.1 | 48.5 | 77.1 | 42.5 | 74.0 | 32.0 | 69.4 | 19.9 | 64.8 | 9.7 | 57.8 | 50.2 |
| 25 | 49.8 | 77.1 | 48.4 | 77.1 | 42.2 | 74.0 | 31.6 | 69.4 | 19.0 | 64.8 | 8.3 | 57.8 | 50.2 |
| 26 | 50.3 | 77.1 | 48.9 | 77.1 | 42.7 | 74.0 | 31.7 | 69.4 | 18.6 | 64.8 | 7.3 | 57.8 | 50.2 |
| 27 | 52.6 | 77.1 | 51.1 | 77.1 | 44.9 | 74.0 | 33.9 | 69.4 | 20.3 | 64.8 | 5.9 | 57.8 | 50.2 |
| 28 | 49.5 | 77.1 | 48.0 | 77.1 | 41.8 | 74.0 | 30.3 | 69.4 | 15.9 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 48.1 | 77.1 | 46.6 | 77.1 | 40.4 | 74.0 | 28.7 | 69.4 | 13.4 | 64.8 | | 57.8 | 50.2 |
| 30 | 47.3 | 77.1 | 45.8 | 77.1 | 39.5 | 74.0 | 27.6 | 69.4 | 11.3 | 64.8 | | 57.8 | 50.2 |
| 31 | 46.7 | 77.1 | 45.3 | 77.1 | 38.9 | 74.0 | 26.9 | 69.4 | 9.3 | 64.8 | | 57.8 | 50.2 |
| 32 | 46.3 | 77.1 | 44.9 | 77.1 | 38.5 | 74.0 | 26.3 | 69.4 | 7.1 | 64.8 | | 57.8 | 50.2 |
| 33 | 46.0 | 77.1 | 44.6 | 77.1 | 38.2 | 74.0 | 25.9 | 69.4 | 4.7 | 64.8 | | 57.8 | 50.2 |
| 34 | 45.9 | 77.1 | 44.4 | 77.1 | 38.1 | 74.0 | 25.6 | 69.4 | 1.0 | 64.8 | | 57.8 | 50.2 |
| 35 | 45.8 | 77.1 | 44.4 | 77.1 | 38.0 | 74.0 | 25.5 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 36 | 45.8 | 77.1 | 44.4 | 77.1 | 38.0 | 74.0 | 25.5 | 69.4 | | 64.8 | | 57.8 | 50.2 |

Table A29. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 48 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 11.5 | 21.5 | 11.5 | 21.5 | 11.1 | 20.6 | 1.3 | 19.4 | 1.0 | 18.1 | 1.1 | 16.1 | 21.6 |
| 1 | 12.8 | 21.5 | 12.7 | 21.5 | 12.1 | 20.6 | 2.7 | 19.4 | 6.3 | 18.1 | 3.4 | 16.1 | 21.6 |
| 2 | 11.5 | 21.5 | 11.4 | 21.5 | 10.8 | 20.6 | 4.7 | 19.4 | 4.1 | 18.1 | 6.3 | 16.1 | 21.6 |
| 3 | 11.2 | 21.5 | 11.0 | 21.5 | 10.3 | 20.6 | 7.7 | 19.4 | 4.6 | 18.1 | 4.7 | 16.1 | 21.6 |
| 4 | 11.6 | 21.5 | 11.5 | 21.5 | 10.7 | 20.6 | 6.1 | 19.4 | 5.9 | 18.1 | 4.8 | 16.1 | 21.6 |
| 5 | 12.4 | 21.5 | 12.2 | 21.5 | 11.3 | 20.6 | 6.0 | 19.4 | 9.4 | 18.1 | 5.9 | 16.1 | 21.6 |
| 6 | 13.8 | 21.5 | 13.7 | 21.5 | 12.7 | 20.6 | 6.5 | 19.4 | 7.0 | 18.1 | 8.5 | 16.1 | 21.6 |
| 7 | 17.0 | 21.5 | 16.8 | 21.5 | 15.7 | 20.6 | 7.4 | 19.4 | 6.6 | 18.1 | 6.4 | 16.1 | 21.6 |
| 8 | 14.9 | 21.5 | 14.8 | 21.5 | 13.6 | 20.6 | 9.0 | 19.4 | 6.9 | 18.1 | 5.6 | 16.1 | 21.6 |
| 9 | 14.7 | 21.5 | 14.5 | 21.5 | 13.2 | 20.6 | 12.2 | 19.4 | 7.5 | 18.1 | 5.6 | 16.1 | 21.6 |
| 10 | 15.5 | 21.5 | 15.4 | 21.5 | 13.9 | 20.6 | 10.4 | 19.4 | 8.7 | 18.1 | 6.0 | 16.1 | 21.6 |
| 11 | 18.3 | 21.5 | 18.0 | 21.5 | 16.4 | 20.6 | 10.2 | 19.4 | 12.1 | 18.1 | 7.0 | 16.1 | 21.6 |
| 12 | 15.7 | 21.5 | 15.5 | 21.5 | 13.7 | 20.6 | 11.2 | 19.4 | 9.5 | 18.1 | 9.5 | 16.1 | 21.6 |
| 13 | 15.0 | 21.5 | 14.7 | 21.5 | 12.8 | 20.6 | 13.7 | 19.4 | 9.2 | 18.1 | 7.2 | 16.1 | 21.6 |
| 14 | 14.9 | 21.5 | 14.7 | 21.5 | 12.5 | 20.6 | 11.5 | 19.4 | 9.8 | 18.1 | 6.4 | 16.1 | 21.6 |
| 15 | 15.3 | 21.5 | 15.0 | 21.5 | 12.7 | 20.6 | 10.7 | 19.4 | 12.6 | 18.1 | 6.7 | 16.1 | 21.6 |
| 16 | 16.4 | 21.5 | 16.1 | 21.5 | 13.5 | 20.6 | 10.6 | 19.4 | 9.5 | 18.1 | 8.6 | 16.1 | 21.6 |
| 17 | 19.3 | 21.5 | 18.9 | 21.5 | 16.1 | 20.6 | 11.0 | 19.4 | 8.5 | 18.1 | 5.6 | 16.1 | 21.6 |
| 18 | 16.8 | 21.5 | 16.5 | 21.5 | 13.5 | 20.6 | 12.0 | 19.4 | 8.1 | 18.1 | 4.1 | 16.1 | 21.6 |
| 19 | 16.3 | 21.5 | 16.0 | 21.5 | 12.7 | 20.6 | 14.6 | 19.4 | 8.1 | 18.1 | 3.3 | 16.1 | 21.6 |
| 20 | 16.9 | 21.5 | 16.5 | 21.5 | 13.1 | 20.6 | 12.4 | 19.4 | 8.8 | 18.1 | 0.0 | 16.1 | 21.6 |
| 21 | 19.4 | 21.5 | 18.9 | 21.5 | 15.1 | 20.6 | 11.7 | 19.4 | 11.6 | 18.1 | | 16.1 | 21.6 |
| 22 | 16.6 | 21.5 | 16.1 | 21.5 | 12.1 | 20.6 | 12.2 | 19.4 | 8.5 | 18.1 | | 16.1 | 21.6 |
| 23 | 15.6 | 21.5 | 15.1 | 21.5 | 10.7 | 20.6 | 14.3 | 19.4 | 7.6 | 18.1 | | 16.1 | 21.6 |
| 24 | 15.3 | 21.5 | 14.7 | 21.5 | 10.1 | 20.6 | 11.5 | 19.4 | 7.6 | 18.1 | | 16.1 | 21.6 |
| 25 | 15.4 | 21.5 | 14.8 | 21.5 | 9.9 | 20.6 | 10.2 | 19.4 | 9.9 | 18.1 | | 16.1 | 21.6 |
| 26 | 16.2 | 21.5 | 15.7 | 21.5 | 10.4 | 20.6 | 9.6 | 19.4 | 6.2 | 18.1 | | 16.1 | 21.6 |
| 27 | 18.9 | 21.5 | 18.2 | 21.5 | 12.5 | 20.6 | 9.4 | 19.4 | 4.7 | 18.1 | | 16.1 | 21.6 |
| 28 | 16.2 | 21.5 | 15.6 | 21.5 | 9.6 | 20.6 | 9.9 | 19.4 | 3.8 | 18.1 | | 16.1 | 21.6 |
| 29 | 15.5 | 21.5 | 14.8 | 21.5 | 8.5 | 20.6 | 11.9 | 19.4 | 0.0 | 18.1 | | 16.1 | 21.6 |
| 30 | 15.8 | 21.5 | 15.1 | 21.5 | 8.5 | 20.6 | 8.9 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 31 | 18.0 | 21.5 | 17.2 | 21.5 | 10.2 | 20.6 | 7.3 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 32 | 14.9 | 21.5 | 14.1 | 21.5 | 6.8 | 20.6 | 6.3 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 33 | 13.6 | 21.5 | 12.7 | 21.5 | 4.9 | 20.6 | 5.5 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 34 | 13.0 | 21.5 | 12.0 | 21.5 | 3.8 | 20.6 | 4.8 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 35 | 12.7 | 21.5 | 11.8 | 21.5 | 2.8 | 20.6 | 4.2 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 36 | 13.2 | 21.5 | 12.2 | 21.5 | 2.0 | 20.6 | 3.7 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 37 | 15.4 | 21.5 | 14.3 | 21.5 | 1.4 | 20.6 | 3.2 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 38 | 12.1 | 21.5 | 11.0 | 21.5 | 0.0 | 20.6 | 2.7 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 39 | 10.6 | 21.5 | 9.4 | 21.5 | | 20.6 | 2.3 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 40 | 9.7 | 21.5 | 8.4 | 21.5 | | 20.6 | 2.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 41 | 9.0 | 21.5 | 7.7 | 21.5 | | 20.6 | 0.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 42 | 8.4 | 21.5 | 7.0 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 43 | 7.9 | 21.5 | 6.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 44 | 7.6 | 21.5 | 6.1 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 45 | 7.3 | 21.5 | 5.7 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 46 | 7.0 | 21.5 | 5.4 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 47 | 6.9 | 21.5 | 5.2 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 48 | 6.8 | 21.5 | 5.1 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |

Table A30. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 48 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 27.3 | 40.0 | 27.2 | 40.0 | 25.2 | 38.4 | 22.0 | 36.0 | 16.9 | 33.6 | 13.9 | 30.0 | 32.4 |
| 1 | 28.2 | 40.0 | 28.1 | 40.0 | 26.1 | 38.4 | 22.3 | 36.0 | 18.4 | 33.6 | 14.1 | 30.0 | 32.4 |
| 2 | 26.6 | 40.0 | 26.5 | 40.0 | 24.3 | 38.4 | 20.7 | 36.0 | 16.1 | 33.6 | 12.3 | 30.0 | 32.4 |
| 3 | 26.0 | 40.0 | 25.9 | 40.0 | 23.6 | 38.4 | 19.8 | 36.0 | 15.2 | 33.6 | 11.2 | 30.0 | 32.4 |
| 4 | 26.2 | 40.0 | 26.1 | 40.0 | 23.7 | 38.4 | 19.7 | 36.0 | 15.0 | 33.6 | 10.9 | 30.0 | 32.4 |
| 5 | 26.8 | 40.0 | 26.6 | 40.0 | 24.2 | 38.4 | 20.0 | 36.0 | 15.2 | 33.6 | 11.0 | 30.0 | 32.4 |
| 6 | 28.0 | 40.0 | 27.9 | 40.0 | 25.3 | 38.4 | 21.0 | 36.0 | 16.0 | 33.6 | 11.8 | 30.0 | 32.4 |
| 7 | 31.1 | 40.0 | 30.9 | 40.0 | 28.3 | 38.4 | 23.6 | 36.0 | 18.9 | 33.6 | 14.1 | 30.0 | 32.4 |
| 8 | 28.9 | 40.0 | 28.7 | 40.0 | 25.9 | 38.4 | 21.3 | 36.0 | 15.9 | 33.6 | 11.6 | 30.0 | 32.4 |
| 9 | 28.5 | 40.0 | 28.3 | 40.0 | 25.4 | 38.4 | 20.6 | 36.0 | 15.1 | 33.6 | 10.6 | 30.0 | 32.4 |
| 10 | 29.3 | 40.0 | 29.0 | 40.0 | 26.0 | 38.4 | 21.1 | 36.0 | 15.3 | 33.6 | 10.7 | 30.0 | 32.4 |
| 11 | 31.9 | 40.0 | 31.6 | 40.0 | 28.6 | 38.4 | 23.2 | 36.0 | 17.7 | 33.6 | 12.4 | 30.0 | 32.4 |
| 12 | 29.2 | 40.0 | 28.9 | 40.0 | 25.8 | 38.4 | 20.4 | 36.0 | 14.3 | 33.6 | 9.3 | 30.0 | 32.4 |
| 13 | 28.4 | 40.0 | 28.1 | 40.0 | 24.8 | 38.4 | 19.2 | 36.0 | 12.9 | 33.6 | 7.7 | 30.0 | 32.4 |
| 14 | 28.3 | 40.0 | 27.9 | 40.0 | 24.5 | 38.4 | 18.7 | 36.0 | 12.2 | 33.6 | 6.7 | 30.0 | 32.4 |
| 15 | 28.6 | 40.0 | 28.2 | 40.0 | 24.7 | 38.4 | 18.6 | 36.0 | 11.9 | 33.6 | 6.1 | 30.0 | 32.4 |
| 16 | 29.6 | 40.0 | 29.2 | 40.0 | 25.5 | 38.4 | 19.3 | 36.0 | 12.1 | 33.6 | 6.1 | 30.0 | 32.4 |
| 17 | 32.4 | 40.0 | 32.0 | 40.0 | 28.2 | 38.4 | 21.5 | 36.0 | 14.6 | 33.6 | 7.6 | 30.0 | 32.4 |
| 18 | 29.9 | 40.0 | 29.5 | 40.0 | 25.6 | 38.4 | 18.8 | 36.0 | 11.1 | 33.6 | 4.6 | 30.0 | 32.4 |
| 19 | 29.4 | 40.0 | 28.9 | 40.0 | 24.8 | 38.4 | 17.8 | 36.0 | 9.8 | 33.6 | 2.1 | 30.0 | 32.4 |
| 20 | 29.9 | 40.0 | 29.4 | 40.0 | 25.2 | 38.4 | 17.9 | 36.0 | 9.5 | 33.6 | 0.0 | 30.0 | 32.4 |
| 21 | 32.3 | 40.0 | 31.8 | 40.0 | 27.4 | 38.4 | 19.6 | 36.0 | 11.4 | 33.6 | | 30.0 | 32.4 |
| 22 | 29.4 | 40.0 | 28.9 | 40.0 | 24.4 | 38.4 | 16.5 | 36.0 | 7.3 | 33.6 | | 30.0 | 32.4 |
| 23 | 28.3 | 40.0 | 27.8 | 40.0 | 23.1 | 38.4 | 14.9 | 36.0 | 5.3 | 33.6 | | 30.0 | 32.4 |
| 24 | 28.0 | 40.0 | 27.4 | 40.0 | 22.6 | 38.4 | 14.0 | 36.0 | 4.0 | 33.6 | | 30.0 | 32.4 |
| 25 | 28.0 | 40.0 | 27.4 | 40.0 | 22.5 | 38.4 | 13.6 | 36.0 | 2.5 | 33.6 | | 30.0 | 32.4 |
| 26 | 28.8 | 40.0 | 28.2 | 40.0 | 23.1 | 38.4 | 13.9 | 36.0 | 0.0 | 33.6 | | 30.0 | 32.4 |
| 27 | 31.4 | 40.0 | 30.7 | 40.0 | 25.5 | 38.4 | 15.7 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 28 | 28.7 | 40.0 | 28.0 | 40.0 | 22.6 | 38.4 | 12.6 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 29 | 27.9 | 40.0 | 27.1 | 40.0 | 21.5 | 38.4 | 11.1 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 30 | 28.1 | 40.0 | 27.3 | 40.0 | 21.6 | 38.4 | 10.9 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 31 | 30.3 | 40.0 | 29.5 | 40.0 | 23.5 | 38.4 | 12.1 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 32 | 27.1 | 40.0 | 26.3 | 40.0 | 20.1 | 38.4 | 8.5 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 33 | 25.8 | 40.0 | 24.9 | 40.0 | 18.6 | 38.4 | 6.6 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 34 | 25.1 | 40.0 | 24.2 | 40.0 | 17.7 | 38.4 | 4.9 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 35 | 24.8 | 40.0 | 23.9 | 40.0 | 17.1 | 38.4 | 3.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 36 | 25.2 | 40.0 | 24.2 | 40.0 | 17.3 | 38.4 | 0.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 37 | 27.4 | 40.0 | 26.4 | 40.0 | 19.1 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 38 | 24.1 | 40.0 | 23.1 | 40.0 | 15.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 39 | 22.6 | 40.0 | 21.5 | 40.0 | 13.7 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 40 | 21.7 | 40.0 | 20.5 | 40.0 | 12.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 41 | 20.9 | 40.0 | 19.7 | 40.0 | 11.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 42 | 20.4 | 40.0 | 19.1 | 40.0 | 10.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 43 | 19.9 | 40.0 | 18.7 | 40.0 | 9.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 44 | 19.5 | 40.0 | 18.3 | 40.0 | 8.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 45 | 19.2 | 40.0 | 18.0 | 40.0 | 7.7 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 46 | 19.0 | 40.0 | 17.7 | 40.0 | 7.0 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 47 | 18.9 | 40.0 | 17.5 | 40.0 | 6.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 48 | 18.8 | 40.0 | 17.4 | 40.0 | 6.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |

Table A31. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 48 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 45.1 | 59.8 | 44.2 | 59.8 | 40.7 | 57.3 | 35.2 | 53.8 | 27.0 | 50.2 | 21.3 | 44.8 | 41.4 |
| 1 | 45.8 | 59.8 | 45.2 | 59.8 | 41.4 | 57.3 | 35.2 | 53.8 | 28.4 | 50.2 | 21.2 | 44.8 | 41.4 |
| 2 | 43.8 | 59.8 | 43.1 | 59.8 | 39.3 | 57.3 | 33.3 | 53.8 | 25.7 | 50.2 | 19.2 | 44.8 | 41.4 |
| 3 | 42.9 | 59.8 | 42.2 | 59.8 | 38.2 | 57.3 | 32.1 | 53.8 | 24.6 | 50.2 | 17.9 | 44.8 | 41.4 |
| 4 | 42.9 | 59.8 | 42.1 | 59.8 | 38.1 | 57.3 | 31.8 | 53.8 | 24.3 | 50.2 | 17.4 | 44.8 | 41.4 |
| 5 | 43.2 | 59.8 | 42.4 | 59.8 | 38.3 | 57.3 | 31.9 | 53.8 | 24.3 | 50.2 | 17.4 | 44.8 | 41.4 |
| 6 | 44.2 | 59.8 | 43.4 | 59.8 | 39.2 | 57.3 | 32.7 | 53.8 | 24.9 | 50.2 | 18.0 | 44.8 | 41.4 |
| 7 | 47.1 | 59.8 | 46.4 | 59.8 | 41.9 | 57.3 | 35.1 | 53.8 | 27.7 | 50.2 | 20.2 | 44.8 | 41.4 |
| 8 | 44.6 | 59.8 | 43.8 | 59.8 | 39.4 | 57.3 | 32.7 | 53.8 | 24.6 | 50.2 | 17.6 | 44.8 | 41.4 |
| 9 | 44.1 | 59.8 | 43.2 | 59.8 | 38.7 | 57.3 | 31.8 | 53.8 | 23.7 | 50.2 | 16.5 | 44.8 | 41.4 |
| 10 | 44.7 | 59.8 | 43.7 | 59.8 | 39.1 | 57.3 | 32.2 | 53.8 | 23.9 | 50.2 | 16.6 | 44.8 | 41.4 |
| 11 | 47.1 | 59.8 | 46.3 | 59.8 | 41.5 | 57.3 | 34.2 | 53.8 | 26.2 | 50.2 | 18.2 | 44.8 | 41.4 |
| 12 | 44.3 | 59.8 | 43.3 | 59.8 | 38.5 | 57.3 | 31.3 | 53.8 | 22.7 | 50.2 | 15.1 | 44.8 | 41.4 |
| 13 | 43.3 | 59.8 | 42.3 | 59.8 | 37.4 | 57.3 | 30.0 | 53.8 | 21.3 | 50.2 | 13.4 | 44.8 | 41.4 |
| 14 | 43.0 | 59.8 | 42.0 | 59.8 | 37.0 | 57.3 | 29.5 | 53.8 | 20.6 | 50.2 | 12.5 | 44.8 | 41.4 |
| 15 | 43.2 | 59.8 | 42.2 | 59.8 | 37.0 | 57.3 | 29.4 | 53.8 | 20.3 | 50.2 | 11.9 | 44.8 | 41.4 |
| 16 | 44.1 | 59.8 | 43.0 | 59.8 | 37.8 | 57.3 | 30.0 | 53.8 | 20.6 | 50.2 | 12.1 | 44.8 | 41.4 |
| 17 | 46.8 | 59.8 | 45.8 | 59.8 | 40.4 | 57.3 | 32.2 | 53.8 | 23.1 | 50.2 | 13.6 | 44.8 | 41.4 |
| 18 | 44.2 | 59.8 | 43.1 | 59.8 | 37.6 | 57.3 | 29.5 | 53.8 | 19.7 | 50.2 | 10.3 | 44.8 | 41.4 |
| 19 | 43.5 | 59.8 | 42.4 | 59.8 | 36.8 | 57.3 | 28.5 | 53.8 | 18.5 | 50.2 | 8.3 | 44.8 | 41.4 |
| 20 | 43.9 | 59.8 | 42.7 | 59.8 | 37.1 | 57.3 | 28.6 | 53.8 | 18.2 | 50.2 | 7.0 | 44.8 | 41.4 |
| 21 | 46.3 | 59.8 | 45.2 | 59.8 | 39.3 | 57.3 | 30.4 | 53.8 | 20.2 | 50.2 | 5.8 | 44.8 | 41.4 |
| 22 | 43.3 | 59.8 | 42.0 | 59.8 | 36.1 | 57.3 | 27.3 | 53.8 | 16.3 | 50.2 | 4.9 | 44.8 | 41.4 |
| 23 | 42.1 | 59.8 | 40.9 | 59.8 | 34.8 | 57.3 | 25.8 | 53.8 | 14.5 | 50.2 | 3.7 | 44.8 | 41.4 |
| 24 | 41.7 | 59.8 | 40.4 | 59.8 | 34.2 | 57.3 | 25.0 | 53.8 | 13.3 | 50.2 | 0.0 | 44.8 | 41.4 |
| 25 | 41.7 | 59.8 | 40.4 | 59.8 | 34.1 | 57.3 | 24.6 | 53.8 | 12.5 | 50.2 | | 44.8 | 41.4 |
| 26 | 42.4 | 59.8 | 41.0 | 59.8 | 34.6 | 57.3 | 24.9 | 53.8 | 12.2 | 50.2 | | 44.8 | 41.4 |
| 27 | 44.9 | 59.8 | 43.7 | 59.8 | 37.0 | 57.3 | 26.8 | 53.8 | 14.1 | 50.2 | | 44.8 | 41.4 |
| 28 | 42.2 | 59.8 | 40.7 | 59.8 | 34.0 | 57.3 | 23.9 | 53.8 | 10.0 | 50.2 | | 44.8 | 41.4 |
| 29 | 41.3 | 59.8 | 39.9 | 59.8 | 32.9 | 57.3 | 22.5 | 53.8 | 7.9 | 50.2 | | 44.8 | 41.4 |
| 30 | 41.5 | 59.8 | 40.0 | 59.8 | 33.0 | 57.3 | 22.3 | 53.8 | 6.6 | 50.2 | | 44.8 | 41.4 |
| 31 | 43.7 | 59.8 | 42.3 | 59.8 | 34.9 | 57.3 | 23.7 | 53.8 | 4.8 | 50.2 | | 44.8 | 41.4 |
| 32 | 40.5 | 59.8 | 38.9 | 59.8 | 31.5 | 57.3 | 20.3 | 53.8 | 0.0 | 50.2 | | 44.8 | 41.4 |
| 33 | 39.1 | 59.8 | 37.5 | 59.8 | 29.9 | 57.3 | 18.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 34 | 38.4 | 59.8 | 36.8 | 59.8 | 29.0 | 57.3 | 17.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 35 | 38.1 | 59.8 | 36.5 | 59.8 | 28.5 | 57.3 | 16.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 36 | 38.5 | 59.8 | 36.9 | 59.8 | 28.7 | 57.3 | 16.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 37 | 40.7 | 59.8 | 39.1 | 59.8 | 30.6 | 57.3 | 17.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 38 | 37.4 | 59.8 | 35.7 | 59.8 | 27.1 | 57.3 | 13.6 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 39 | 35.9 | 59.8 | 34.2 | 59.8 | 25.3 | 57.3 | 11.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 40 | 35.0 | 59.8 | 33.3 | 59.8 | 24.1 | 57.3 | 9.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 41 | 34.3 | 59.8 | 32.5 | 59.8 | 23.1 | 57.3 | 7.8 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 42 | 33.7 | 59.8 | 31.9 | 59.8 | 22.4 | 57.3 | 6.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 43 | 33.3 | 59.8 | 31.5 | 59.8 | 21.7 | 57.3 | 4.6 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 44 | 32.9 | 59.8 | 31.1 | 59.8 | 21.2 | 57.3 | 2.9 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 45 | 32.7 | 59.8 | 30.9 | 59.8 | 20.7 | 57.3 | 0.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 46 | 32.5 | 59.8 | 30.7 | 59.8 | 20.4 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 47 | 32.4 | 59.8 | 30.5 | 59.8 | 20.1 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 48 | 32.3 | 59.8 | 30.5 | 59.8 | 20.0 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |

Table A32. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 54 ft, One Railing with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 59.8 | 77.1 | 58.7 | 77.1 | 53.7 | 74.0 | 45.4 | 69.4 | 36.4 | 64.8 | 28.4 | 57.8 | 50.2 |
| 1 | 60.5 | 77.1 | 59.4 | 77.1 | 54.3 | 74.0 | 46.5 | 69.4 | 37.7 | 64.8 | 28.2 | 57.8 | 50.2 |
| 2 | 58.2 | 77.1 | 57.1 | 77.1 | 51.9 | 74.0 | 43.9 | 69.4 | 34.8 | 64.8 | 26.0 | 57.8 | 50.2 |
| 3 | 57.1 | 77.1 | 55.9 | 77.1 | 50.7 | 74.0 | 42.7 | 69.4 | 33.5 | 64.8 | 24.6 | 57.8 | 50.2 |
| 4 | 56.9 | 77.1 | 55.7 | 77.1 | 50.4 | 74.0 | 42.2 | 69.4 | 33.0 | 64.8 | 24.0 | 57.8 | 50.2 |
| 5 | 57.0 | 77.1 | 55.8 | 77.1 | 50.4 | 74.0 | 42.2 | 69.4 | 32.9 | 64.8 | 23.9 | 57.8 | 50.2 |
| 6 | 57.9 | 77.1 | 56.6 | 77.1 | 51.2 | 74.0 | 42.8 | 69.4 | 33.4 | 64.8 | 24.5 | 57.8 | 50.2 |
| 7 | 60.6 | 77.1 | 59.3 | 77.1 | 53.8 | 74.0 | 45.4 | 69.4 | 36.1 | 64.8 | 26.6 | 57.8 | 50.2 |
| 8 | 58.0 | 77.1 | 56.7 | 77.1 | 51.1 | 74.0 | 42.5 | 69.4 | 32.9 | 64.8 | 23.9 | 57.8 | 50.2 |
| 9 | 57.3 | 77.1 | 56.0 | 77.1 | 50.3 | 74.0 | 41.6 | 69.4 | 32.0 | 64.8 | 22.8 | 57.8 | 50.2 |
| 10 | 57.7 | 77.1 | 56.4 | 77.1 | 50.6 | 74.0 | 41.8 | 69.4 | 32.0 | 64.8 | 22.9 | 57.8 | 50.2 |
| 11 | 60.1 | 77.1 | 58.7 | 77.1 | 52.8 | 74.0 | 44.1 | 69.4 | 34.3 | 64.8 | 24.6 | 57.8 | 50.2 |
| 12 | 57.1 | 77.1 | 55.7 | 77.1 | 49.8 | 74.0 | 40.7 | 69.4 | 30.7 | 64.8 | 21.5 | 57.8 | 50.2 |
| 13 | 56.0 | 77.1 | 54.6 | 77.1 | 48.5 | 74.0 | 39.4 | 69.4 | 29.3 | 64.8 | 19.9 | 57.8 | 50.2 |
| 14 | 55.6 | 77.1 | 54.2 | 77.1 | 48.0 | 74.0 | 38.8 | 69.4 | 28.6 | 64.8 | 19.0 | 57.8 | 50.2 |
| 15 | 55.7 | 77.1 | 54.2 | 77.1 | 48.0 | 74.0 | 38.6 | 69.4 | 28.3 | 64.8 | 18.6 | 57.8 | 50.2 |
| 16 | 56.5 | 77.1 | 55.0 | 77.1 | 48.6 | 74.0 | 39.1 | 69.4 | 28.6 | 64.8 | 18.9 | 57.8 | 50.2 |
| 17 | 59.1 | 77.1 | 57.6 | 77.1 | 51.1 | 74.0 | 41.6 | 69.4 | 31.1 | 64.8 | 20.7 | 57.8 | 50.2 |
| 18 | 56.4 | 77.1 | 54.8 | 77.1 | 48.3 | 74.0 | 38.5 | 69.4 | 27.7 | 64.8 | 17.7 | 57.8 | 50.2 |
| 19 | 55.6 | 77.1 | 54.1 | 77.1 | 47.4 | 74.0 | 37.5 | 69.4 | 26.5 | 64.8 | 16.3 | 57.8 | 50.2 |
| 20 | 56.0 | 77.1 | 54.4 | 77.1 | 47.6 | 74.0 | 37.5 | 69.4 | 26.3 | 64.8 | 16.0 | 57.8 | 50.2 |
| 21 | 58.2 | 77.1 | 56.6 | 77.1 | 49.8 | 74.0 | 39.6 | 69.4 | 28.4 | 64.8 | 17.2 | 57.8 | 50.2 |
| 22 | 55.2 | 77.1 | 53.5 | 77.1 | 46.6 | 74.0 | 36.1 | 69.4 | 24.5 | 64.8 | 13.6 | 57.8 | 50.2 |
| 23 | 54.0 | 77.1 | 52.3 | 77.1 | 45.2 | 74.0 | 34.6 | 69.4 | 22.8 | 64.8 | 11.5 | 57.8 | 50.2 |
| 24 | 53.5 | 77.1 | 51.8 | 77.1 | 44.6 | 74.0 | 33.8 | 69.4 | 21.7 | 64.8 | 9.9 | 57.8 | 50.2 |
| 25 | 53.4 | 77.1 | 51.7 | 77.1 | 44.4 | 74.0 | 33.3 | 69.4 | 21.1 | 64.8 | 8.6 | 57.8 | 50.2 |
| 26 | 54.1 | 77.1 | 52.3 | 77.1 | 44.9 | 74.0 | 33.6 | 69.4 | 21.1 | 64.8 | 7.6 | 57.8 | 50.2 |
| 27 | 56.6 | 77.1 | 54.8 | 77.1 | 47.2 | 74.0 | 35.9 | 69.4 | 23.2 | 64.8 | 6.2 | 57.8 | 50.2 |
| 28 | 53.8 | 77.1 | 52.0 | 77.1 | 44.3 | 74.0 | 32.5 | 69.4 | 19.4 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 52.8 | 77.1 | 51.0 | 77.1 | 43.2 | 74.0 | 31.2 | 69.4 | 17.8 | 64.8 | | 57.8 | 50.2 |
| 30 | 53.0 | 77.1 | 51.2 | 77.1 | 43.2 | 74.0 | 30.9 | 69.4 | 17.2 | 64.8 | | 57.8 | 50.2 |
| 31 | 55.1 | 77.1 | 53.3 | 77.1 | 45.2 | 74.0 | 32.7 | 69.4 | 18.8 | 64.8 | | 57.8 | 50.2 |
| 32 | 51.9 | 77.1 | 50.1 | 77.1 | 41.8 | 74.0 | 28.8 | 69.4 | 14.4 | 64.8 | | 57.8 | 50.2 |
| 33 | 50.5 | 77.1 | 48.6 | 77.1 | 40.2 | 74.0 | 27.0 | 69.4 | 12.2 | 64.8 | | 57.8 | 50.2 |
| 34 | 49.8 | 77.1 | 47.9 | 77.1 | 39.4 | 74.0 | 25.7 | 69.4 | 10.4 | 64.8 | | 57.8 | 50.2 |
| 35 | 49.6 | 77.1 | 47.6 | 77.1 | 38.9 | 74.0 | 24.8 | 69.4 | 9.0 | 64.8 | | 57.8 | 50.2 |
| 36 | 50.0 | 77.1 | 48.0 | 77.1 | 39.1 | 74.0 | 24.5 | 69.4 | 7.2 | 64.8 | | 57.8 | 50.2 |
| 37 | 52.1 | 77.1 | 50.2 | 77.1 | 41.1 | 74.0 | 26.2 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 38 | 48.9 | 77.1 | 46.9 | 77.1 | 37.7 | 74.0 | 22.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 39 | 47.3 | 77.1 | 45.4 | 77.1 | 36.0 | 74.0 | 19.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 40 | 46.4 | 77.1 | 44.4 | 77.1 | 34.9 | 74.0 | 18.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 41 | 45.7 | 77.1 | 43.7 | 77.1 | 34.0 | 74.0 | 16.3 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 42 | 45.2 | 77.1 | 43.1 | 77.1 | 33.4 | 74.0 | 14.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 43 | 44.7 | 77.1 | 42.7 | 77.1 | 32.8 | 74.0 | 13.2 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 44 | 44.4 | 77.1 | 42.4 | 77.1 | 32.4 | 74.0 | 11.6 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 45 | 44.2 | 77.1 | 42.1 | 77.1 | 32.0 | 74.0 | 10.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 46 | 44.0 | 77.1 | 41.9 | 77.1 | 31.8 | 74.0 | 8.3 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 47 | 43.9 | 77.1 | 41.8 | 77.1 | 31.6 | 74.0 | 7.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 48 | 43.8 | 77.1 | 41.8 | 77.1 | 31.5 | 74.0 | 6.7 | 69.4 | | 64.8 | | 57.8 | 50.2 |

Table A33. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 14 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 16.3 | 28.1 | 16.1 | 28.1 | 15.8 | 27.0 | 14.8 | 25.3 | 13.3 | 23.6 | 12.0 | 21.1 | 21.6 |
| 1 | 17.6 | 28.1 | 17.4 | 28.1 | 16.9 | 27.0 | 15.8 | 25.3 | 14.9 | 23.6 | 12.9 | 21.1 | 21.6 |
| 2 | 13.9 | 28.1 | 13.7 | 28.1 | 13.3 | 27.0 | 12.3 | 25.3 | 11.0 | 23.6 | 9.5 | 21.1 | 21.6 |
| 3 | 12.2 | 28.1 | 12.1 | 28.1 | 11.6 | 27.0 | 10.6 | 25.3 | 9.4 | 23.6 | 7.9 | 21.1 | 21.6 |
| 4 | 11.4 | 28.1 | 11.2 | 28.1 | 10.8 | 27.0 | 9.8 | 25.3 | 8.6 | 23.6 | 7.1 | 21.1 | 21.6 |
| 5 | 10.9 | 28.1 | 10.8 | 28.1 | 10.4 | 27.0 | 9.4 | 25.3 | 8.3 | 23.6 | 6.8 | 21.1 | 21.6 |
| 6 | 11.2 | 28.1 | 11.1 | 28.1 | 10.7 | 27.0 | 9.8 | 25.3 | 8.6 | 23.6 | 7.3 | 21.1 | 21.6 |
| 7 | 13.3 | 28.1 | 13.0 | 28.1 | 12.6 | 27.0 | 11.6 | 25.3 | 11.0 | 23.6 | 9.2 | 21.1 | 21.6 |
| 8 | 9.9 | 28.1 | 9.7 | 28.1 | 9.4 | 27.0 | 8.6 | 25.3 | 7.5 | 23.6 | 6.3 | 21.1 | 21.6 |
| 9 | 8.2 | 28.1 | 8.1 | 28.1 | 7.8 | 27.0 | 6.9 | 25.3 | 6.0 | 23.6 | 4.9 | 21.1 | 21.6 |
| 10 | 7.1 | 28.1 | 7.0 | 28.1 | 6.7 | 27.0 | 5.8 | 25.3 | 5.0 | 23.6 | 4.0 | 21.1 | 21.6 |
| 11 | 6.2 | 28.1 | 6.1 | 28.1 | 5.8 | 27.0 | 5.0 | 25.3 | 4.2 | 23.6 | 3.4 | 21.1 | 21.6 |
| 12 | 5.5 | 28.1 | 5.3 | 28.1 | 5.1 | 27.0 | 4.3 | 25.3 | 3.4 | 23.6 | 3.1 | 21.1 | 21.6 |
| 13 | 4.7 | 28.1 | 4.5 | 28.1 | 4.3 | 27.0 | 3.4 | 25.3 | 2.8 | 23.6 | 3.6 | 21.1 | 21.6 |
| 14 | 4.5 | 28.1 | 4.4 | 28.1 | 4.2 | 27.0 | 3.4 | 25.3 | 2.3 | 23.6 | 2.0 | 21.1 | 21.6 |

Table A34. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 14 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 25.3 | 47.2 | 24.9 | 47.2 | 23.7 | 45.3 | 21.8 | 42.5 | 19.2 | 39.6 | 17.0 | 35.4 | 32.4 |
| 1 | 26.6 | 47.2 | 26.2 | 47.2 | 24.9 | 45.3 | 23.0 | 42.5 | 20.9 | 39.6 | 17.9 | 35.4 | 32.4 |
| 2 | 22.9 | 47.2 | 22.4 | 47.2 | 21.2 | 45.3 | 19.3 | 42.5 | 16.8 | 39.6 | 14.4 | 35.4 | 32.4 |
| 3 | 21.2 | 47.2 | 20.7 | 47.2 | 19.5 | 45.3 | 17.6 | 42.5 | 15.2 | 39.6 | 12.6 | 35.4 | 32.4 |
| 4 | 20.3 | 47.2 | 19.8 | 47.2 | 18.6 | 45.3 | 16.7 | 42.5 | 14.3 | 39.6 | 11.7 | 35.4 | 32.4 |
| 5 | 19.8 | 47.2 | 19.4 | 47.2 | 18.2 | 45.3 | 16.3 | 42.5 | 13.8 | 39.6 | 11.3 | 35.4 | 32.4 |
| 6 | 20.1 | 47.2 | 19.6 | 47.2 | 18.4 | 45.3 | 16.5 | 42.5 | 14.0 | 39.6 | 11.6 | 35.4 | 32.4 |
| 7 | 22.1 | 47.2 | 21.7 | 47.2 | 20.4 | 45.3 | 18.6 | 42.5 | 16.4 | 39.6 | 13.3 | 35.4 | 32.4 |
| 8 | 18.7 | 47.2 | 18.3 | 47.2 | 17.1 | 45.3 | 15.2 | 42.5 | 12.7 | 39.6 | 10.3 | 35.4 | 32.4 |
| 9 | 17.0 | 47.2 | 16.6 | 47.2 | 15.4 | 45.3 | 13.6 | 42.5 | 11.2 | 39.6 | 8.6 | 35.4 | 32.4 |
| 10 | 16.0 | 47.2 | 15.6 | 47.2 | 14.4 | 45.3 | 12.5 | 42.5 | 10.1 | 39.6 | 7.5 | 35.4 | 32.4 |
| 11 | 15.1 | 47.2 | 14.7 | 47.2 | 13.5 | 45.3 | 11.7 | 42.5 | 9.3 | 39.6 | 6.7 | 35.4 | 32.4 |
| 12 | 14.4 | 47.2 | 14.0 | 47.2 | 12.8 | 45.3 | 11.0 | 42.5 | 8.6 | 39.6 | 6.0 | 35.4 | 32.4 |
| 13 | 13.6 | 47.2 | 13.2 | 47.2 | 12.1 | 45.3 | 10.3 | 42.5 | 7.9 | 39.6 | 5.2 | 35.4 | 32.4 |
| 14 | 13.5 | 47.2 | 13.2 | 47.2 | 12.0 | 45.3 | 10.2 | 42.5 | 7.6 | 39.6 | 5.3 | 35.4 | 32.4 |

Table A35. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 14 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 36.1 | 62.9 | 35.4 | 62.9 | 33.4 | 60.4 | 30.2 | 56.6 | 26.5 | 52.8 | 22.2 | 47.2 | 41.4 |
| 1 | 37.4 | 62.9 | 36.8 | 62.9 | 34.7 | 60.4 | 31.5 | 56.6 | 27.7 | 52.8 | 23.0 | 47.2 | 41.4 |
| 2 | 33.7 | 62.9 | 32.9 | 62.9 | 30.9 | 60.4 | 27.8 | 56.6 | 24.0 | 52.8 | 19.6 | 47.2 | 41.4 |
| 3 | 32.0 | 62.9 | 31.3 | 62.9 | 29.2 | 60.4 | 26.1 | 56.6 | 22.3 | 52.8 | 17.8 | 47.2 | 41.4 |
| 4 | 31.1 | 62.9 | 30.4 | 62.9 | 28.4 | 60.4 | 25.2 | 56.6 | 21.4 | 52.8 | 16.9 | 47.2 | 41.4 |
| 5 | 30.7 | 62.9 | 30.0 | 62.9 | 27.9 | 60.4 | 24.8 | 56.6 | 20.9 | 52.8 | 16.4 | 47.2 | 41.4 |
| 6 | 31.0 | 62.9 | 30.2 | 62.9 | 28.2 | 60.4 | 25.0 | 56.6 | 21.2 | 52.8 | 16.7 | 47.2 | 41.4 |
| 7 | 33.0 | 62.9 | 32.4 | 62.9 | 30.3 | 60.4 | 27.1 | 56.6 | 23.3 | 52.8 | 18.5 | 47.2 | 41.4 |
| 8 | 29.7 | 62.9 | 28.9 | 62.9 | 26.9 | 60.4 | 23.8 | 56.6 | 19.9 | 52.8 | 15.4 | 47.2 | 41.4 |
| 9 | 28.1 | 62.9 | 27.4 | 62.9 | 25.3 | 60.4 | 22.2 | 56.6 | 18.3 | 52.8 | 13.8 | 47.2 | 41.4 |
| 10 | 27.1 | 62.9 | 26.3 | 62.9 | 24.3 | 60.4 | 21.2 | 56.6 | 17.3 | 52.8 | 12.8 | 47.2 | 41.4 |
| 11 | 26.2 | 62.9 | 25.5 | 62.9 | 23.5 | 60.4 | 20.4 | 56.6 | 16.6 | 52.8 | 12.0 | 47.2 | 41.4 |
| 12 | 25.6 | 62.9 | 24.9 | 62.9 | 22.9 | 60.4 | 19.8 | 56.6 | 16.0 | 52.8 | 11.4 | 47.2 | 41.4 |
| 13 | 24.9 | 62.9 | 24.3 | 62.9 | 22.3 | 60.4 | 19.1 | 56.6 | 15.3 | 52.8 | 10.7 | 47.2 | 41.4 |
| 14 | 23.3 | 62.9 | 24.2 | 62.9 | 22.2 | 60.4 | 19.1 | 56.6 | 15.3 | 52.8 | 10.8 | 47.2 | 41.4 |

Table A36. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 54 ft, Deck Width = 14 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 46.1 | 75.3 | 45.2 | 75.3 | 42.4 | 72.3 | 37.9 | 67.8 | 32.8 | 63.3 | 26.8 | 56.5 | 50.2 |
| 1 | 47.4 | 75.3 | 46.4 | 75.3 | 43.6 | 72.3 | 39.4 | 67.8 | 34.4 | 63.3 | 28.0 | 56.5 | 50.2 |
| 2 | 43.7 | 75.3 | 42.7 | 75.3 | 39.9 | 72.3 | 35.5 | 67.8 | 30.4 | 63.3 | 24.3 | 56.5 | 50.2 |
| 3 | 42.1 | 75.3 | 41.1 | 75.3 | 38.3 | 72.3 | 33.9 | 67.8 | 28.8 | 63.3 | 22.5 | 56.5 | 50.2 |
| 4 | 41.2 | 75.3 | 40.2 | 75.3 | 37.4 | 72.3 | 33.0 | 67.8 | 27.9 | 63.3 | 21.6 | 56.5 | 50.2 |
| 5 | 40.8 | 75.3 | 39.8 | 75.3 | 37.0 | 72.3 | 32.6 | 67.8 | 27.5 | 63.3 | 21.0 | 56.5 | 50.2 |
| 6 | 41.1 | 75.3 | 40.1 | 75.3 | 37.3 | 72.3 | 32.9 | 67.8 | 27.7 | 63.3 | 20.8 | 56.5 | 50.2 |
| 7 | 43.2 | 75.3 | 42.2 | 75.3 | 39.4 | 72.3 | 35.2 | 67.8 | 30.1 | 63.3 | 21.3 | 56.5 | 50.2 |
| 8 | 39.9 | 75.3 | 38.9 | 75.3 | 36.1 | 72.3 | 31.7 | 67.8 | 26.5 | 63.3 | 23.5 | 56.5 | 50.2 |
| 9 | 38.4 | 75.3 | 37.4 | 75.3 | 34.6 | 72.3 | 30.2 | 67.8 | 25.0 | 63.3 | 20.3 | 56.5 | 50.2 |
| 10 | 37.4 | 75.3 | 36.4 | 75.3 | 33.6 | 72.3 | 29.2 | 67.8 | 24.1 | 63.3 | 18.9 | 56.5 | 50.2 |
| 11 | 36.6 | 75.3 | 35.6 | 75.3 | 32.8 | 72.3 | 28.5 | 67.8 | 23.3 | 63.3 | 18.0 | 56.5 | 50.2 |
| 12 | 36.0 | 75.3 | 35.1 | 75.3 | 32.3 | 72.3 | 27.9 | 67.8 | 22.8 | 63.3 | 17.4 | 56.5 | 50.2 |
| 13 | 35.5 | 75.3 | 34.5 | 75.3 | 31.7 | 72.3 | 27.3 | 67.8 | 22.3 | 63.3 | 16.8 | 56.5 | 50.2 |
| 14 | 33.8 | 75.3 | 32.8 | 75.3 | 31.6 | 72.3 | 27.2 | 67.8 | 22.1 | 63.3 | 16.8 | 56.5 | 50.2 |

Table A37. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 24 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 20.9 | 24.1 | 20.6 | 24.1 | 19.9 | 23.2 | 18.1 | 21.7 | 15.5 | 20.2 | 13.1 | 18.1 | 21.6 |
| 1 | 22.3 | 24.1 | 21.9 | 24.1 | 21.0 | 23.2 | 19.1 | 21.7 | 17.1 | 20.2 | 14.0 | 18.1 | 21.6 |
| 2 | 18.6 | 24.1 | 18.3 | 24.1 | 17.5 | 23.2 | 15.7 | 21.7 | 13.2 | 20.2 | 10.6 | 18.1 | 21.6 |
| 3 | 17.1 | 24.1 | 16.8 | 24.1 | 16.0 | 23.2 | 14.1 | 21.7 | 11.7 | 20.2 | 8.9 | 18.1 | 21.6 |
| 4 | 16.4 | 24.1 | 16.1 | 24.1 | 15.3 | 23.2 | 13.4 | 21.7 | 10.9 | 20.2 | 8.1 | 18.1 | 21.6 |
| 5 | 16.2 | 24.1 | 15.9 | 24.1 | 15.1 | 23.2 | 13.2 | 21.7 | 10.7 | 20.2 | 7.9 | 18.1 | 21.6 |
| 6 | 16.8 | 24.1 | 16.5 | 24.1 | 15.7 | 23.2 | 13.8 | 21.7 | 11.1 | 20.2 | 8.4 | 18.1 | 21.6 |
| 7 | 19.2 | 24.1 | 18.9 | 24.1 | 18.0 | 23.2 | 16.0 | 21.7 | 13.8 | 20.2 | 10.4 | 18.1 | 21.6 |
| 8 | 16.4 | 24.1 | 16.1 | 24.1 | 15.3 | 23.2 | 13.4 | 21.7 | 10.6 | 20.2 | 7.8 | 18.1 | 21.6 |
| 9 | 15.4 | 24.1 | 15.1 | 24.1 | 14.4 | 23.2 | 12.5 | 21.7 | 9.7 | 20.2 | 6.7 | 18.1 | 21.6 |
| 10 | 15.6 | 24.1 | 15.3 | 24.1 | 14.6 | 23.2 | 12.7 | 21.7 | 9.7 | 20.2 | 6.7 | 18.1 | 21.6 |
| 11 | 17.7 | 24.1 | 17.3 | 24.1 | 16.5 | 23.2 | 14.5 | 21.7 | 11.9 | 20.2 | 8.3 | 18.1 | 21.6 |
| 12 | 14.4 | 24.1 | 14.1 | 24.1 | 13.4 | 23.2 | 11.5 | 21.7 | 8.3 | 20.2 | 5.1 | 18.1 | 21.6 |
| 13 | 12.9 | 24.1 | 12.7 | 24.1 | 12.0 | 23.2 | 10.1 | 21.7 | 6.8 | 20.2 | 3.6 | 18.1 | 21.6 |
| 14 | 12.2 | 24.1 | 11.9 | 24.1 | 11.2 | 23.2 | 9.3 | 21.7 | 5.8 | 20.2 | 2.2 | 18.1 | 21.6 |
| 15 | 11.8 | 24.1 | 11.5 | 24.1 | 10.9 | 23.2 | 9.0 | 21.7 | 5.2 | 20.2 | 0.0 | 18.1 | 21.6 |
| 16 | 12.1 | 24.1 | 11.8 | 24.1 | 11.2 | 23.2 | 9.4 | 21.7 | 5.1 | 20.2 | | 18.1 | 21.6 |
| 17 | 14.1 | 24.1 | 13.8 | 24.1 | 13.1 | 23.2 | 11.2 | 21.7 | 7.3 | 20.2 | | 18.1 | 21.6 |
| 18 | 10.7 | 24.1 | 10.4 | 24.1 | 9.8 | 23.2 | 8.1 | 21.7 | 3.2 | 20.2 | | 18.1 | 21.6 |
| 19 | 9.0 | 24.1 | 8.7 | 24.1 | 8.1 | 23.2 | 6.5 | 21.7 | 0.0 | 20.2 | | 18.1 | 21.6 |
| 20 | 7.8 | 24.1 | 7.6 | 24.1 | 6.9 | 23.2 | 5.4 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 21 | 6.9 | 24.1 | 6.6 | 24.1 | 5.9 | 23.2 | 4.5 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 22 | 6.1 | 24.1 | 5.8 | 24.1 | 5.1 | 23.2 | 4.0 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 23 | 5.3 | 24.1 | 4.9 | 24.1 | 4.1 | 23.2 | 2.9 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 24 | 5.1 | 24.1 | 4.8 | 24.1 | 3.9 | 23.2 | 1.4 | 21.7 | | 20.2 | | 18.1 | 21.6 |

Table A38. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 34.1 | 45.6 | 33.7 | 45.6 | 31.7 | 43.8 | 28.5 | 41.0 | 24.3 | 38.3 | 20.2 | 34.2 | 32.4 |
| 1 | 35.3 | 45.6 | 34.9 | 45.6 | 32.9 | 43.8 | 29.7 | 41.0 | 25.8 | 38.3 | 21.0 | 34.2 | 32.4 |
| 2 | 31.6 | 45.6 | 31.2 | 45.6 | 29.1 | 43.8 | 25.9 | 41.0 | 21.7 | 38.3 | 17.5 | 34.2 | 32.4 |
| 3 | 29.9 | 45.6 | 29.5 | 45.6 | 27.5 | 43.8 | 24.2 | 41.0 | 20.1 | 38.3 | 15.7 | 34.2 | 32.4 |
| 4 | 29.1 | 45.6 | 28.7 | 45.6 | 26.6 | 43.8 | 23.3 | 41.0 | 19.2 | 38.3 | 14.8 | 34.2 | 32.4 |
| 5 | 28.8 | 45.6 | 28.3 | 45.6 | 26.3 | 43.8 | 23.0 | 41.0 | 18.8 | 38.3 | 14.4 | 34.2 | 32.4 |
| 6 | 29.2 | 45.6 | 28.8 | 45.6 | 26.7 | 43.8 | 23.4 | 41.0 | 19.1 | 38.3 | 14.8 | 34.2 | 32.4 |
| 7 | 31.5 | 45.6 | 31.1 | 45.6 | 29.0 | 43.8 | 25.7 | 41.0 | 21.7 | 38.3 | 16.7 | 34.2 | 32.4 |
| 8 | 28.5 | 45.6 | 28.1 | 45.6 | 26.0 | 43.8 | 22.6 | 41.0 | 18.3 | 38.3 | 13.9 | 34.2 | 32.4 |
| 9 | 27.4 | 45.6 | 27.0 | 45.6 | 24.9 | 43.8 | 21.6 | 41.0 | 17.3 | 38.3 | 12.8 | 34.2 | 32.4 |
| 10 | 27.5 | 45.6 | 27.1 | 45.6 | 25.0 | 43.8 | 21.6 | 41.0 | 17.2 | 38.3 | 12.7 | 34.2 | 32.4 |
| 11 | 29.4 | 45.6 | 29.0 | 45.6 | 26.9 | 43.8 | 23.5 | 41.0 | 19.4 | 38.3 | 14.3 | 34.2 | 32.4 |
| 12 | 26.1 | 45.6 | 25.6 | 45.6 | 23.6 | 43.8 | 20.2 | 41.0 | 15.7 | 38.3 | 11.1 | 34.2 | 32.4 |
| 13 | 24.5 | 45.6 | 24.1 | 45.6 | 22.0 | 43.8 | 18.6 | 41.0 | 14.2 | 38.3 | 9.3 | 34.2 | 32.4 |
| 14 | 23.6 | 45.6 | 23.3 | 45.6 | 21.2 | 43.8 | 17.7 | 41.0 | 13.3 | 38.3 | 8.3 | 34.2 | 32.4 |
| 15 | 23.2 | 45.6 | 22.8 | 45.6 | 20.8 | 43.8 | 17.3 | 41.0 | 12.7 | 38.3 | 7.7 | 34.2 | 32.4 |
| 16 | 23.4 | 45.6 | 23.0 | 45.6 | 21.0 | 43.8 | 17.5 | 41.0 | 12.8 | 38.3 | 7.7 | 34.2 | 32.4 |
| 17 | 25.4 | 45.6 | 25.0 | 45.6 | 23.0 | 43.8 | 19.4 | 41.0 | 15.0 | 38.3 | 9.2 | 34.2 | 32.4 |
| 18 | 21.9 | 45.6 | 21.6 | 45.6 | 19.5 | 43.8 | 15.9 | 41.0 | 11.1 | 38.3 | 6.2 | 34.2 | 32.4 |
| 19 | 20.2 | 45.6 | 19.9 | 45.6 | 17.8 | 43.8 | 14.2 | 41.0 | 9.2 | 38.3 | 3.7 | 34.2 | 32.4 |
| 20 | 19.1 | 45.6 | 18.7 | 45.6 | 16.7 | 43.8 | 13.0 | 41.0 | 7.9 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 18.1 | 45.6 | 17.8 | 45.6 | 15.7 | 43.8 | 11.9 | 41.0 | 6.6 | 38.3 | | 34.2 | 32.4 |
| 22 | 17.4 | 45.6 | 17.1 | 45.6 | 15.0 | 43.8 | 11.1 | 41.0 | 5.5 | 38.3 | | 34.2 | 32.4 |
| 23 | 16.5 | 45.6 | 16.2 | 45.6 | 14.1 | 43.8 | 10.1 | 41.0 | 3.3 | 38.3 | | 34.2 | 32.4 |
| 24 | 16.5 | 45.6 | 16.2 | 45.6 | 14.1 | 43.8 | 10.1 | 41.0 | 2.4 | 38.3 | | 34.2 | 32.4 |

Table A39. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 47.7 | 65.3 | 46.8 | 65.3 | 43.8 | 62.7 | 38.8 | 58.8 | 32.9 | 54.9 | 26.5 | 49.0 | 41.4 |
| 1 | 48.9 | 65.3 | 48.1 | 65.3 | 44.9 | 62.7 | 39.9 | 58.8 | 34.0 | 54.9 | 27.3 | 49.0 | 41.4 |
| 2 | 45.1 | 65.3 | 44.2 | 65.3 | 41.1 | 62.7 | 36.1 | 58.8 | 30.2 | 54.9 | 23.7 | 49.0 | 41.4 |
| 3 | 43.4 | 65.3 | 42.6 | 65.3 | 39.4 | 62.7 | 34.3 | 58.8 | 28.4 | 54.9 | 21.9 | 49.0 | 41.4 |
| 4 | 42.6 | 65.3 | 41.7 | 65.3 | 38.5 | 62.7 | 33.4 | 58.8 | 27.4 | 54.9 | 20.9 | 49.0 | 41.4 |
| 5 | 42.2 | 65.3 | 41.3 | 65.3 | 38.2 | 62.7 | 33.0 | 58.8 | 26.9 | 54.9 | 20.4 | 49.0 | 41.4 |
| 6 | 42.6 | 65.3 | 41.7 | 65.3 | 38.6 | 62.7 | 33.3 | 58.8 | 27.2 | 54.9 | 20.8 | 49.0 | 41.4 |
| 7 | 44.9 | 65.3 | 44.1 | 65.3 | 40.8 | 62.7 | 35.6 | 58.8 | 29.4 | 54.9 | 22.6 | 49.0 | 41.4 |
| 8 | 41.9 | 65.3 | 41.0 | 65.3 | 37.8 | 62.7 | 32.5 | 58.8 | 26.3 | 54.9 | 19.8 | 49.0 | 41.4 |
| 9 | 40.8 | 65.3 | 39.9 | 65.3 | 36.7 | 62.7 | 31.4 | 58.8 | 25.1 | 54.9 | 18.5 | 49.0 | 41.4 |
| 10 | 40.9 | 65.3 | 40.0 | 65.3 | 36.7 | 62.7 | 31.4 | 58.8 | 25.0 | 54.9 | 18.4 | 49.0 | 41.4 |
| 11 | 42.8 | 65.3 | 42.0 | 65.3 | 38.7 | 62.7 | 33.3 | 58.8 | 26.8 | 54.9 | 19.9 | 49.0 | 41.4 |
| 12 | 39.5 | 65.3 | 38.6 | 65.3 | 35.3 | 62.7 | 29.9 | 58.8 | 23.4 | 54.9 | 16.6 | 49.0 | 41.4 |
| 13 | 37.9 | 65.3 | 37.1 | 65.3 | 33.8 | 62.7 | 28.3 | 58.8 | 21.7 | 54.9 | 14.8 | 49.0 | 41.4 |
| 14 | 37.1 | 65.3 | 36.3 | 65.3 | 33.0 | 62.7 | 27.5 | 58.8 | 20.7 | 54.9 | 13.7 | 49.0 | 41.4 |
| 15 | 36.7 | 65.3 | 35.8 | 65.3 | 32.6 | 62.7 | 27.0 | 58.8 | 20.2 | 54.9 | 13.0 | 49.0 | 41.4 |
| 16 | 37.0 | 65.3 | 36.1 | 65.3 | 32.8 | 62.7 | 27.3 | 58.8 | 20.2 | 54.9 | 13.0 | 49.0 | 41.4 |
| 17 | 39.0 | 65.3 | 38.3 | 65.3 | 34.9 | 62.7 | 29.3 | 58.8 | 22.1 | 54.9 | 14.4 | 49.0 | 41.4 |
| 18 | 35.6 | 65.3 | 34.8 | 65.3 | 31.5 | 62.7 | 25.9 | 58.8 | 18.5 | 54.9 | 10.9 | 49.0 | 41.4 |
| 19 | 34.0 | 65.3 | 33.2 | 65.3 | 29.9 | 62.7 | 24.2 | 58.8 | 16.7 | 54.9 | 8.7 | 49.0 | 41.4 |
| 20 | 32.9 | 65.3 | 32.1 | 65.3 | 28.8 | 62.7 | 23.1 | 58.8 | 15.5 | 54.9 | 7.0 | 49.0 | 41.4 |
| 21 | 32.1 | 65.3 | 31.3 | 65.3 | 28.0 | 62.7 | 22.3 | 58.8 | 14.4 | 54.9 | 5.5 | 49.0 | 41.4 |
| 22 | 31.4 | 65.3 | 30.6 | 65.3 | 27.4 | 62.7 | 21.6 | 58.8 | 13.6 | 54.9 | 4.1 | 49.0 | 41.4 |
| 23 | 30.7 | 65.3 | 30.0 | 65.3 | 26.7 | 62.7 | 20.9 | 58.8 | 12.7 | 54.9 | 2.6 | 49.0 | 41.4 |
| 24 | 29.0 | 65.3 | 29.9 | 65.3 | 26.7 | 62.7 | 20.9 | 58.8 | 12.7 | 54.9 | 0.0 | 49.0 | 41.4 |

Table A40. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 59.3 | 81.7 | 58.2 | 81.7 | 54.1 | 78.4 | 47.6 | 73.5 | 39.9 | 68.6 | 30.8 | 61.3 | 50.2 |
| 1 | 60.5 | 81.7 | 59.4 | 81.7 | 55.3 | 78.4 | 49.0 | 73.5 | 41.3 | 68.6 | 31.9 | 61.3 | 50.2 |
| 2 | 56.8 | 81.7 | 55.6 | 81.7 | 51.5 | 78.4 | 45.0 | 73.5 | 37.2 | 68.6 | 28.0 | 61.3 | 50.2 |
| 3 | 55.1 | 81.7 | 53.9 | 81.7 | 49.8 | 78.4 | 43.2 | 73.5 | 35.4 | 68.6 | 26.1 | 61.3 | 50.2 |
| 4 | 54.3 | 81.7 | 53.1 | 81.7 | 48.9 | 78.4 | 42.3 | 73.5 | 34.5 | 68.6 | 25.0 | 61.3 | 50.2 |
| 5 | 53.9 | 81.7 | 52.7 | 81.7 | 48.6 | 78.4 | 41.9 | 73.5 | 34.0 | 68.6 | 24.3 | 61.3 | 50.2 |
| 6 | 54.4 | 81.7 | 53.1 | 81.7 | 49.0 | 78.4 | 42.2 | 73.5 | 34.2 | 68.6 | 24.0 | 61.3 | 50.2 |
| 7 | 56.7 | 81.7 | 55.4 | 81.7 | 51.2 | 78.4 | 44.6 | 73.5 | 36.7 | 68.6 | 24.4 | 61.3 | 50.2 |
| 8 | 53.7 | 81.7 | 52.4 | 81.7 | 48.2 | 78.4 | 41.4 | 73.5 | 33.3 | 68.6 | 26.5 | 61.3 | 50.2 |
| 9 | 52.6 | 81.7 | 51.4 | 81.7 | 47.2 | 78.4 | 40.4 | 73.5 | 32.1 | 68.6 | 23.4 | 61.3 | 50.2 |
| 10 | 52.7 | 81.7 | 51.5 | 81.7 | 47.2 | 78.4 | 40.3 | 73.5 | 32.0 | 68.6 | 22.2 | 61.3 | 50.2 |
| 11 | 54.7 | 81.7 | 53.4 | 81.7 | 49.2 | 78.4 | 42.5 | 73.5 | 34.1 | 68.6 | 22.1 | 61.3 | 50.2 |
| 12 | 51.4 | 81.7 | 50.1 | 81.7 | 45.9 | 78.4 | 38.9 | 73.5 | 30.4 | 68.6 | 23.8 | 61.3 | 50.2 |
| 13 | 49.9 | 81.7 | 48.6 | 81.7 | 44.4 | 78.4 | 37.4 | 73.5 | 28.8 | 68.6 | 20.2 | 61.3 | 50.2 |
| 14 | 49.1 | 81.7 | 47.9 | 81.7 | 43.6 | 78.4 | 36.6 | 73.5 | 27.9 | 68.6 | 18.4 | 61.3 | 50.2 |
| 15 | 48.7 | 81.7 | 47.5 | 81.7 | 43.2 | 78.4 | 36.3 | 73.5 | 27.4 | 68.6 | 17.2 | 61.3 | 50.2 |
| 16 | 49.1 | 81.7 | 47.8 | 81.7 | 43.6 | 78.4 | 36.5 | 73.5 | 27.5 | 68.6 | 16.4 | 61.3 | 50.2 |
| 17 | 51.2 | 81.7 | 49.9 | 81.7 | 45.7 | 78.4 | 38.8 | 73.5 | 29.8 | 68.6 | 16.2 | 61.3 | 50.2 |
| 18 | 47.8 | 81.7 | 46.6 | 81.7 | 42.4 | 78.4 | 35.3 | 73.5 | 26.1 | 68.6 | 17.7 | 61.3 | 50.2 |
| 19 | 46.3 | 81.7 | 45.1 | 81.7 | 40.8 | 78.4 | 33.8 | 73.5 | 24.5 | 68.6 | 13.8 | 61.3 | 50.2 |
| 20 | 45.3 | 81.7 | 44.1 | 81.7 | 39.9 | 78.4 | 32.8 | 73.5 | 23.4 | 68.6 | 11.6 | 61.3 | 50.2 |
| 21 | 44.5 | 81.7 | 43.3 | 81.7 | 39.1 | 78.4 | 32.1 | 73.5 | 22.6 | 68.6 | 9.9 | 61.3 | 50.2 |
| 22 | 44.0 | 81.7 | 42.8 | 81.7 | 38.6 | 78.4 | 31.5 | 73.5 | 22.0 | 68.6 | 8.7 | 61.3 | 50.2 |
| 23 | 43.4 | 81.7 | 42.2 | 81.7 | 38.0 | 78.4 | 30.9 | 73.5 | 21.3 | 68.6 | 7.4 | 61.3 | 50.2 |
| 24 | 41.5 | 81.7 | 39.7 | 81.7 | 38.1 | 78.4 | 30.9 | 73.5 | 21.3 | 68.6 | 7.6 | 61.3 | 50.2 |

Table A41. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 36 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 22.5 | 22.6 | 22.2 | 22.6 | 21.2 | 21.7 | 18.8 | 20.3 | 15.8 | 19.0 | 13.1 | 17.0 | 21.6 |
| 1 | 23.9 | 22.6 | 23.5 | 22.6 | 22.4 | 21.7 | 19.8 | 20.3 | 17.4 | 19.0 | 14.0 | 17.0 | 21.6 |
| 2 | 20.4 | 22.6 | 20.0 | 22.6 | 19.0 | 21.7 | 16.4 | 20.3 | 13.4 | 19.0 | 10.6 | 17.0 | 21.6 |
| 3 | 18.9 | 22.6 | 18.6 | 22.6 | 17.5 | 21.7 | 14.8 | 20.3 | 11.9 | 19.0 | 8.9 | 17.0 | 21.6 |
| 4 | 18.3 | 22.6 | 17.9 | 22.6 | 16.8 | 21.7 | 14.1 | 20.3 | 11.1 | 19.0 | 8.1 | 17.0 | 21.6 |
| 5 | 18.2 | 22.6 | 17.9 | 22.6 | 16.7 | 21.7 | 13.9 | 20.3 | 10.9 | 19.0 | 7.9 | 17.0 | 21.6 |
| 6 | 18.9 | 22.6 | 18.6 | 22.6 | 17.4 | 21.7 | 14.6 | 20.3 | 11.3 | 19.0 | 8.4 | 17.0 | 21.6 |
| 7 | 21.4 | 22.6 | 21.1 | 22.6 | 19.8 | 21.7 | 16.8 | 20.3 | 13.9 | 19.0 | 10.4 | 17.0 | 21.6 |
| 8 | 18.7 | 22.6 | 18.4 | 22.6 | 17.2 | 21.7 | 14.2 | 20.3 | 10.7 | 19.0 | 7.7 | 17.0 | 21.6 |
| 9 | 18.0 | 22.6 | 17.6 | 22.6 | 16.3 | 21.7 | 13.2 | 20.3 | 9.7 | 19.0 | 6.6 | 17.0 | 21.6 |
| 10 | 18.3 | 22.6 | 18.0 | 22.6 | 16.7 | 21.7 | 13.4 | 20.3 | 9.7 | 19.0 | 6.6 | 17.0 | 21.6 |
| 11 | 20.6 | 22.6 | 20.2 | 22.6 | 18.7 | 21.7 | 15.3 | 20.3 | 11.9 | 19.0 | 8.2 | 17.0 | 21.6 |
| 12 | 17.6 | 22.6 | 17.3 | 22.6 | 15.8 | 21.7 | 12.3 | 20.3 | 8.2 | 19.0 | 5.0 | 17.0 | 21.6 |
| 13 | 16.4 | 22.6 | 16.1 | 22.6 | 14.6 | 21.7 | 10.9 | 20.3 | 6.6 | 19.0 | 3.4 | 17.0 | 21.6 |
| 14 | 15.9 | 22.6 | 15.6 | 22.6 | 14.0 | 21.7 | 10.1 | 20.3 | 5.5 | 19.0 | 2.0 | 17.0 | 21.6 |
| 15 | 15.9 | 22.6 | 15.6 | 22.6 | 13.9 | 21.7 | 9.9 | 20.3 | 4.8 | 19.0 | 0.0 | 17.0 | 21.6 |
| 16 | 16.6 | 22.6 | 16.3 | 22.6 | 14.6 | 21.7 | 10.3 | 20.3 | 4.6 | 19.0 | | 17.0 | 21.6 |
| 17 | 19.1 | 22.6 | 18.8 | 22.6 | 16.9 | 21.7 | 12.3 | 20.3 | 6.7 | 19.0 | | 17.0 | 21.6 |
| 18 | 16.3 | 22.6 | 16.0 | 22.6 | 14.2 | 21.7 | 9.4 | 20.3 | 2.4 | 19.0 | | 17.0 | 21.6 |
| 19 | 15.4 | 22.6 | 15.1 | 22.6 | 13.2 | 21.7 | 8.2 | 20.3 | 0.0 | 19.0 | | 17.0 | 21.6 |
| 20 | 15.6 | 22.6 | 15.3 | 22.6 | 13.4 | 21.7 | 8.1 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 21 | 17.7 | 22.6 | 17.4 | 22.6 | 15.3 | 21.7 | 9.6 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 22 | 14.5 | 22.6 | 14.2 | 22.6 | 12.1 | 21.7 | 6.2 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 23 | 13.0 | 22.6 | 12.8 | 22.6 | 10.6 | 21.7 | 4.5 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 24 | 12.3 | 22.6 | 12.0 | 22.6 | 9.9 | 21.7 | 3.1 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 25 | 11.9 | 22.6 | 11.6 | 22.6 | 9.5 | 21.7 | 0.0 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 26 | 12.2 | 22.6 | 11.9 | 22.6 | 9.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 27 | 14.2 | 22.6 | 13.9 | 22.6 | 11.7 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 28 | 10.8 | 22.6 | 10.6 | 22.6 | 8.5 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 29 | 9.1 | 22.6 | 8.9 | 22.6 | 6.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 30 | 8.0 | 22.6 | 7.7 | 22.6 | 5.7 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 31 | 7.1 | 22.6 | 6.8 | 22.6 | 4.8 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 32 | 6.3 | 22.6 | 6.0 | 22.6 | 4.1 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 33 | 5.6 | 22.6 | 5.2 | 22.6 | 3.5 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 34 | 5.0 | 22.6 | 4.6 | 22.6 | 3.0 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 35 | 4.3 | 22.6 | 3.9 | 22.6 | 2.6 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 36 | 4.2 | 22.6 | 3.7 | 22.6 | 0.5 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |

Table A42. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 36 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 38.2 | 42.3 | 37.9 | 42.3 | 35.4 | 40.6 | 31.3 | 38.1 | 25.5 | 35.5 | 20.5 | 31.7 | 32.4 |
| 1 | 39.5 | 42.3 | 39.2 | 42.3 | 36.6 | 40.6 | 32.2 | 38.1 | 27.0 | 35.5 | 21.3 | 31.7 | 32.4 |
| 2 | 35.8 | 42.3 | 35.5 | 42.3 | 32.9 | 40.6 | 28.6 | 38.1 | 22.9 | 35.5 | 17.8 | 31.7 | 32.4 |
| 3 | 34.1 | 42.3 | 33.8 | 42.3 | 31.2 | 40.6 | 26.9 | 38.1 | 21.2 | 35.5 | 16.0 | 31.7 | 32.4 |
| 4 | 33.4 | 42.3 | 33.1 | 42.3 | 30.4 | 40.6 | 26.0 | 38.1 | 20.3 | 35.5 | 15.0 | 31.7 | 32.4 |
| 5 | 33.1 | 42.3 | 32.8 | 42.3 | 30.1 | 40.6 | 25.7 | 38.1 | 19.9 | 35.5 | 14.6 | 31.7 | 32.4 |
| 6 | 33.6 | 42.3 | 33.3 | 42.3 | 30.6 | 40.6 | 26.1 | 38.1 | 20.2 | 35.5 | 15.0 | 31.7 | 32.4 |
| 7 | 36.0 | 42.3 | 35.7 | 42.3 | 33.0 | 40.6 | 28.2 | 38.1 | 22.7 | 35.5 | 16.9 | 31.7 | 32.4 |
| 8 | 33.2 | 42.3 | 32.8 | 42.3 | 30.0 | 40.6 | 25.4 | 38.1 | 19.4 | 35.5 | 14.1 | 31.7 | 32.4 |
| 9 | 32.2 | 42.3 | 31.8 | 42.3 | 29.1 | 40.6 | 24.4 | 38.1 | 18.3 | 35.5 | 12.9 | 31.7 | 32.4 |
| 10 | 32.4 | 42.3 | 32.0 | 42.3 | 29.2 | 40.6 | 24.5 | 38.1 | 18.3 | 35.5 | 12.8 | 31.7 | 32.4 |
| 11 | 34.5 | 42.3 | 34.1 | 42.3 | 31.3 | 40.6 | 26.3 | 38.1 | 20.5 | 35.5 | 14.3 | 31.7 | 32.4 |
| 12 | 31.3 | 42.3 | 30.9 | 42.3 | 28.1 | 40.6 | 23.2 | 38.1 | 16.8 | 35.5 | 11.0 | 31.7 | 32.4 |
| 13 | 29.9 | 42.3 | 29.5 | 42.3 | 26.7 | 40.6 | 21.8 | 38.1 | 15.3 | 35.5 | 9.3 | 31.7 | 32.4 |
| 14 | 29.2 | 42.3 | 28.9 | 42.3 | 26.0 | 40.6 | 21.0 | 38.1 | 14.4 | 35.5 | 8.2 | 31.7 | 32.4 |
| 15 | 29.0 | 42.3 | 28.6 | 42.3 | 25.8 | 40.6 | 20.8 | 38.1 | 13.9 | 35.5 | 7.5 | 31.7 | 32.4 |
| 16 | 29.6 | 42.3 | 29.2 | 42.3 | 26.3 | 40.6 | 21.2 | 38.1 | 14.1 | 35.5 | 7.4 | 31.7 | 32.4 |
| 17 | 31.9 | 42.3 | 31.5 | 42.3 | 28.6 | 40.6 | 23.3 | 38.1 | 16.5 | 35.5 | 8.9 | 31.7 | 32.4 |
| 18 | 28.9 | 42.3 | 28.5 | 42.3 | 25.6 | 40.6 | 20.4 | 38.1 | 12.9 | 35.5 | 5.8 | 31.7 | 32.4 |
| 19 | 27.9 | 42.3 | 27.5 | 42.3 | 24.6 | 40.6 | 19.3 | 38.1 | 11.6 | 35.5 | 3.2 | 31.7 | 32.4 |
| 20 | 27.9 | 42.3 | 27.5 | 42.3 | 24.6 | 40.6 | 19.2 | 38.1 | 11.2 | 35.5 | 0.0 | 31.7 | 32.4 |
| 21 | 29.8 | 42.3 | 29.4 | 42.3 | 26.5 | 40.6 | 20.9 | 38.1 | 13.1 | 35.5 | | 31.7 | 32.4 |
| 22 | 26.4 | 42.3 | 26.0 | 42.3 | 23.1 | 40.6 | 17.5 | 38.1 | 9.0 | 35.5 | | 31.7 | 32.4 |
| 23 | 24.8 | 42.3 | 24.4 | 42.3 | 21.5 | 40.6 | 15.8 | 38.1 | 7.0 | 35.5 | | 31.7 | 32.4 |
| 24 | 23.9 | 42.3 | 23.6 | 42.3 | 20.5 | 40.6 | 14.8 | 38.1 | 5.7 | 35.5 | | 31.7 | 32.4 |
| 25 | 23.4 | 42.3 | 23.1 | 42.3 | 20.0 | 40.6 | 14.2 | 38.1 | 4.1 | 35.5 | | 31.7 | 32.4 |
| 26 | 23.6 | 42.3 | 23.2 | 42.3 | 20.1 | 40.6 | 14.3 | 38.1 | 0.0 | 35.5 | | 31.7 | 32.4 |
| 27 | 25.5 | 42.3 | 25.1 | 42.3 | 22.0 | 40.6 | 15.9 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 28 | 22.0 | 42.3 | 21.6 | 42.3 | 18.4 | 40.6 | 12.4 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 29 | 20.3 | 42.3 | 19.8 | 42.3 | 16.6 | 40.6 | 10.5 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 30 | 19.0 | 42.3 | 18.6 | 42.3 | 15.3 | 40.6 | 9.1 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 31 | 18.0 | 42.3 | 17.6 | 42.3 | 14.2 | 40.6 | 7.9 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 32 | 17.2 | 42.3 | 16.8 | 42.3 | 13.2 | 40.6 | 6.8 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 33 | 16.5 | 42.3 | 16.0 | 42.3 | 12.3 | 40.6 | 6.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 34 | 15.8 | 42.3 | 15.3 | 42.3 | 11.5 | 40.6 | 4.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 35 | 15.1 | 42.3 | 14.6 | 42.3 | 10.6 | 40.6 | 7.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 36 | 15.1 | 42.3 | 14.5 | 42.3 | 10.4 | 40.6 | 0.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |

Table A43. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 53.1 | 60.4 | 52.2 | 60.4 | 48.5 | 58.0 | 42.3 | 54.4 | 34.7 | 50.7 | 27.5 | 45.3 | 41.4 |
| 1 | 54.3 | 60.4 | 53.5 | 60.4 | 49.6 | 58.0 | 43.4 | 54.4 | 36.1 | 50.7 | 28.2 | 45.3 | 41.4 |
| 2 | 50.5 | 60.4 | 49.6 | 60.4 | 45.8 | 58.0 | 39.5 | 54.4 | 31.9 | 50.7 | 24.6 | 45.3 | 41.4 |
| 3 | 48.8 | 60.4 | 47.9 | 60.4 | 44.0 | 58.0 | 37.7 | 54.4 | 30.2 | 50.7 | 22.8 | 45.3 | 41.4 |
| 4 | 48.0 | 60.4 | 47.1 | 60.4 | 43.1 | 58.0 | 36.8 | 54.4 | 29.2 | 50.7 | 21.8 | 45.3 | 41.4 |
| 5 | 47.6 | 60.4 | 46.7 | 60.4 | 42.7 | 58.0 | 36.4 | 54.4 | 28.7 | 50.7 | 21.3 | 45.3 | 41.4 |
| 6 | 48.1 | 60.4 | 47.1 | 60.4 | 43.1 | 58.0 | 36.7 | 54.4 | 29.0 | 50.7 | 21.6 | 45.3 | 41.4 |
| 7 | 50.4 | 60.4 | 49.6 | 60.4 | 45.4 | 58.0 | 38.9 | 54.4 | 31.4 | 50.7 | 23.5 | 45.3 | 41.4 |
| 8 | 47.4 | 60.4 | 46.5 | 60.4 | 42.4 | 58.0 | 35.9 | 54.4 | 28.0 | 50.7 | 20.6 | 45.3 | 41.4 |
| 9 | 46.4 | 60.4 | 45.4 | 60.4 | 41.3 | 58.0 | 34.7 | 54.4 | 26.9 | 50.7 | 19.4 | 45.3 | 41.4 |
| 10 | 46.5 | 60.4 | 45.5 | 60.4 | 41.3 | 58.0 | 34.7 | 54.4 | 26.8 | 50.7 | 19.3 | 45.3 | 41.4 |
| 11 | 48.5 | 60.4 | 47.6 | 60.4 | 43.3 | 58.0 | 36.7 | 54.4 | 28.9 | 50.7 | 20.8 | 45.3 | 41.4 |
| 12 | 45.2 | 60.4 | 44.2 | 60.4 | 40.0 | 58.0 | 33.3 | 54.4 | 25.2 | 50.7 | 17.6 | 45.3 | 41.4 |
| 13 | 43.8 | 60.4 | 42.8 | 60.4 | 38.5 | 58.0 | 31.8 | 54.4 | 23.7 | 50.7 | 15.8 | 45.3 | 41.4 |
| 14 | 43.1 | 60.4 | 42.1 | 60.4 | 37.8 | 58.0 | 31.0 | 54.4 | 22.8 | 50.7 | 14.8 | 45.3 | 41.4 |
| 15 | 42.8 | 60.4 | 41.8 | 60.4 | 37.5 | 58.0 | 30.6 | 54.4 | 22.4 | 50.7 | 14.2 | 45.3 | 41.4 |
| 16 | 43.3 | 60.4 | 42.3 | 60.4 | 37.9 | 58.0 | 31.0 | 54.4 | 22.6 | 50.7 | 14.4 | 45.3 | 41.4 |
| 17 | 45.6 | 60.4 | 44.7 | 60.4 | 40.2 | 58.0 | 33.2 | 54.4 | 25.0 | 50.7 | 16.0 | 45.3 | 41.4 |
| 18 | 42.6 | 60.4 | 41.6 | 60.4 | 37.2 | 58.0 | 30.1 | 54.4 | 21.4 | 50.7 | 12.9 | 45.3 | 41.4 |
| 19 | 41.5 | 60.4 | 40.5 | 60.4 | 36.0 | 58.0 | 28.9 | 54.4 | 20.2 | 50.7 | 11.3 | 45.3 | 41.4 |
| 20 | 41.5 | 60.4 | 40.5 | 60.4 | 36.0 | 58.0 | 28.7 | 54.4 | 19.9 | 50.7 | 10.8 | 45.3 | 41.4 |
| 21 | 43.4 | 60.4 | 42.5 | 60.4 | 37.9 | 58.0 | 30.5 | 54.4 | 21.8 | 50.7 | 11.9 | 45.3 | 41.4 |
| 22 | 40.0 | 60.4 | 39.0 | 60.4 | 34.4 | 58.0 | 27.0 | 54.4 | 17.8 | 50.7 | 8.6 | 45.3 | 41.4 |
| 23 | 38.4 | 60.4 | 37.4 | 60.4 | 32.8 | 58.0 | 25.2 | 54.4 | 15.9 | 50.7 | 5.6 | 45.3 | 41.4 |
| 24 | 37.5 | 60.4 | 36.5 | 60.4 | 31.8 | 58.0 | 24.1 | 54.4 | 14.7 | 50.7 | 0.0 | 45.3 | 41.4 |
| 25 | 37.0 | 60.4 | 36.0 | 60.4 | 31.3 | 58.0 | 23.4 | 54.4 | 13.8 | 50.7 | | 45.3 | 41.4 |
| 26 | 37.2 | 60.4 | 36.2 | 60.4 | 31.4 | 58.0 | 23.4 | 54.4 | 13.6 | 50.7 | | 45.3 | 41.4 |
| 27 | 39.2 | 60.4 | 38.3 | 60.4 | 33.3 | 58.0 | 25.1 | 54.4 | 15.4 | 50.7 | | 45.3 | 41.4 |
| 28 | 35.7 | 60.4 | 34.7 | 60.4 | 29.8 | 58.0 | 21.4 | 54.4 | 11.3 | 50.7 | | 45.3 | 41.4 |
| 29 | 34.0 | 60.4 | 33.0 | 60.4 | 28.0 | 58.0 | 19.4 | 54.4 | 9.1 | 50.7 | | 45.3 | 41.4 |
| 30 | 32.8 | 60.4 | 31.8 | 60.4 | 26.8 | 58.0 | 17.9 | 54.4 | 7.7 | 50.7 | | 45.3 | 41.4 |
| 31 | 31.9 | 60.4 | 30.9 | 60.4 | 25.8 | 58.0 | 16.6 | 54.4 | 5.9 | 50.7 | | 45.3 | 41.4 |
| 32 | 31.1 | 60.4 | 30.1 | 60.4 | 24.9 | 58.0 | 15.5 | 54.4 | 0.0 | 50.7 | | 45.3 | 41.4 |
| 33 | 30.4 | 60.4 | 29.4 | 60.4 | 24.2 | 58.0 | 14.4 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 34 | 29.9 | 60.4 | 28.9 | 60.4 | 23.6 | 58.0 | 13.5 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 35 | 29.3 | 60.4 | 28.3 | 60.4 | 22.9 | 58.0 | 12.3 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 36 | 27.8 | 60.4 | 28.3 | 60.4 | 22.8 | 58.0 | 12.2 | 54.4 | | 50.7 | | 45.3 | 41.4 |

Table A44. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 65.0 | 77.1 | 63.8 | 77.1 | 59.0 | 74.0 | 51.3 | 69.4 | 42.5 | 64.8 | 33.6 | 57.8 | 50.2 |
| 1 | 66.2 | 77.1 | 64.9 | 77.1 | 60.1 | 74.0 | 52.6 | 69.4 | 43.9 | 64.8 | 34.3 | 57.8 | 50.2 |
| 2 | 62.3 | 77.1 | 61.1 | 77.1 | 56.3 | 74.0 | 48.5 | 69.4 | 39.7 | 64.8 | 30.7 | 57.8 | 50.2 |
| 3 | 60.6 | 77.1 | 59.4 | 77.1 | 54.5 | 74.0 | 46.7 | 69.4 | 37.9 | 64.8 | 28.8 | 57.8 | 50.2 |
| 4 | 59.8 | 77.1 | 58.5 | 77.1 | 53.6 | 74.0 | 45.7 | 69.4 | 36.9 | 64.8 | 27.7 | 57.8 | 50.2 |
| 5 | 59.4 | 77.1 | 58.1 | 77.1 | 53.2 | 74.0 | 45.3 | 69.4 | 36.4 | 64.8 | 27.2 | 57.8 | 50.2 |
| 6 | 59.8 | 77.1 | 58.5 | 77.1 | 53.5 | 74.0 | 45.5 | 69.4 | 36.6 | 64.8 | 27.5 | 57.8 | 50.2 |
| 7 | 62.1 | 77.1 | 60.8 | 77.1 | 55.8 | 74.0 | 47.9 | 69.4 | 39.0 | 64.8 | 29.4 | 57.8 | 50.2 |
| 8 | 59.1 | 77.1 | 57.8 | 77.1 | 52.7 | 74.0 | 44.6 | 69.4 | 35.5 | 64.8 | 26.5 | 57.8 | 50.2 |
| 9 | 58.1 | 77.1 | 56.7 | 77.1 | 51.6 | 74.0 | 43.4 | 69.4 | 34.4 | 64.8 | 25.2 | 57.8 | 50.2 |
| 10 | 58.2 | 77.1 | 56.8 | 77.1 | 51.6 | 74.0 | 43.4 | 69.4 | 34.2 | 64.8 | 25.1 | 57.8 | 50.2 |
| 11 | 60.2 | 77.1 | 58.8 | 77.1 | 53.6 | 74.0 | 45.4 | 69.4 | 36.3 | 64.8 | 26.6 | 57.8 | 50.2 |
| 12 | 56.9 | 77.1 | 55.5 | 77.1 | 50.3 | 74.0 | 41.9 | 69.4 | 32.6 | 64.8 | 23.4 | 57.8 | 50.2 |
| 13 | 55.4 | 77.1 | 54.1 | 77.1 | 48.8 | 74.0 | 40.3 | 69.4 | 31.0 | 64.8 | 21.7 | 57.8 | 50.2 |
| 14 | 54.7 | 77.1 | 53.4 | 77.1 | 48.0 | 74.0 | 39.5 | 69.4 | 30.1 | 64.8 | 20.7 | 57.8 | 50.2 |
| 15 | 54.5 | 77.1 | 53.1 | 77.1 | 47.7 | 74.0 | 39.1 | 69.4 | 29.6 | 64.8 | 20.2 | 57.8 | 50.2 |
| 16 | 55.0 | 77.1 | 53.6 | 77.1 | 48.1 | 74.0 | 39.4 | 69.4 | 29.8 | 64.8 | 20.4 | 57.8 | 50.2 |
| 17 | 57.3 | 77.1 | 55.9 | 77.1 | 50.4 | 74.0 | 41.8 | 69.4 | 32.1 | 64.8 | 22.1 | 57.8 | 50.2 |
| 18 | 54.3 | 77.1 | 52.9 | 77.1 | 47.4 | 74.0 | 38.5 | 69.4 | 28.6 | 64.8 | 19.0 | 57.8 | 50.2 |
| 19 | 53.2 | 77.1 | 51.8 | 77.1 | 46.3 | 74.0 | 37.3 | 69.4 | 27.2 | 64.8 | 17.5 | 57.8 | 50.2 |
| 20 | 53.2 | 77.1 | 51.8 | 77.1 | 46.3 | 74.0 | 37.1 | 69.4 | 26.9 | 64.8 | 17.1 | 57.8 | 50.2 |
| 21 | 55.2 | 77.1 | 53.8 | 77.1 | 48.2 | 74.0 | 39.1 | 69.4 | 28.8 | 64.8 | 18.3 | 57.8 | 50.2 |
| 22 | 51.8 | 77.1 | 50.4 | 77.1 | 44.7 | 74.0 | 35.4 | 69.4 | 24.8 | 64.8 | 14.7 | 57.8 | 50.2 |
| 23 | 50.2 | 77.1 | 48.8 | 77.1 | 43.2 | 74.0 | 33.7 | 69.4 | 22.9 | 64.8 | 12.5 | 57.8 | 50.2 |
| 24 | 49.4 | 77.1 | 48.0 | 77.1 | 42.3 | 74.0 | 32.6 | 69.4 | 21.6 | 64.8 | 10.9 | 57.8 | 50.2 |
| 25 | 49.0 | 77.1 | 47.6 | 77.1 | 41.8 | 74.0 | 32.0 | 69.4 | 20.7 | 64.8 | 9.6 | 57.8 | 50.2 |
| 26 | 49.2 | 77.1 | 47.8 | 77.1 | 42.0 | 74.0 | 32.0 | 69.4 | 20.3 | 64.8 | 8.6 | 57.8 | 50.2 |
| 27 | 51.2 | 77.1 | 49.8 | 77.1 | 44.0 | 74.0 | 34.0 | 69.4 | 22.1 | 64.8 | 7.1 | 57.8 | 50.2 |
| 28 | 47.8 | 77.1 | 46.4 | 77.1 | 40.5 | 74.0 | 30.2 | 69.4 | 17.7 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 46.2 | 77.1 | 44.8 | 77.1 | 38.8 | 74.0 | 28.3 | 69.4 | 15.4 | 64.8 | | 57.8 | 50.2 |
| 30 | 45.1 | 77.1 | 43.7 | 77.1 | 37.7 | 74.0 | 27.0 | 69.4 | 13.5 | 64.8 | | 57.8 | 50.2 |
| 31 | 44.2 | 77.1 | 42.8 | 77.1 | 36.8 | 74.0 | 26.0 | 69.4 | 11.8 | 64.8 | | 57.8 | 50.2 |
| 32 | 43.5 | 77.1 | 42.2 | 77.1 | 36.1 | 74.0 | 25.1 | 69.4 | 9.9 | 64.8 | | 57.8 | 50.2 |
| 33 | 43.0 | 77.1 | 41.6 | 77.1 | 35.5 | 74.0 | 24.3 | 69.4 | 8.2 | 64.8 | | 57.8 | 50.2 |
| 34 | 42.5 | 77.1 | 41.1 | 77.1 | 35.0 | 74.0 | 23.6 | 69.4 | 5.6 | 64.8 | | 57.8 | 50.2 |
| 35 | 42.0 | 77.1 | 40.6 | 77.1 | 34.5 | 74.0 | 22.7 | 69.4 | 4.1 | 64.8 | | 57.8 | 50.2 |
| 36 | 40.4 | 77.1 | 37.4 | 77.1 | 34.5 | 74.0 | 22.6 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |

Table A45. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 48 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 23.0 | 21.5 | 22.8 | 21.5 | 21.6 | 20.6 | 18.9 | 19.4 | 15.8 | 18.1 | 13.1 | 16.1 | 21.6 |
| 1 | 24.5 | 21.5 | 24.1 | 21.5 | 22.8 | 20.6 | 20.0 | 19.4 | 17.4 | 18.1 | 14.0 | 16.1 | 21.6 |
| 2 | 20.9 | 21.5 | 20.6 | 21.5 | 19.3 | 20.6 | 16.6 | 19.4 | 13.4 | 18.1 | 10.6 | 16.1 | 21.6 |
| 3 | 19.5 | 21.5 | 19.2 | 21.5 | 17.8 | 20.6 | 15.0 | 19.4 | 11.9 | 18.1 | 8.9 | 16.1 | 21.6 |
| 4 | 18.9 | 21.5 | 18.6 | 21.5 | 17.2 | 20.6 | 14.3 | 19.4 | 11.1 | 18.1 | 8.1 | 16.1 | 21.6 |
| 5 | 18.9 | 21.5 | 18.6 | 21.5 | 17.1 | 20.6 | 14.1 | 19.4 | 10.9 | 18.1 | 7.9 | 16.1 | 21.6 |
| 6 | 19.6 | 21.5 | 19.3 | 21.5 | 17.8 | 20.6 | 14.7 | 19.4 | 11.3 | 18.1 | 8.4 | 16.1 | 21.6 |
| 7 | 22.2 | 21.5 | 21.9 | 21.5 | 20.2 | 20.6 | 16.9 | 19.4 | 13.9 | 18.1 | 10.4 | 16.1 | 21.6 |
| 8 | 19.6 | 21.5 | 19.3 | 21.5 | 17.6 | 20.6 | 14.3 | 19.4 | 10.7 | 18.1 | 7.7 | 16.1 | 21.6 |
| 9 | 18.9 | 21.5 | 18.6 | 21.5 | 16.8 | 20.6 | 13.4 | 19.4 | 9.7 | 18.1 | 6.6 | 16.1 | 21.6 |
| 10 | 19.3 | 21.5 | 19.0 | 21.5 | 17.2 | 20.6 | 13.6 | 19.4 | 9.7 | 18.1 | 6.6 | 16.1 | 21.6 |
| 11 | 21.6 | 21.5 | 21.3 | 21.5 | 19.3 | 20.6 | 15.4 | 19.4 | 11.9 | 18.1 | 8.2 | 16.1 | 21.6 |
| 12 | 18.7 | 21.5 | 18.4 | 21.5 | 16.4 | 20.6 | 12.4 | 19.4 | 8.1 | 18.1 | 5.0 | 16.1 | 21.6 |
| 13 | 17.6 | 21.5 | 17.3 | 21.5 | 15.1 | 20.6 | 10.9 | 19.4 | 6.5 | 18.1 | 3.4 | 16.1 | 21.6 |
| 14 | 17.3 | 21.5 | 17.0 | 21.5 | 14.6 | 20.6 | 10.2 | 19.4 | 5.5 | 18.1 | 2.2 | 16.1 | 21.6 |
| 15 | 17.4 | 21.5 | 17.1 | 21.5 | 14.6 | 20.6 | 9.9 | 19.4 | 4.7 | 18.1 | 0.0 | 16.1 | 21.6 |
| 16 | 18.2 | 21.5 | 17.9 | 21.5 | 15.2 | 20.6 | 10.3 | 19.4 | 4.5 | 18.1 | | 16.1 | 21.6 |
| 17 | 20.9 | 21.5 | 20.5 | 21.5 | 17.6 | 20.6 | 12.2 | 19.4 | 6.6 | 18.1 | | 16.1 | 21.6 |
| 18 | 18.3 | 21.5 | 18.0 | 21.5 | 14.9 | 20.6 | 9.3 | 19.4 | 2.3 | 18.1 | | 16.1 | 21.6 |
| 19 | 17.6 | 21.5 | 17.2 | 21.5 | 13.9 | 20.6 | 8.0 | 19.4 | 0.0 | 18.1 | | 16.1 | 21.6 |
| 20 | 18.0 | 21.5 | 17.6 | 21.5 | 14.1 | 20.6 | 7.8 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 21 | 20.3 | 21.5 | 19.9 | 21.5 | 16.0 | 20.6 | 9.2 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 22 | 17.4 | 21.5 | 16.9 | 21.5 | 12.9 | 20.6 | 5.8 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 23 | 16.2 | 21.5 | 15.8 | 21.5 | 11.5 | 20.6 | 3.9 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 24 | 15.8 | 21.5 | 15.3 | 21.5 | 10.7 | 20.6 | 2.4 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 25 | 15.8 | 21.5 | 15.3 | 21.5 | 10.4 | 20.6 | 0.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 26 | 16.5 | 21.5 | 16.0 | 21.5 | 10.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 27 | 19.1 | 21.5 | 18.5 | 21.5 | 13.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 28 | 16.3 | 21.5 | 15.7 | 21.5 | 10.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 29 | 15.4 | 21.5 | 14.8 | 21.5 | 8.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 30 | 15.6 | 21.5 | 15.1 | 21.5 | 8.8 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 31 | 17.7 | 21.5 | 17.1 | 21.5 | 10.5 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 32 | 14.5 | 21.5 | 13.9 | 21.5 | 7.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 33 | 13.1 | 21.5 | 12.5 | 21.5 | 5.3 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 34 | 12.3 | 21.5 | 11.7 | 21.5 | 4.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 35 | 11.9 | 21.5 | 11.4 | 21.5 | 3.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 36 | 12.2 | 21.5 | 11.7 | 21.5 | 2.4 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 37 | 14.3 | 21.5 | 13.6 | 21.5 | 1.8 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 38 | 10.9 | 21.5 | 10.3 | 21.5 | 0.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 39 | 9.2 | 21.5 | 8.6 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 40 | 8.1 | 21.5 | 7.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 41 | 7.2 | 21.5 | 6.6 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 42 | 6.4 | 21.5 | 5.8 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 43 | 5.7 | 21.5 | 5.1 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 44 | 5.1 | 21.5 | 4.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 45 | 4.6 | 21.5 | 3.9 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 46 | 4.1 | 21.5 | 3.3 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 47 | 3.5 | 21.5 | 2.7 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 48 | 3.4 | 21.5 | 2.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |

Table A46. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 48 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 40.3 | 40.0 | 40.1 | 40.0 | 37.1 | 38.4 | 32.0 | 36.0 | 25.7 | 33.6 | 20.5 | 30.0 | 32.4 |
| 1 | 41.6 | 40.0 | 41.4 | 40.0 | 38.4 | 38.4 | 32.9 | 36.0 | 27.2 | 33.6 | 21.3 | 30.0 | 32.4 |
| 2 | 38.0 | 40.0 | 37.7 | 40.0 | 34.6 | 38.4 | 29.4 | 36.0 | 23.1 | 33.6 | 17.8 | 30.0 | 32.4 |
| 3 | 36.4 | 40.0 | 36.2 | 40.0 | 33.0 | 38.4 | 27.6 | 36.0 | 21.4 | 33.6 | 16.0 | 30.0 | 32.4 |
| 4 | 35.7 | 40.0 | 35.4 | 40.0 | 32.2 | 38.4 | 26.7 | 36.0 | 20.5 | 33.6 | 15.0 | 30.0 | 32.4 |
| 5 | 35.5 | 40.0 | 35.2 | 40.0 | 32.0 | 38.4 | 26.4 | 36.0 | 20.1 | 33.6 | 14.6 | 30.0 | 32.4 |
| 6 | 36.1 | 40.0 | 35.8 | 40.0 | 32.5 | 38.4 | 26.9 | 36.0 | 20.4 | 33.6 | 15.0 | 30.0 | 32.4 |
| 7 | 38.6 | 40.0 | 38.2 | 40.0 | 34.9 | 38.4 | 28.9 | 36.0 | 22.9 | 33.6 | 16.9 | 30.0 | 32.4 |
| 8 | 35.7 | 40.0 | 35.4 | 40.0 | 32.0 | 38.4 | 26.2 | 36.0 | 19.6 | 33.6 | 14.1 | 30.0 | 32.4 |
| 9 | 34.9 | 40.0 | 34.5 | 40.0 | 31.1 | 38.4 | 25.2 | 36.0 | 18.5 | 33.6 | 12.9 | 30.0 | 32.4 |
| 10 | 35.1 | 40.0 | 34.8 | 40.0 | 31.3 | 38.4 | 25.3 | 36.0 | 18.4 | 33.6 | 12.8 | 30.0 | 32.4 |
| 11 | 37.3 | 40.0 | 37.0 | 40.0 | 33.4 | 38.4 | 27.1 | 36.0 | 20.6 | 33.6 | 14.3 | 30.0 | 32.4 |
| 12 | 34.3 | 40.0 | 33.9 | 40.0 | 30.2 | 38.4 | 24.0 | 36.0 | 16.9 | 33.6 | 11.0 | 30.0 | 32.4 |
| 13 | 33.0 | 40.0 | 32.6 | 40.0 | 28.9 | 38.4 | 22.5 | 36.0 | 15.3 | 33.6 | 9.3 | 30.0 | 32.4 |
| 14 | 32.5 | 40.0 | 32.1 | 40.0 | 28.4 | 38.4 | 21.8 | 36.0 | 14.4 | 33.6 | 8.2 | 30.0 | 32.4 |
| 15 | 32.4 | 40.0 | 32.0 | 40.0 | 28.2 | 38.4 | 21.5 | 36.0 | 13.9 | 33.6 | 7.5 | 30.0 | 32.4 |
| 16 | 33.1 | 40.0 | 32.7 | 40.0 | 28.8 | 38.4 | 22.0 | 36.0 | 14.1 | 33.6 | 7.5 | 30.0 | 32.4 |
| 17 | 35.6 | 40.0 | 35.2 | 40.0 | 31.2 | 38.4 | 24.0 | 36.0 | 16.4 | 33.6 | 8.9 | 30.0 | 32.4 |
| 18 | 32.8 | 40.0 | 32.4 | 40.0 | 28.4 | 38.4 | 21.2 | 36.0 | 12.8 | 33.6 | 5.8 | 30.0 | 32.4 |
| 19 | 31.9 | 40.0 | 31.5 | 40.0 | 27.4 | 38.4 | 20.0 | 36.0 | 11.4 | 33.6 | 3.2 | 30.0 | 32.4 |
| 20 | 32.1 | 40.0 | 31.7 | 40.0 | 27.6 | 38.4 | 20.0 | 36.0 | 11.0 | 33.6 | 0.0 | 30.0 | 32.4 |
| 21 | 34.3 | 40.0 | 33.8 | 40.0 | 29.6 | 38.4 | 21.6 | 36.0 | 12.7 | 33.6 | | 30.0 | 32.4 |
| 22 | 31.1 | 40.0 | 30.6 | 40.0 | 26.4 | 38.4 | 18.3 | 36.0 | 8.6 | 33.6 | | 30.0 | 32.4 |
| 23 | 29.8 | 40.0 | 29.3 | 40.0 | 25.0 | 38.4 | 16.6 | 36.0 | 6.5 | 33.6 | | 30.0 | 32.4 |
| 24 | 29.1 | 40.0 | 28.7 | 40.0 | 24.2 | 38.4 | 15.6 | 36.0 | 5.1 | 33.6 | | 30.0 | 32.4 |
| 25 | 29.0 | 40.0 | 28.4 | 40.0 | 24.0 | 38.4 | 15.1 | 36.0 | 3.4 | 33.6 | | 30.0 | 32.4 |
| 26 | 29.5 | 40.0 | 29.0 | 40.0 | 24.4 | 38.4 | 15.3 | 36.0 | 0.0 | 33.6 | | 30.0 | 32.4 |
| 27 | 31.8 | 40.0 | 31.3 | 40.0 | 26.7 | 38.4 | 17.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 28 | 28.8 | 40.0 | 28.3 | 40.0 | 23.6 | 38.4 | 13.9 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 29 | 27.8 | 40.0 | 27.2 | 40.0 | 22.5 | 38.4 | 12.4 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 30 | 27.8 | 40.0 | 27.2 | 40.0 | 22.4 | 38.4 | 12.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 31 | 29.7 | 40.0 | 29.1 | 40.0 | 24.3 | 38.4 | 13.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 32 | 26.3 | 40.0 | 25.7 | 40.0 | 20.8 | 38.4 | 9.6 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 33 | 24.7 | 40.0 | 24.1 | 40.0 | 19.1 | 38.4 | 7.6 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 34 | 23.7 | 40.0 | 23.1 | 40.0 | 18.1 | 38.4 | 6.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 35 | 23.2 | 40.0 | 22.6 | 40.0 | 17.5 | 38.4 | 4.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 36 | 23.4 | 40.0 | 22.7 | 40.0 | 17.6 | 38.4 | 0.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 37 | 25.2 | 40.0 | 24.6 | 40.0 | 19.4 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 38 | 21.7 | 40.0 | 21.0 | 40.0 | 15.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 39 | 19.9 | 40.0 | 19.2 | 40.0 | 13.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 40 | 18.6 | 40.0 | 17.9 | 40.0 | 12.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 41 | 17.6 | 40.0 | 16.8 | 40.0 | 11.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 42 | 16.7 | 40.0 | 15.9 | 40.0 | 10.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 43 | 15.9 | 40.0 | 15.1 | 40.0 | 9.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 44 | 15.2 | 40.0 | 14.3 | 40.0 | 8.4 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 45 | 14.6 | 40.0 | 13.6 | 40.0 | 7.5 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 46 | 14.0 | 40.0 | 13.0 | 40.0 | 6.6 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 47 | 13.4 | 40.0 | 12.3 | 40.0 | 5.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 48 | 12.6 | 40.0 | 12.2 | 40.0 | 4.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |

Table A47. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 48 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 56.6 | 59.8 | 55.7 | 59.8 | 51.2 | 57.3 | 44.1 | 53.8 | 35.1 | 50.2 | 27.2 | 44.8 | 41.4 |
| 1 | 57.8 | 59.8 | 57.0 | 59.8 | 52.3 | 57.3 | 44.9 | 53.8 | 36.6 | 50.2 | 28.0 | 44.8 | 41.4 |
| 2 | 54.0 | 59.8 | 53.1 | 59.8 | 48.5 | 57.3 | 41.2 | 53.8 | 32.4 | 50.2 | 24.4 | 44.8 | 41.4 |
| 3 | 52.3 | 59.8 | 51.4 | 59.8 | 46.8 | 57.3 | 39.4 | 53.8 | 30.6 | 50.2 | 22.5 | 44.8 | 41.4 |
| 4 | 51.5 | 59.8 | 50.6 | 59.8 | 45.9 | 57.3 | 38.5 | 53.8 | 29.6 | 50.2 | 21.5 | 44.8 | 41.4 |
| 5 | 51.2 | 59.8 | 50.3 | 59.8 | 45.5 | 57.3 | 38.0 | 53.8 | 29.2 | 50.2 | 21.0 | 44.8 | 41.4 |
| 6 | 51.7 | 59.8 | 50.7 | 59.8 | 45.9 | 57.3 | 38.4 | 53.8 | 29.4 | 50.2 | 21.3 | 44.8 | 41.4 |
| 7 | 54.1 | 59.8 | 53.2 | 59.8 | 48.2 | 57.3 | 40.4 | 53.8 | 31.8 | 50.2 | 23.2 | 44.8 | 41.4 |
| 8 | 51.2 | 59.8 | 50.1 | 59.8 | 45.2 | 57.3 | 37.6 | 53.8 | 28.4 | 50.2 | 20.3 | 44.8 | 41.4 |
| 9 | 50.2 | 59.8 | 49.2 | 59.8 | 44.2 | 57.3 | 36.5 | 53.8 | 27.3 | 50.2 | 19.0 | 44.8 | 41.4 |
| 10 | 50.3 | 59.8 | 49.3 | 59.8 | 44.3 | 57.3 | 36.5 | 53.8 | 27.2 | 50.2 | 18.9 | 44.8 | 41.4 |
| 11 | 52.4 | 59.8 | 51.5 | 59.8 | 46.3 | 57.3 | 38.2 | 53.8 | 29.3 | 50.2 | 20.4 | 44.8 | 41.4 |
| 12 | 49.2 | 59.8 | 48.2 | 59.8 | 43.0 | 57.3 | 35.2 | 53.8 | 25.6 | 50.2 | 17.1 | 44.8 | 41.4 |
| 13 | 47.9 | 59.8 | 46.8 | 59.8 | 41.6 | 57.3 | 33.6 | 53.8 | 24.1 | 50.2 | 15.3 | 44.8 | 41.4 |
| 14 | 47.3 | 59.8 | 46.2 | 59.8 | 40.9 | 57.3 | 32.9 | 53.8 | 23.2 | 50.2 | 14.2 | 44.8 | 41.4 |
| 15 | 47.1 | 59.8 | 46.0 | 59.8 | 40.7 | 57.3 | 32.6 | 53.8 | 22.7 | 50.2 | 13.6 | 44.8 | 41.4 |
| 16 | 47.7 | 59.8 | 46.5 | 59.8 | 41.2 | 57.3 | 33.0 | 53.8 | 22.9 | 50.2 | 13.6 | 44.8 | 41.4 |
| 17 | 50.1 | 59.8 | 49.0 | 59.8 | 43.5 | 57.3 | 35.0 | 53.8 | 25.3 | 50.2 | 15.1 | 44.8 | 41.4 |
| 18 | 47.2 | 59.8 | 46.0 | 59.8 | 40.6 | 57.3 | 32.2 | 53.8 | 21.7 | 50.2 | 11.7 | 44.8 | 41.4 |
| 19 | 46.2 | 59.8 | 45.0 | 59.8 | 39.5 | 57.3 | 31.1 | 53.8 | 20.4 | 50.2 | 9.7 | 44.8 | 41.4 |
| 20 | 46.3 | 59.8 | 45.1 | 59.8 | 39.6 | 57.3 | 31.1 | 53.8 | 20.1 | 50.2 | 8.2 | 44.8 | 41.4 |
| 21 | 48.3 | 59.8 | 47.3 | 59.8 | 41.6 | 57.3 | 32.7 | 53.8 | 22.0 | 50.2 | 7.0 | 44.8 | 41.4 |
| 22 | 45.1 | 59.8 | 43.9 | 59.8 | 38.3 | 57.3 | 29.5 | 53.8 | 18.0 | 50.2 | 6.1 | 44.8 | 41.4 |
| 23 | 43.7 | 59.8 | 42.5 | 59.8 | 36.8 | 57.3 | 27.8 | 53.8 | 16.1 | 50.2 | 4.8 | 44.8 | 41.4 |
| 24 | 42.9 | 59.8 | 41.8 | 59.8 | 36.0 | 57.3 | 26.9 | 53.8 | 14.8 | 50.2 | 0.0 | 44.8 | 41.4 |
| 25 | 42.7 | 59.8 | 41.5 | 59.8 | 35.6 | 57.3 | 26.4 | 53.8 | 13.9 | 50.2 | | 44.8 | 41.4 |
| 26 | 43.1 | 59.8 | 41.9 | 59.8 | 36.0 | 57.3 | 26.7 | 53.8 | 13.6 | 50.2 | | 44.8 | 41.4 |
| 27 | 45.4 | 59.8 | 44.3 | 59.8 | 38.2 | 57.3 | 28.5 | 53.8 | 15.5 | 50.2 | | 44.8 | 41.4 |
| 28 | 42.4 | 59.8 | 41.1 | 59.8 | 35.1 | 57.3 | 25.5 | 53.8 | 11.3 | 50.2 | | 44.8 | 41.4 |
| 29 | 41.2 | 59.8 | 40.0 | 59.8 | 33.8 | 57.3 | 24.1 | 53.8 | 9.2 | 50.2 | | 44.8 | 41.4 |
| 30 | 41.2 | 59.8 | 39.9 | 59.8 | 33.7 | 57.3 | 23.8 | 53.8 | 7.8 | 50.2 | | 44.8 | 41.4 |
| 31 | 43.1 | 59.8 | 41.9 | 59.8 | 35.5 | 57.3 | 25.2 | 53.8 | 5.9 | 50.2 | | 44.8 | 41.4 |
| 32 | 39.6 | 59.8 | 38.3 | 59.8 | 31.9 | 57.3 | 21.7 | 53.8 | 0.0 | 50.2 | | 44.8 | 41.4 |
| 33 | 38.0 | 59.8 | 36.7 | 59.8 | 30.2 | 57.3 | 19.7 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 34 | 37.0 | 59.8 | 35.7 | 59.8 | 29.1 | 57.3 | 18.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 35 | 36.5 | 59.8 | 35.1 | 59.8 | 28.4 | 57.3 | 17.6 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 36 | 36.6 | 59.8 | 35.2 | 59.8 | 28.4 | 57.3 | 17.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 37 | 38.5 | 59.8 | 37.2 | 59.8 | 30.1 | 57.3 | 18.8 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 38 | 35.0 | 59.8 | 33.5 | 59.8 | 26.4 | 57.3 | 15.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 39 | 33.1 | 59.8 | 31.7 | 59.8 | 24.4 | 57.3 | 12.9 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 40 | 31.9 | 59.8 | 30.5 | 59.8 | 23.0 | 57.3 | 11.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 41 | 30.9 | 59.8 | 29.4 | 59.8 | 21.8 | 57.3 | 9.7 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 42 | 30.1 | 59.8 | 28.5 | 59.8 | 20.7 | 57.3 | 8.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 43 | 29.3 | 59.8 | 27.8 | 59.8 | 19.8 | 57.3 | 7.2 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 44 | 28.7 | 59.8 | 27.1 | 59.8 | 18.9 | 57.3 | 5.7 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 45 | 28.1 | 59.8 | 26.5 | 59.8 | 18.0 | 57.3 | 0.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 46 | 27.6 | 59.8 | 25.9 | 59.8 | 17.3 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 47 | 27.0 | 59.8 | 25.3 | 59.8 | 16.4 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 48 | 25.7 | 59.8 | 25.3 | 59.8 | 16.2 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |

Table A48. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 54 ft, One Railing with Edge Loading E2.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 69.0 | 77.1 | 67.8 | 77.1 | 62.3 | 74.0 | 53.5 | 69.4 | 43.5 | 64.8 | 33.7 | 57.8 | 50.2 |
| 1 | 70.2 | 77.1 | 68.9 | 77.1 | 63.3 | 74.0 | 54.8 | 69.4 | 44.8 | 64.8 | 34.4 | 57.8 | 50.2 |
| 2 | 66.4 | 77.1 | 65.1 | 77.1 | 59.5 | 74.0 | 50.7 | 69.4 | 40.6 | 64.8 | 30.7 | 57.8 | 50.2 |
| 3 | 64.6 | 77.1 | 63.4 | 77.1 | 57.7 | 74.0 | 48.9 | 69.4 | 38.8 | 64.8 | 28.9 | 57.8 | 50.2 |
| 4 | 63.8 | 77.1 | 62.5 | 77.1 | 56.8 | 74.0 | 47.9 | 69.4 | 37.8 | 64.8 | 27.8 | 57.8 | 50.2 |
| 5 | 63.4 | 77.1 | 62.1 | 77.1 | 56.3 | 74.0 | 47.4 | 69.4 | 37.3 | 64.8 | 27.3 | 57.8 | 50.2 |
| 6 | 63.9 | 77.1 | 62.5 | 77.1 | 56.7 | 74.0 | 47.7 | 69.4 | 37.5 | 64.8 | 27.6 | 57.8 | 50.2 |
| 7 | 66.2 | 77.1 | 64.8 | 77.1 | 58.9 | 74.0 | 50.0 | 69.4 | 39.9 | 64.8 | 29.5 | 57.8 | 50.2 |
| 8 | 63.2 | 77.1 | 61.8 | 77.1 | 55.9 | 74.0 | 46.7 | 69.4 | 36.5 | 64.8 | 26.6 | 57.8 | 50.2 |
| 9 | 62.2 | 77.1 | 60.8 | 77.1 | 54.8 | 74.0 | 45.6 | 69.4 | 35.3 | 64.8 | 25.3 | 57.8 | 50.2 |
| 10 | 62.3 | 77.1 | 60.9 | 77.1 | 54.9 | 74.0 | 45.5 | 69.4 | 35.1 | 64.8 | 25.2 | 57.8 | 50.2 |
| 11 | 64.4 | 77.1 | 62.9 | 77.1 | 56.8 | 74.0 | 47.6 | 69.4 | 37.3 | 64.8 | 26.7 | 57.8 | 50.2 |
| 12 | 61.1 | 77.1 | 59.7 | 77.1 | 53.5 | 74.0 | 44.1 | 69.4 | 33.5 | 64.8 | 23.5 | 57.8 | 50.2 |
| 13 | 59.7 | 77.1 | 58.3 | 77.1 | 52.1 | 74.0 | 42.6 | 69.4 | 32.0 | 64.8 | 21.8 | 57.8 | 50.2 |
| 14 | 59.1 | 77.1 | 57.6 | 77.1 | 51.3 | 74.0 | 41.8 | 69.4 | 31.1 | 64.8 | 20.8 | 57.8 | 50.2 |
| 15 | 58.9 | 77.1 | 57.4 | 77.1 | 51.0 | 74.0 | 41.4 | 69.4 | 30.6 | 64.8 | 20.3 | 57.8 | 50.2 |
| 16 | 59.4 | 77.1 | 57.9 | 77.1 | 51.5 | 74.0 | 41.8 | 69.4 | 30.8 | 64.8 | 20.5 | 57.8 | 50.2 |
| 17 | 61.8 | 77.1 | 60.2 | 77.1 | 53.8 | 74.0 | 44.1 | 69.4 | 33.2 | 64.8 | 22.2 | 57.8 | 50.2 |
| 18 | 58.8 | 77.1 | 57.3 | 77.1 | 50.8 | 74.0 | 40.9 | 69.4 | 29.7 | 64.8 | 19.1 | 57.8 | 50.2 |
| 19 | 57.8 | 77.1 | 56.3 | 77.1 | 49.7 | 74.0 | 39.7 | 69.4 | 28.4 | 64.8 | 17.6 | 57.8 | 50.2 |
| 20 | 57.9 | 77.1 | 56.4 | 77.1 | 49.7 | 74.0 | 39.6 | 69.4 | 28.2 | 64.8 | 17.3 | 57.8 | 50.2 |
| 21 | 60.0 | 77.1 | 58.4 | 77.1 | 51.7 | 74.0 | 41.7 | 69.4 | 30.1 | 64.8 | 18.4 | 57.8 | 50.2 |
| 22 | 56.7 | 77.1 | 55.1 | 77.1 | 48.3 | 74.0 | 38.0 | 69.4 | 26.2 | 64.8 | 14.8 | 57.8 | 50.2 |
| 23 | 55.2 | 77.1 | 53.6 | 77.1 | 46.8 | 74.0 | 36.4 | 69.4 | 24.4 | 64.8 | 12.6 | 57.8 | 50.2 |
| 24 | 54.5 | 77.1 | 52.9 | 77.1 | 46.0 | 74.0 | 35.5 | 69.4 | 23.3 | 64.8 | 11.1 | 57.8 | 50.2 |
| 25 | 54.2 | 77.1 | 52.6 | 77.1 | 45.6 | 74.0 | 35.0 | 69.4 | 22.6 | 64.8 | 9.7 | 57.8 | 50.2 |
| 26 | 54.7 | 77.1 | 53.0 | 77.1 | 46.0 | 74.0 | 35.2 | 69.4 | 22.5 | 64.8 | 8.7 | 57.8 | 50.2 |
| 27 | 56.9 | 77.1 | 55.3 | 77.1 | 48.2 | 74.0 | 37.4 | 69.4 | 24.6 | 64.8 | 7.2 | 57.8 | 50.2 |
| 28 | 53.9 | 77.1 | 52.2 | 77.1 | 45.0 | 74.0 | 33.9 | 69.4 | 20.8 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 52.8 | 77.1 | 51.1 | 77.1 | 43.8 | 74.0 | 32.5 | 69.4 | 19.2 | 64.8 | | 57.8 | 50.2 |
| 30 | 52.8 | 77.1 | 51.1 | 77.1 | 43.7 | 74.0 | 32.2 | 69.4 | 18.5 | 64.8 | | 57.8 | 50.2 |
| 31 | 54.7 | 77.1 | 52.9 | 77.1 | 45.5 | 74.0 | 34.0 | 69.4 | 20.1 | 64.8 | | 57.8 | 50.2 |
| 32 | 51.2 | 77.1 | 49.5 | 77.1 | 41.9 | 74.0 | 30.0 | 69.4 | 15.7 | 64.8 | | 57.8 | 50.2 |
| 33 | 49.6 | 77.1 | 47.9 | 77.1 | 40.2 | 74.0 | 28.1 | 69.4 | 13.4 | 64.8 | | 57.8 | 50.2 |
| 34 | 48.7 | 77.1 | 46.9 | 77.1 | 39.1 | 74.0 | 26.8 | 69.4 | 11.6 | 64.8 | | 57.8 | 50.2 |
| 35 | 48.2 | 77.1 | 46.4 | 77.1 | 38.5 | 74.0 | 25.9 | 69.4 | 10.2 | 64.8 | | 57.8 | 50.2 |
| 36 | 48.3 | 77.1 | 46.6 | 77.1 | 38.5 | 74.0 | 25.6 | 69.4 | 8.4 | 64.8 | | 57.8 | 50.2 |
| 37 | 50.3 | 77.1 | 48.5 | 77.1 | 40.3 | 74.0 | 27.2 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 38 | 46.8 | 77.1 | 45.0 | 77.1 | 36.7 | 74.0 | 23.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 39 | 45.0 | 77.1 | 43.2 | 77.1 | 34.8 | 74.0 | 20.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 40 | 43.9 | 77.1 | 42.0 | 77.1 | 33.4 | 74.0 | 19.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 41 | 42.9 | 77.1 | 41.1 | 77.1 | 32.3 | 74.0 | 17.5 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 42 | 42.1 | 77.1 | 40.3 | 77.1 | 31.4 | 74.0 | 16.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 43 | 41.5 | 77.1 | 39.6 | 77.1 | 30.6 | 74.0 | 14.5 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 44 | 40.9 | 77.1 | 39.0 | 77.1 | 29.8 | 74.0 | 13.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 45 | 40.4 | 77.1 | 38.4 | 77.1 | 29.1 | 74.0 | 11.6 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 46 | 40.0 | 77.1 | 38.0 | 77.1 | 28.6 | 74.0 | 10.3 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 47 | 39.5 | 77.1 | 37.9 | 77.1 | 28.0 | 74.0 | 8.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 48 | 38.1 | 77.1 | 37.5 | 77.1 | 27.9 | 74.0 | 7.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |

Table A49. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 14 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 8.1 | 28.1 | 8.1 | 28.1 | 8.1 | 27.0 | 7.7 | 25.3 | 6.3 | 23.6 | 6.6 | 21.1 | 21.6 |
| 1 | 9.4 | 28.1 | 9.2 | 28.1 | 9.1 | 27.0 | 8.6 | 25.3 | 8.3 | 23.6 | 7.2 | 21.1 | 21.6 |
| 2 | 7.5 | 28.1 | 7.5 | 28.1 | 7.4 | 27.0 | 6.9 | 25.3 | 6.2 | 23.6 | 5.6 | 21.1 | 21.6 |
| 3 | 6.7 | 28.1 | 6.6 | 28.1 | 6.5 | 27.0 | 6.0 | 25.3 | 5.4 | 23.6 | 4.7 | 21.1 | 21.6 |
| 4 | 6.6 | 28.1 | 6.5 | 28.1 | 6.4 | 27.0 | 5.9 | 25.3 | 5.3 | 23.6 | 4.5 | 21.1 | 21.6 |
| 5 | 6.7 | 28.1 | 6.7 | 28.1 | 6.5 | 27.0 | 6.1 | 25.3 | 5.5 | 23.6 | 4.7 | 21.1 | 21.6 |
| 6 | 7.5 | 28.1 | 7.5 | 28.1 | 7.3 | 27.0 | 6.9 | 25.3 | 6.2 | 23.6 | 5.5 | 21.1 | 21.6 |
| 7 | 10.0 | 28.1 | 9.9 | 28.1 | 9.7 | 27.0 | 9.1 | 25.3 | 8.9 | 23.6 | 7.7 | 21.1 | 21.6 |
| 8 | 7.0 | 28.1 | 6.9 | 28.1 | 6.8 | 27.0 | 6.4 | 25.3 | 5.7 | 23.6 | 5.0 | 21.1 | 21.6 |
| 9 | 5.6 | 28.1 | 5.6 | 28.1 | 5.5 | 27.0 | 5.0 | 25.3 | 4.4 | 23.6 | 3.7 | 21.1 | 21.6 |
| 10 | 4.8 | 28.1 | 4.8 | 28.1 | 4.7 | 27.0 | 4.2 | 25.3 | 3.6 | 23.6 | 2.9 | 21.1 | 21.6 |
| 11 | 4.2 | 28.1 | 4.1 | 28.1 | 4.0 | 27.0 | 3.5 | 25.3 | 3.0 | 23.6 | 2.4 | 21.1 | 21.6 |
| 12 | 3.7 | 28.1 | 3.7 | 28.1 | 3.6 | 27.0 | 3.0 | 25.3 | 2.5 | 23.6 | 2.0 | 21.1 | 21.6 |
| 13 | 3.2 | 28.1 | 3.1 | 28.1 | 3.0 | 27.0 | 2.4 | 25.3 | 2.0 | 23.6 | 2.2 | 21.1 | 21.6 |
| 14 | 3.2 | 28.1 | 3.1 | 28.1 | 3.0 | 27.0 | 2.5 | 25.3 | 1.8 | 23.6 | 0.5 | 21.1 | 21.6 |

Table A50. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 14 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 16.3 | 47.2 | 16.0 | 47.2 | 15.3 | 45.3 | 14.2 | 42.5 | 12.0 | 39.6 | 11.4 | 35.4 | 32.4 |
| 1 | 17.2 | 47.2 | 17.0 | 47.2 | 16.3 | 45.3 | 15.2 | 42.5 | 13.9 | 39.6 | 11.6 | 35.4 | 32.4 |
| 2 | 15.1 | 47.2 | 14.9 | 47.2 | 14.2 | 45.3 | 13.0 | 42.5 | 11.3 | 39.6 | 9.8 | 35.4 | 32.4 |
| 3 | 14.1 | 47.2 | 13.8 | 47.2 | 13.1 | 45.3 | 12.0 | 42.5 | 10.4 | 39.6 | 8.7 | 35.4 | 32.4 |
| 4 | 13.8 | 47.2 | 13.6 | 47.2 | 12.9 | 45.3 | 11.7 | 42.5 | 10.1 | 39.6 | 8.3 | 35.4 | 32.4 |
| 5 | 13.9 | 47.2 | 13.6 | 47.2 | 12.9 | 45.3 | 11.8 | 42.5 | 10.1 | 39.6 | 8.3 | 35.4 | 32.4 |
| 6 | 14.5 | 47.2 | 14.3 | 47.2 | 13.6 | 45.3 | 12.4 | 42.5 | 10.7 | 39.6 | 9.0 | 35.4 | 32.4 |
| 7 | 16.9 | 47.2 | 16.7 | 47.2 | 16.0 | 45.3 | 14.8 | 42.5 | 13.4 | 39.6 | 11.0 | 35.4 | 32.4 |
| 8 | 13.8 | 47.2 | 13.6 | 47.2 | 12.9 | 45.3 | 11.7 | 42.5 | 10.0 | 39.6 | 8.2 | 35.4 | 32.4 |
| 9 | 12.4 | 47.2 | 12.2 | 47.2 | 11.5 | 45.3 | 10.4 | 42.5 | 8.7 | 39.6 | 6.8 | 35.4 | 32.4 |
| 10 | 11.6 | 47.2 | 11.4 | 47.2 | 10.7 | 45.3 | 9.6 | 42.5 | 7.9 | 39.6 | 5.9 | 35.4 | 32.4 |
| 11 | 11.0 | 47.2 | 10.7 | 47.2 | 10.1 | 45.3 | 8.9 | 42.5 | 7.3 | 39.6 | 5.2 | 35.4 | 32.4 |
| 12 | 10.5 | 47.2 | 10.3 | 47.2 | 9.6 | 45.3 | 8.4 | 42.5 | 6.8 | 39.6 | 4.7 | 35.4 | 32.4 |
| 13 | 9.9 | 47.2 | 9.7 | 47.2 | 9.1 | 45.3 | 7.9 | 42.5 | 6.2 | 39.6 | 4.1 | 35.4 | 32.4 |
| 14 | 9.9 | 47.2 | 9.7 | 47.2 | 9.1 | 45.3 | 7.9 | 42.5 | 6.1 | 39.6 | 4.2 | 35.4 | 32.4 |

Table A51. Longitudinal Moment Distribution at Critical Section for One-Lane
Single Span Bridge – Deck Span = 46 ft, Deck Width = 14 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 26.5 | 62.9 | 25.8 | 62.9 | 24.7 | 60.4 | 22.6 | 56.6 | 19.9 | 52.8 | 17.0 | 47.2 | 41.4 |
| 1 | 27.3 | 62.9 | 27.0 | 62.9 | 25.6 | 60.4 | 23.4 | 56.6 | 20.7 | 52.8 | 17.1 | 47.2 | 41.4 |
| 2 | 25.1 | 62.9 | 24.6 | 62.9 | 23.3 | 60.4 | 21.2 | 56.6 | 18.4 | 52.8 | 15.1 | 47.2 | 41.4 |
| 3 | 23.9 | 62.9 | 23.5 | 62.9 | 22.2 | 60.4 | 20.0 | 56.6 | 17.2 | 52.8 | 13.8 | 47.2 | 41.4 |
| 4 | 23.6 | 62.9 | 23.1 | 62.9 | 21.8 | 60.4 | 19.6 | 56.6 | 16.9 | 52.8 | 13.4 | 47.2 | 41.4 |
| 5 | 23.5 | 62.9 | 23.1 | 62.9 | 21.8 | 60.4 | 19.6 | 56.6 | 16.8 | 52.8 | 13.3 | 47.2 | 41.4 |
| 6 | 24.1 | 62.9 | 23.7 | 62.9 | 22.4 | 60.4 | 20.2 | 56.6 | 17.4 | 52.8 | 13.9 | 47.2 | 41.4 |
| 7 | 26.5 | 62.9 | 26.1 | 62.9 | 24.7 | 60.4 | 22.5 | 56.6 | 19.7 | 52.8 | 15.9 | 47.2 | 41.4 |
| 8 | 23.4 | 62.9 | 22.9 | 62.9 | 21.6 | 60.4 | 19.4 | 56.6 | 16.6 | 52.8 | 13.1 | 47.2 | 41.4 |
| 9 | 22.0 | 62.9 | 21.5 | 62.9 | 20.2 | 60.4 | 18.0 | 56.6 | 15.2 | 52.8 | 11.6 | 47.2 | 41.4 |
| 10 | 21.2 | 62.9 | 20.7 | 62.9 | 19.4 | 60.4 | 17.2 | 56.6 | 14.4 | 52.8 | 10.7 | 47.2 | 41.4 |
| 11 | 20.5 | 62.9 | 20.1 | 62.9 | 18.8 | 60.4 | 16.6 | 56.6 | 13.8 | 52.8 | 10.1 | 47.2 | 41.4 |
| 12 | 20.0 | 62.9 | 19.6 | 62.9 | 18.3 | 60.4 | 16.1 | 56.6 | 13.3 | 52.8 | 9.6 | 47.2 | 41.4 |
| 13 | 19.5 | 62.9 | 19.1 | 62.9 | 17.8 | 60.4 | 15.6 | 56.6 | 12.8 | 52.8 | 9.1 | 47.2 | 41.4 |
| 14 | 18.3 | 62.9 | 19.1 | 62.9 | 17.8 | 60.4 | 15.7 | 56.6 | 12.9 | 52.8 | 9.2 | 47.2 | 41.4 |

Table A52. Longitudinal Moment Distribution at Critical Section for One-Lane Single Span Bridge – Deck Span = 54 ft, Deck Width = 14 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 36.6 | 75.3 | 35.9 | 75.3 | 32.2 | 72.3 | 30.4 | 67.8 | 26.3 | 63.3 | 21.7 | 56.5 | 50.2 |
| 1 | 37.5 | 75.3 | 36.8 | 75.3 | 30.3 | 72.3 | 31.6 | 67.8 | 27.8 | 63.3 | 22.5 | 56.5 | 50.2 |
| 2 | 35.0 | 75.3 | 34.3 | 75.3 | 31.0 | 72.3 | 29.1 | 67.8 | 25.0 | 63.3 | 20.0 | 56.5 | 50.2 |
| 3 | 33.8 | 75.3 | 33.1 | 75.3 | 30.4 | 72.3 | 27.9 | 67.8 | 23.8 | 63.3 | 18.7 | 56.5 | 50.2 |
| 4 | 33.4 | 75.3 | 32.7 | 75.3 | 30.1 | 72.3 | 27.5 | 67.8 | 23.4 | 63.3 | 18.2 | 56.5 | 50.2 |
| 5 | 33.3 | 75.3 | 32.6 | 75.3 | 29.9 | 72.3 | 27.4 | 67.8 | 23.3 | 63.3 | 17.9 | 56.5 | 50.2 |
| 6 | 33.9 | 75.3 | 33.2 | 75.3 | 29.9 | 72.3 | 27.9 | 67.8 | 23.8 | 63.3 | 18.0 | 56.5 | 50.2 |
| 7 | 36.2 | 75.3 | 35.5 | 75.3 | 29.0 | 72.3 | 30.4 | 67.8 | 26.4 | 63.3 | 18.6 | 56.5 | 50.2 |
| 8 | 33.1 | 75.3 | 32.4 | 75.3 | 29.1 | 72.3 | 27.1 | 67.8 | 23.0 | 63.3 | 21.0 | 56.5 | 50.2 |
| 9 | 31.7 | 75.3 | 31.0 | 75.3 | 28.4 | 72.3 | 25.8 | 67.8 | 21.7 | 63.3 | 18.0 | 56.5 | 50.2 |
| 10 | 30.9 | 75.3 | 30.2 | 75.3 | 27.7 | 72.3 | 24.9 | 67.8 | 20.9 | 63.3 | 16.7 | 56.5 | 50.2 |
| 11 | 30.2 | 75.3 | 29.6 | 75.3 | 27.2 | 72.3 | 24.3 | 67.8 | 20.2 | 63.3 | 15.9 | 56.5 | 50.2 |
| 12 | 29.8 | 75.3 | 29.1 | 75.3 | 26.7 | 72.3 | 23.9 | 67.8 | 19.8 | 63.3 | 15.4 | 56.5 | 50.2 |
| 13 | 29.3 | 75.3 | 28.6 | 75.3 | 26.3 | 72.3 | 23.4 | 67.8 | 19.4 | 63.3 | 14.9 | 56.5 | 50.2 |
| 14 | 28.0 | 75.3 | 27.3 | 75.3 | 26.3 | 72.3 | 23.3 | 67.8 | 19.3 | 63.3 | 14.9 | 56.5 | 50.2 |

Table A53. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 10.4 | 24.1 | 10.4 | 24.1 | 10.2 | 23.2 | 9.5 | 21.7 | 7.5 | 20.2 | 7.2 | 18.1 | 21.6 |
| 1 | 11.7 | 24.1 | 11.5 | 24.1 | 11.1 | 23.2 | 10.3 | 21.7 | 9.5 | 20.2 | 7.8 | 18.1 | 21.6 |
| 2 | 10.2 | 24.1 | 10.1 | 24.1 | 9.8 | 23.2 | 8.9 | 21.7 | 7.5 | 20.2 | 6.3 | 18.1 | 21.6 |
| 3 | 9.6 | 24.1 | 9.5 | 24.1 | 9.1 | 23.2 | 8.3 | 21.7 | 6.8 | 20.2 | 5.4 | 18.1 | 21.6 |
| 4 | 9.9 | 24.1 | 9.7 | 24.1 | 9.4 | 23.2 | 8.4 | 21.7 | 6.9 | 20.2 | 5.3 | 18.1 | 21.6 |
| 5 | 10.4 | 24.1 | 10.3 | 24.1 | 9.9 | 23.2 | 8.9 | 21.7 | 7.3 | 20.2 | 5.5 | 18.1 | 21.6 |
| 6 | 11.6 | 24.1 | 11.5 | 24.1 | 11.1 | 23.2 | 10.0 | 21.7 | 8.2 | 20.2 | 6.4 | 18.1 | 21.6 |
| 7 | 14.6 | 24.1 | 14.4 | 24.1 | 13.9 | 23.2 | 12.7 | 21.7 | 11.2 | 20.2 | 8.8 | 18.1 | 21.6 |
| 8 | 12.2 | 24.1 | 12.1 | 24.1 | 11.7 | 23.2 | 10.4 | 21.7 | 8.4 | 20.2 | 6.3 | 18.1 | 21.6 |
| 9 | 11.7 | 24.1 | 11.5 | 24.1 | 11.1 | 23.2 | 9.8 | 21.7 | 7.7 | 20.2 | 5.4 | 18.1 | 21.6 |
| 10 | 12.3 | 24.1 | 12.1 | 24.1 | 11.6 | 23.2 | 10.3 | 21.7 | 7.9 | 20.2 | 5.5 | 18.1 | 21.6 |
| 11 | 14.7 | 24.1 | 14.4 | 24.1 | 13.9 | 23.2 | 12.4 | 21.7 | 10.3 | 20.2 | 7.2 | 18.1 | 21.6 |
| 12 | 11.7 | 24.1 | 11.5 | 24.1 | 11.1 | 23.2 | 9.6 | 21.7 | 6.9 | 20.2 | 4.1 | 18.1 | 21.6 |
| 13 | 10.5 | 24.1 | 10.3 | 24.1 | 9.8 | 23.2 | 8.4 | 21.7 | 5.5 | 20.2 | 2.7 | 18.1 | 21.6 |
| 14 | 10.0 | 24.1 | 9.8 | 24.1 | 9.3 | 23.2 | 7.8 | 21.7 | 4.7 | 20.2 | 1.4 | 18.1 | 21.6 |
| 15 | 9.8 | 24.1 | 9.6 | 24.1 | 9.2 | 23.2 | 7.6 | 21.7 | 4.2 | 20.2 | 0.0 | 18.1 | 21.6 |
| 16 | 10.3 | 24.1 | 10.1 | 24.1 | 9.7 | 23.2 | 8.1 | 21.7 | 4.2 | 20.2 | | 18.1 | 21.6 |
| 17 | 12.5 | 24.1 | 12.3 | 24.1 | 11.7 | 23.2 | 10.1 | 21.7 | 6.5 | 20.2 | | 18.1 | 21.6 |
| 18 | 9.3 | 24.1 | 9.1 | 24.1 | 8.6 | 23.2 | 7.2 | 21.7 | 2.5 | 20.2 | | 18.1 | 21.6 |
| 19 | 7.7 | 24.1 | 7.5 | 24.1 | 7.1 | 23.2 | 5.6 | 21.7 | 0.0 | 20.2 | | 18.1 | 21.6 |
| 20 | 6.7 | 24.1 | 6.5 | 24.1 | 6.0 | 23.2 | 4.6 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 21 | 5.9 | 24.1 | 5.7 | 24.1 | 5.1 | 23.2 | 3.8 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 22 | 5.3 | 24.1 | 5.0 | 24.1 | 4.4 | 23.2 | 3.3 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 23 | 4.6 | 24.1 | 4.3 | 24.1 | 3.6 | 23.2 | 2.3 | 21.7 | | 20.2 | | 18.1 | 21.6 |
| 24 | 4.5 | 24.1 | 4.2 | 24.1 | 3.5 | 23.2 | 1.1 | 21.7 | | 20.2 | | 18.1 | 21.6 |

Table A54. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 24 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 22.5 | 45.6 | 22.3 | 45.6 | 21.1 | 43.8 | 19.1 | 41.0 | 15.5 | 38.3 | 13.7 | 34.2 | 32.4 |
| 1 | 23.4 | 45.6 | 23.2 | 45.6 | 22.0 | 43.8 | 19.9 | 41.0 | 17.4 | 38.3 | 13.8 | 34.2 | 32.4 |
| 2 | 21.6 | 45.6 | 21.3 | 45.6 | 20.1 | 43.8 | 18.0 | 41.0 | 15.0 | 38.3 | 12.1 | 34.2 | 32.4 |
| 3 | 20.7 | 45.6 | 20.5 | 45.6 | 19.2 | 43.8 | 17.1 | 41.0 | 14.1 | 38.3 | 11.0 | 34.2 | 32.4 |
| 4 | 20.7 | 45.6 | 20.5 | 45.6 | 19.2 | 43.8 | 17.0 | 41.0 | 14.0 | 38.3 | 10.8 | 34.2 | 32.4 |
| 5 | 21.0 | 45.6 | 20.8 | 45.6 | 19.4 | 43.8 | 17.2 | 41.0 | 14.2 | 38.3 | 10.9 | 34.2 | 32.4 |
| 6 | 22.0 | 45.6 | 21.8 | 45.6 | 20.4 | 43.8 | 18.1 | 41.0 | 14.9 | 38.3 | 11.7 | 34.2 | 32.4 |
| 7 | 24.8 | 45.6 | 24.5 | 45.6 | 23.2 | 43.8 | 20.8 | 41.0 | 17.9 | 38.3 | 13.9 | 34.2 | 32.4 |
| 8 | 22.2 | 45.6 | 22.0 | 45.6 | 20.6 | 43.8 | 18.2 | 41.0 | 14.9 | 38.3 | 11.5 | 34.2 | 32.4 |
| 9 | 21.5 | 45.6 | 21.3 | 45.6 | 19.9 | 43.8 | 17.4 | 41.0 | 14.2 | 38.3 | 10.5 | 34.2 | 32.4 |
| 10 | 21.9 | 45.6 | 21.7 | 45.6 | 20.3 | 43.8 | 17.8 | 41.0 | 14.3 | 38.3 | 10.7 | 34.2 | 32.4 |
| 11 | 24.2 | 45.6 | 24.0 | 45.6 | 22.5 | 43.8 | 20.0 | 41.0 | 16.8 | 38.3 | 12.4 | 34.2 | 32.4 |
| 12 | 21.2 | 45.6 | 20.9 | 45.6 | 19.5 | 43.8 | 16.9 | 41.0 | 13.3 | 38.3 | 9.4 | 34.2 | 32.4 |
| 13 | 19.9 | 45.6 | 19.7 | 45.6 | 18.2 | 43.8 | 15.5 | 41.0 | 11.9 | 38.3 | 7.8 | 34.2 | 32.4 |
| 14 | 19.3 | 45.6 | 19.1 | 45.6 | 17.6 | 43.8 | 14.9 | 41.0 | 11.2 | 38.3 | 6.8 | 34.2 | 32.4 |
| 15 | 19.1 | 45.6 | 18.9 | 45.6 | 17.4 | 43.8 | 14.6 | 41.0 | 10.8 | 38.3 | 6.3 | 34.2 | 32.4 |
| 16 | 19.5 | 45.6 | 19.3 | 45.6 | 17.8 | 43.8 | 15.0 | 41.0 | 11.0 | 38.3 | 6.4 | 34.2 | 32.4 |
| 17 | 21.7 | 45.6 | 21.5 | 45.6 | 20.0 | 43.8 | 17.1 | 41.0 | 13.3 | 38.3 | 8.0 | 34.2 | 32.4 |
| 18 | 18.5 | 45.6 | 18.3 | 45.6 | 16.7 | 43.8 | 13.8 | 41.0 | 9.5 | 38.3 | 5.0 | 34.2 | 32.4 |
| 19 | 17.0 | 45.6 | 16.8 | 45.6 | 15.2 | 43.8 | 12.2 | 41.0 | 7.7 | 38.3 | 2.6 | 34.2 | 32.4 |
| 20 | 16.0 | 45.6 | 15.8 | 45.6 | 14.2 | 43.8 | 11.1 | 41.0 | 6.5 | 38.3 | 0.0 | 34.2 | 32.4 |
| 21 | 15.2 | 45.6 | 15.1 | 45.6 | 13.4 | 43.8 | 10.2 | 41.0 | 5.3 | 38.3 | | 34.2 | 32.4 |
| 22 | 14.7 | 45.6 | 14.5 | 45.6 | 12.8 | 43.8 | 9.6 | 41.0 | 4.3 | 38.3 | | 34.2 | 32.4 |
| 23 | 14.0 | 45.6 | 13.8 | 45.6 | 12.1 | 43.8 | 8.8 | 41.0 | 2.4 | 38.3 | | 34.2 | 32.4 |
| 24 | 14.0 | 45.6 | 13.9 | 45.6 | 12.2 | 43.8 | 8.8 | 41.0 | 1.8 | 38.3 | | 34.2 | 32.4 |

Table A55. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 36.5 | 65.3 | 35.8 | 65.3 | 33.8 | 62.7 | 30.0 | 58.8 | 25.5 | 54.9 | 20.7 | 49.0 | 41.4 |
| 1 | 37.3 | 65.3 | 36.8 | 65.3 | 34.5 | 62.7 | 30.7 | 58.8 | 26.1 | 54.9 | 20.6 | 49.0 | 41.4 |
| 2 | 35.1 | 65.3 | 34.5 | 65.3 | 32.3 | 62.7 | 28.5 | 58.8 | 23.8 | 54.9 | 18.6 | 49.0 | 41.4 |
| 3 | 34.1 | 65.3 | 33.5 | 65.3 | 31.2 | 62.7 | 27.3 | 58.8 | 22.6 | 54.9 | 17.3 | 49.0 | 41.4 |
| 4 | 33.9 | 65.3 | 33.3 | 65.3 | 31.0 | 62.7 | 27.0 | 58.8 | 22.3 | 54.9 | 16.9 | 49.0 | 41.4 |
| 5 | 34.0 | 65.3 | 33.4 | 65.3 | 31.1 | 62.7 | 27.1 | 58.8 | 22.3 | 54.9 | 16.8 | 49.0 | 41.4 |
| 6 | 34.9 | 65.3 | 34.3 | 65.3 | 31.9 | 62.7 | 27.9 | 58.8 | 22.9 | 54.9 | 17.5 | 49.0 | 41.4 |
| 7 | 37.6 | 65.3 | 37.0 | 65.3 | 34.5 | 62.7 | 30.4 | 58.8 | 25.4 | 54.9 | 19.6 | 49.0 | 41.4 |
| 8 | 34.9 | 65.3 | 34.2 | 65.3 | 31.8 | 62.7 | 27.7 | 58.8 | 22.6 | 54.9 | 17.0 | 49.0 | 41.4 |
| 9 | 34.1 | 65.3 | 33.5 | 65.3 | 31.0 | 62.7 | 26.8 | 58.8 | 21.7 | 54.9 | 16.0 | 49.0 | 41.4 |
| 10 | 34.4 | 65.3 | 33.8 | 65.3 | 31.3 | 62.7 | 27.1 | 58.8 | 21.8 | 54.9 | 16.1 | 49.0 | 41.4 |
| 11 | 36.6 | 65.3 | 36.1 | 65.3 | 33.5 | 62.7 | 29.2 | 58.8 | 23.8 | 54.9 | 17.7 | 49.0 | 41.4 |
| 12 | 33.5 | 65.3 | 32.9 | 65.3 | 30.4 | 62.7 | 26.0 | 58.8 | 20.5 | 54.9 | 14.6 | 49.0 | 41.4 |
| 13 | 32.2 | 65.3 | 31.6 | 65.3 | 29.1 | 62.7 | 24.7 | 58.8 | 19.0 | 54.9 | 12.9 | 49.0 | 41.4 |
| 14 | 31.6 | 65.3 | 31.0 | 65.3 | 28.5 | 62.7 | 24.0 | 58.8 | 18.2 | 54.9 | 11.9 | 49.0 | 41.4 |
| 15 | 31.4 | 65.3 | 30.8 | 65.3 | 28.2 | 62.7 | 23.7 | 58.8 | 17.8 | 54.9 | 11.4 | 49.0 | 41.4 |
| 16 | 31.9 | 65.3 | 31.2 | 65.3 | 28.7 | 62.7 | 24.1 | 58.8 | 18.0 | 54.9 | 11.4 | 49.0 | 41.4 |
| 17 | 34.1 | 65.3 | 33.6 | 65.3 | 30.9 | 62.7 | 26.3 | 58.8 | 20.0 | 54.9 | 12.9 | 49.0 | 41.4 |
| 18 | 30.9 | 65.3 | 30.2 | 65.3 | 27.7 | 62.7 | 23.0 | 58.8 | 16.5 | 54.9 | 9.4 | 49.0 | 41.4 |
| 19 | 29.4 | 65.3 | 28.8 | 65.3 | 26.2 | 62.7 | 21.5 | 58.8 | 14.8 | 54.9 | 7.3 | 49.0 | 41.4 |
| 20 | 28.4 | 65.3 | 27.9 | 65.3 | 25.3 | 62.7 | 20.5 | 58.8 | 13.7 | 54.9 | 5.7 | 49.0 | 41.4 |
| 21 | 27.7 | 65.3 | 27.2 | 65.3 | 24.6 | 62.7 | 19.8 | 58.8 | 12.7 | 54.9 | 4.1 | 49.0 | 41.4 |
| 22 | 27.2 | 65.3 | 26.6 | 65.3 | 24.0 | 62.7 | 19.2 | 58.8 | 12.1 | 54.9 | 2.9 | 49.0 | 41.4 |
| 23 | 26.6 | 65.3 | 26.1 | 65.3 | 23.5 | 62.7 | 18.6 | 58.8 | 11.3 | 54.9 | 1.3 | 49.0 | 41.4 |
| 24 | 25.1 | 65.3 | 26.1 | 65.3 | 23.6 | 62.7 | 18.7 | 58.8 | 11.4 | 54.9 | 0.0 | 49.0 | 41.4 |

Table A56. Longitudinal Moment Distribution at Critical Section for Two-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 49.3 | 81.7 | 48.4 | 81.7 | 45.2 | 78.4 | 39.5 | 73.5 | 33.0 | 68.6 | 25.6 | 61.3 | 50.2 |
| 1 | 50.0 | 81.7 | 49.1 | 81.7 | 45.9 | 78.4 | 40.7 | 73.5 | 34.3 | 68.6 | 26.2 | 61.3 | 50.2 |
| 2 | 47.6 | 81.7 | 46.7 | 81.7 | 43.5 | 78.4 | 38.1 | 73.5 | 31.5 | 68.6 | 23.6 | 61.3 | 50.2 |
| 3 | 46.5 | 81.7 | 45.6 | 81.7 | 42.3 | 78.4 | 36.9 | 73.5 | 30.3 | 68.6 | 22.1 | 61.3 | 50.2 |
| 4 | 46.2 | 81.7 | 45.2 | 81.7 | 42.0 | 78.4 | 36.5 | 73.5 | 29.8 | 68.6 | 21.4 | 61.3 | 50.2 |
| 5 | 46.2 | 81.7 | 45.3 | 81.7 | 42.0 | 78.4 | 36.5 | 73.5 | 29.7 | 68.6 | 21.1 | 61.3 | 50.2 |
| 6 | 47.0 | 81.7 | 46.1 | 81.7 | 42.7 | 78.4 | 37.1 | 73.5 | 30.2 | 68.6 | 21.0 | 61.3 | 50.2 |
| 7 | 49.6 | 81.7 | 48.6 | 81.7 | 45.3 | 78.4 | 39.8 | 73.5 | 32.9 | 68.6 | 21.6 | 61.3 | 50.2 |
| 8 | 46.9 | 81.7 | 45.9 | 81.7 | 42.5 | 78.4 | 36.9 | 73.5 | 29.7 | 68.6 | 24.0 | 61.3 | 50.2 |
| 9 | 46.0 | 81.7 | 45.1 | 81.7 | 41.7 | 78.4 | 36.0 | 73.5 | 28.8 | 68.6 | 21.1 | 61.3 | 50.2 |
| 10 | 46.3 | 81.7 | 45.4 | 81.7 | 41.9 | 78.4 | 36.2 | 73.5 | 28.9 | 68.6 | 20.0 | 61.3 | 50.2 |
| 11 | 48.5 | 81.7 | 47.6 | 81.7 | 44.1 | 78.4 | 38.5 | 73.5 | 31.1 | 68.6 | 20.0 | 61.3 | 50.2 |
| 12 | 45.4 | 81.7 | 44.4 | 81.7 | 41.0 | 78.4 | 35.1 | 73.5 | 27.5 | 68.6 | 21.8 | 61.3 | 50.2 |
| 13 | 44.1 | 81.7 | 43.1 | 81.7 | 39.6 | 78.4 | 33.8 | 73.5 | 26.1 | 68.6 | 18.3 | 61.3 | 50.2 |
| 14 | 43.5 | 81.7 | 42.5 | 81.7 | 39.0 | 78.4 | 33.1 | 73.5 | 25.3 | 68.6 | 16.6 | 61.3 | 50.2 |
| 15 | 43.2 | 81.7 | 42.3 | 81.7 | 38.8 | 78.4 | 32.9 | 73.5 | 25.0 | 68.6 | 15.5 | 61.3 | 50.2 |
| 16 | 43.7 | 81.7 | 42.7 | 81.7 | 39.3 | 78.4 | 33.2 | 73.5 | 25.2 | 68.6 | 14.8 | 61.3 | 50.2 |
| 17 | 45.9 | 81.7 | 45.0 | 81.7 | 41.5 | 78.4 | 35.6 | 73.5 | 27.5 | 68.6 | 14.7 | 61.3 | 50.2 |
| 18 | 42.7 | 81.7 | 41.8 | 81.7 | 38.3 | 78.4 | 32.2 | 73.5 | 23.9 | 68.6 | 16.3 | 61.3 | 50.2 |
| 19 | 41.3 | 81.7 | 40.3 | 81.7 | 36.9 | 78.4 | 30.8 | 73.5 | 22.4 | 68.6 | 12.4 | 61.3 | 50.2 |
| 20 | 40.4 | 81.7 | 39.5 | 81.7 | 36.0 | 78.4 | 29.9 | 73.5 | 21.4 | 68.6 | 10.2 | 61.3 | 50.2 |
| 21 | 39.7 | 81.7 | 38.8 | 81.7 | 35.3 | 78.4 | 29.3 | 73.5 | 20.7 | 68.6 | 8.6 | 61.3 | 50.2 |
| 22 | 39.3 | 81.7 | 38.3 | 81.7 | 34.9 | 78.4 | 28.8 | 73.5 | 20.1 | 68.6 | 7.4 | 61.3 | 50.2 |
| 23 | 38.8 | 81.7 | 37.9 | 81.7 | 34.4 | 78.4 | 28.2 | 73.5 | 19.6 | 68.6 | 6.3 | 61.3 | 50.2 |
| 24 | 37.1 | 81.7 | 35.6 | 81.7 | 34.5 | 78.4 | 28.3 | 73.5 | 19.6 | 68.6 | 6.6 | 61.3 | 50.2 |

Table A57. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 36 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 11.2 | 22.6 | 11.2 | 22.6 | 10.9 | 21.7 | 9.9 | 20.3 | 7.6 | 19.0 | 7.2 | 17.0 | 21.6 |
| 1 | 12.5 | 22.6 | 12.4 | 22.6 | 11.9 | 21.7 | 10.7 | 20.3 | 9.7 | 19.0 | 7.8 | 17.0 | 21.6 |
| 2 | 11.2 | 22.6 | 11.1 | 22.6 | 10.6 | 21.7 | 9.3 | 20.3 | 7.6 | 19.0 | 6.3 | 17.0 | 21.6 |
| 3 | 10.7 | 22.6 | 10.6 | 22.6 | 10.1 | 21.7 | 8.7 | 20.3 | 7.0 | 19.0 | 5.4 | 17.0 | 21.6 |
| 4 | 11.1 | 22.6 | 11.0 | 22.6 | 10.4 | 21.7 | 8.9 | 20.3 | 7.0 | 19.0 | 5.3 | 17.0 | 21.6 |
| 5 | 11.8 | 22.6 | 11.7 | 22.6 | 11.1 | 21.7 | 9.4 | 20.3 | 7.4 | 19.0 | 5.5 | 17.0 | 21.6 |
| 6 | 13.2 | 22.6 | 13.0 | 22.6 | 12.4 | 21.7 | 10.6 | 20.3 | 8.3 | 19.0 | 6.4 | 17.0 | 21.6 |
| 7 | 16.4 | 22.6 | 16.1 | 22.6 | 15.3 | 21.7 | 13.2 | 20.3 | 11.3 | 19.0 | 8.7 | 17.0 | 21.6 |
| 8 | 14.2 | 22.6 | 14.0 | 22.6 | 13.2 | 21.7 | 11.0 | 20.3 | 8.4 | 19.0 | 6.3 | 17.0 | 21.6 |
| 9 | 13.9 | 22.6 | 13.7 | 22.6 | 12.8 | 21.7 | 10.4 | 20.3 | 7.7 | 19.0 | 5.3 | 17.0 | 21.6 |
| 10 | 14.6 | 22.6 | 14.4 | 22.6 | 13.5 | 21.7 | 10.9 | 20.3 | 7.9 | 19.0 | 5.5 | 17.0 | 21.6 |
| 11 | 17.3 | 22.6 | 17.0 | 22.6 | 15.9 | 21.7 | 13.1 | 20.3 | 10.3 | 19.0 | 7.1 | 17.0 | 21.6 |
| 12 | 14.6 | 22.6 | 14.4 | 22.6 | 13.2 | 21.7 | 10.3 | 20.3 | 6.7 | 19.0 | 4.0 | 17.0 | 21.6 |
| 13 | 13.7 | 22.6 | 13.5 | 22.6 | 12.2 | 21.7 | 9.1 | 20.3 | 5.3 | 19.0 | 2.6 | 17.0 | 21.6 |
| 14 | 13.5 | 22.6 | 13.3 | 22.6 | 11.9 | 21.7 | 8.5 | 20.3 | 4.3 | 19.0 | 1.2 | 17.0 | 21.6 |
| 15 | 13.7 | 22.6 | 13.5 | 22.6 | 12.1 | 21.7 | 8.4 | 20.3 | 3.7 | 19.0 | 0.0 | 17.0 | 21.6 |
| 16 | 14.6 | 22.6 | 14.4 | 22.6 | 12.9 | 21.7 | 9.0 | 20.3 | 3.7 | 19.0 | | 17.0 | 21.6 |
| 17 | 17.4 | 22.6 | 17.1 | 22.6 | 15.4 | 21.7 | 11.1 | 20.3 | 5.8 | 19.0 | | 17.0 | 21.6 |
| 18 | 14.7 | 22.6 | 14.5 | 22.6 | 12.9 | 21.7 | 8.4 | 20.3 | 1.7 | 19.0 | | 17.0 | 21.6 |
| 19 | 14.0 | 22.6 | 13.8 | 22.6 | 12.0 | 21.7 | 7.3 | 20.3 | 0.0 | 19.0 | | 17.0 | 21.6 |
| 20 | 14.4 | 22.6 | 14.1 | 22.6 | 12.3 | 21.7 | 7.3 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 21 | 16.6 | 22.6 | 16.3 | 22.6 | 14.3 | 21.7 | 8.9 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 22 | 13.5 | 22.6 | 13.2 | 22.6 | 11.3 | 21.7 | 5.6 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 23 | 12.1 | 22.6 | 11.9 | 22.6 | 9.9 | 21.7 | 3.9 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 24 | 11.5 | 22.6 | 11.2 | 22.6 | 9.2 | 21.7 | 2.6 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 25 | 11.2 | 22.6 | 10.9 | 22.6 | 8.9 | 21.7 | 0.0 | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 26 | 11.5 | 22.6 | 11.3 | 22.6 | 9.3 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 27 | 13.6 | 22.6 | 13.4 | 22.6 | 11.3 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 28 | 10.3 | 22.6 | 10.1 | 22.6 | 8.1 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 29 | 8.7 | 22.6 | 8.4 | 22.6 | 6.5 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 30 | 7.6 | 22.6 | 7.3 | 22.6 | 5.4 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 31 | 6.7 | 22.6 | 6.4 | 22.6 | 4.6 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 32 | 6.0 | 22.6 | 5.7 | 22.6 | 3.9 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 33 | 5.3 | 22.6 | 5.0 | 22.6 | 3.3 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 34 | 4.8 | 22.6 | 4.4 | 22.6 | 2.9 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 35 | 4.1 | 22.6 | 3.7 | 22.6 | 2.4 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |
| 36 | 4.0 | 22.6 | 3.5 | 22.6 | 0.4 | 21.7 | | 20.3 | | 19.0 | | 17.0 | 21.6 |

Table A58. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 36 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 25.5 | 42.3 | 25.4 | 42.3 | 23.8 | 40.6 | 21.4 | 38.1 | 16.7 | 35.5 | 13.9 | 31.7 | 32.4 |
| 1 | 26.4 | 42.3 | 26.3 | 42.3 | 24.7 | 40.6 | 21.8 | 38.1 | 18.3 | 35.5 | 14.1 | 31.7 | 32.4 |
| 2 | 24.7 | 42.3 | 24.5 | 42.3 | 22.8 | 40.6 | 20.1 | 38.1 | 15.9 | 35.5 | 12.3 | 31.7 | 32.4 |
| 3 | 24.0 | 42.3 | 23.8 | 42.3 | 22.1 | 40.6 | 19.1 | 38.1 | 15.0 | 35.5 | 11.2 | 31.7 | 32.4 |
| 4 | 24.1 | 42.3 | 23.9 | 42.3 | 22.2 | 40.6 | 19.1 | 38.1 | 14.9 | 35.5 | 10.9 | 31.7 | 32.4 |
| 5 | 24.5 | 42.3 | 24.3 | 42.3 | 22.5 | 40.6 | 19.4 | 38.1 | 15.0 | 35.5 | 11.0 | 31.7 | 32.4 |
| 6 | 25.7 | 42.3 | 25.5 | 42.3 | 23.6 | 40.6 | 20.4 | 38.1 | 15.8 | 35.5 | 11.8 | 31.7 | 32.4 |
| 7 | 28.6 | 42.3 | 28.4 | 42.3 | 26.5 | 40.6 | 22.9 | 38.1 | 18.8 | 35.5 | 14.1 | 31.7 | 32.4 |
| 8 | 26.2 | 42.3 | 26.0 | 42.3 | 24.0 | 40.6 | 20.6 | 38.1 | 15.8 | 35.5 | 11.6 | 31.7 | 32.4 |
| 9 | 25.7 | 42.3 | 25.5 | 42.3 | 23.5 | 40.6 | 19.9 | 38.1 | 15.0 | 35.5 | 10.6 | 31.7 | 32.4 |
| 10 | 26.3 | 42.3 | 26.1 | 42.3 | 24.0 | 40.6 | 20.4 | 38.1 | 15.2 | 35.5 | 10.7 | 31.7 | 32.4 |
| 11 | 28.8 | 42.3 | 28.5 | 42.3 | 26.4 | 40.6 | 22.5 | 38.1 | 17.7 | 35.5 | 12.4 | 31.7 | 32.4 |
| 12 | 25.9 | 42.3 | 25.7 | 42.3 | 23.5 | 40.6 | 19.7 | 38.1 | 14.2 | 35.5 | 9.3 | 31.7 | 32.4 |
| 13 | 24.9 | 42.3 | 24.6 | 42.3 | 22.4 | 40.6 | 18.4 | 38.1 | 12.9 | 35.5 | 7.7 | 31.7 | 32.4 |
| 14 | 24.6 | 42.3 | 24.3 | 42.3 | 22.1 | 40.6 | 17.9 | 38.1 | 12.2 | 35.5 | 6.7 | 31.7 | 32.4 |
| 15 | 24.7 | 42.3 | 24.4 | 42.3 | 22.1 | 40.6 | 17.9 | 38.1 | 11.9 | 35.5 | 6.1 | 31.7 | 32.4 |
| 16 | 25.4 | 42.3 | 25.2 | 42.3 | 22.9 | 40.6 | 18.5 | 38.1 | 12.2 | 35.5 | 6.1 | 31.7 | 32.4 |
| 17 | 28.0 | 42.3 | 27.8 | 42.3 | 25.4 | 40.6 | 20.8 | 38.1 | 14.7 | 35.5 | 7.6 | 31.7 | 32.4 |
| 18 | 25.3 | 42.3 | 25.0 | 42.3 | 22.6 | 40.6 | 18.1 | 38.1 | 11.3 | 35.5 | 4.6 | 31.7 | 32.4 |
| 19 | 24.5 | 42.3 | 24.2 | 42.3 | 21.8 | 40.6 | 17.1 | 38.1 | 10.0 | 35.5 | 2.1 | 31.7 | 32.4 |
| 20 | 24.7 | 42.3 | 24.4 | 42.3 | 22.0 | 40.6 | 17.2 | 38.1 | 9.8 | 35.5 | 0.0 | 31.7 | 32.4 |
| 21 | 26.9 | 42.3 | 26.6 | 42.3 | 24.0 | 40.6 | 19.0 | 38.1 | 11.7 | 35.5 | | 31.7 | 32.4 |
| 22 | 23.6 | 42.3 | 23.3 | 42.3 | 20.8 | 40.6 | 15.8 | 38.1 | 7.8 | 35.5 | | 31.7 | 32.4 |
| 23 | 22.2 | 42.3 | 21.9 | 42.3 | 19.3 | 40.6 | 14.2 | 38.1 | 5.8 | 35.5 | | 31.7 | 32.4 |
| 24 | 21.5 | 42.3 | 21.2 | 42.3 | 18.5 | 40.6 | 13.3 | 38.1 | 4.6 | 35.5 | | 31.7 | 32.4 |
| 25 | 21.1 | 42.3 | 20.8 | 42.3 | 18.1 | 40.6 | 12.8 | 38.1 | 3.1 | 35.5 | | 31.7 | 32.4 |
| 26 | 21.5 | 42.3 | 21.1 | 42.3 | 18.4 | 40.6 | 13.0 | 38.1 | 0.0 | 35.5 | | 31.7 | 32.4 |
| 27 | 23.5 | 42.3 | 23.2 | 42.3 | 20.4 | 40.6 | 14.7 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 28 | 20.1 | 42.3 | 19.8 | 42.3 | 16.9 | 40.6 | 11.3 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 29 | 18.5 | 42.3 | 18.1 | 42.3 | 15.2 | 40.6 | 9.5 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 30 | 17.4 | 42.3 | 17.0 | 42.3 | 14.0 | 40.6 | 8.2 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 31 | 16.5 | 42.3 | 16.1 | 42.3 | 13.0 | 40.6 | 7.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 32 | 15.7 | 42.3 | 15.4 | 42.3 | 12.1 | 40.6 | 6.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 33 | 15.1 | 42.3 | 14.7 | 42.3 | 11.3 | 40.6 | 5.3 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 34 | 14.5 | 42.3 | 14.1 | 42.3 | 10.6 | 40.6 | 4.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 35 | 13.9 | 42.3 | 13.5 | 42.3 | 9.8 | 40.6 | 6.6 | 38.1 | | 35.5 | | 31.7 | 32.4 |
| 36 | 13.9 | 42.3 | 13.5 | 42.3 | 9.7 | 40.6 | 0.0 | 38.1 | | 35.5 | | 31.7 | 32.4 |

Table A59. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 46 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 41.4 | 60.4 | 40.6 | 60.4 | 37.9 | 58.0 | 33.1 | 54.4 | 26.6 | 50.7 | 21.5 | 45.3 | 41.4 |
| 1 | 42.1 | 60.4 | 41.6 | 60.4 | 38.6 | 58.0 | 33.8 | 54.4 | 27.9 | 50.7 | 21.4 | 45.3 | 41.4 |
| 2 | 40.0 | 60.4 | 39.4 | 60.4 | 36.5 | 58.0 | 31.5 | 54.4 | 25.3 | 50.7 | 19.4 | 45.3 | 41.4 |
| 3 | 39.0 | 60.4 | 38.4 | 60.4 | 35.4 | 58.0 | 30.4 | 54.4 | 24.2 | 50.7 | 18.1 | 45.3 | 41.4 |
| 4 | 38.9 | 60.4 | 38.3 | 60.4 | 35.2 | 58.0 | 30.1 | 54.4 | 23.9 | 50.7 | 17.7 | 45.3 | 41.4 |
| 5 | 39.1 | 60.4 | 38.4 | 60.4 | 35.3 | 58.0 | 30.2 | 54.4 | 23.9 | 50.7 | 17.6 | 45.3 | 41.4 |
| 6 | 40.0 | 60.4 | 39.3 | 60.4 | 36.2 | 58.0 | 31.0 | 54.4 | 24.5 | 50.7 | 18.3 | 45.3 | 41.4 |
| 7 | 42.8 | 60.4 | 42.2 | 60.4 | 38.9 | 58.0 | 33.6 | 54.4 | 27.3 | 50.7 | 20.4 | 45.3 | 41.4 |
| 8 | 40.2 | 60.4 | 39.5 | 60.4 | 36.2 | 58.0 | 30.9 | 54.4 | 24.2 | 50.7 | 17.9 | 45.3 | 41.4 |
| 9 | 39.5 | 60.4 | 38.8 | 60.4 | 35.5 | 58.0 | 30.0 | 54.4 | 23.4 | 50.7 | 16.8 | 45.3 | 41.4 |
| 10 | 39.9 | 60.4 | 39.2 | 60.4 | 35.8 | 58.0 | 30.3 | 54.4 | 23.5 | 50.7 | 16.9 | 45.3 | 41.4 |
| 11 | 42.3 | 60.4 | 41.6 | 60.4 | 38.1 | 58.0 | 32.5 | 54.4 | 25.9 | 50.7 | 18.6 | 45.3 | 41.4 |
| 12 | 39.3 | 60.4 | 38.5 | 60.4 | 35.0 | 58.0 | 29.4 | 54.4 | 22.3 | 50.7 | 15.5 | 45.3 | 41.4 |
| 13 | 38.1 | 60.4 | 37.4 | 60.4 | 33.8 | 58.0 | 28.1 | 54.4 | 21.0 | 50.7 | 13.9 | 45.3 | 41.4 |
| 14 | 37.7 | 60.4 | 36.9 | 60.4 | 33.3 | 58.0 | 27.5 | 54.4 | 20.3 | 50.7 | 13.0 | 45.3 | 41.4 |
| 15 | 37.6 | 60.4 | 36.9 | 60.4 | 33.2 | 58.0 | 27.3 | 54.4 | 20.0 | 50.7 | 12.6 | 45.3 | 41.4 |
| 16 | 38.3 | 60.4 | 37.5 | 60.4 | 33.9 | 58.0 | 27.9 | 54.4 | 20.3 | 50.7 | 12.8 | 45.3 | 41.4 |
| 17 | 40.9 | 60.4 | 40.2 | 60.4 | 36.3 | 58.0 | 30.2 | 54.4 | 22.8 | 50.7 | 14.5 | 45.3 | 41.4 |
| 18 | 38.1 | 60.4 | 37.2 | 60.4 | 33.5 | 58.0 | 27.3 | 54.4 | 19.4 | 50.7 | 11.5 | 45.3 | 41.4 |
| 19 | 37.1 | 60.4 | 36.4 | 60.4 | 32.5 | 58.0 | 26.2 | 54.4 | 18.3 | 50.7 | 9.9 | 45.3 | 41.4 |
| 20 | 37.3 | 60.4 | 36.5 | 60.4 | 32.7 | 58.0 | 26.2 | 54.4 | 18.0 | 50.7 | 9.5 | 45.3 | 41.4 |
| 21 | 39.4 | 60.4 | 38.7 | 60.4 | 34.7 | 58.0 | 28.1 | 54.4 | 20.1 | 50.7 | 10.6 | 45.3 | 41.4 |
| 22 | 36.2 | 60.4 | 35.4 | 60.4 | 31.4 | 58.0 | 24.7 | 54.4 | 16.2 | 50.7 | 7.4 | 45.3 | 41.4 |
| 23 | 34.8 | 60.4 | 33.9 | 60.4 | 29.9 | 58.0 | 23.0 | 54.4 | 14.4 | 50.7 | 4.5 | 45.3 | 41.4 |
| 24 | 34.0 | 60.4 | 33.2 | 60.4 | 29.1 | 58.0 | 22.1 | 54.4 | 13.2 | 50.7 | 0.0 | 45.3 | 41.4 |
| 25 | 33.7 | 60.4 | 32.9 | 60.4 | 28.7 | 58.0 | 21.5 | 54.4 | 12.5 | 50.7 | | 45.3 | 41.4 |
| 26 | 34.0 | 60.4 | 33.1 | 60.4 | 28.9 | 58.0 | 21.6 | 54.4 | 12.3 | 50.7 | | 45.3 | 41.4 |
| 27 | 36.1 | 60.4 | 35.3 | 60.4 | 30.9 | 58.0 | 23.4 | 54.4 | 14.2 | 50.7 | | 45.3 | 41.4 |
| 28 | 32.7 | 60.4 | 31.9 | 60.4 | 27.5 | 58.0 | 19.7 | 54.4 | 10.1 | 50.7 | | 45.3 | 41.4 |
| 29 | 31.1 | 60.4 | 30.3 | 60.4 | 25.8 | 58.0 | 17.8 | 54.4 | 8.0 | 50.7 | | 45.3 | 41.4 |
| 30 | 30.1 | 60.4 | 29.2 | 60.4 | 24.7 | 58.0 | 16.4 | 54.4 | 6.7 | 50.7 | | 45.3 | 41.4 |
| 31 | 29.2 | 60.4 | 28.4 | 60.4 | 23.8 | 58.0 | 15.2 | 54.4 | 4.9 | 50.7 | | 45.3 | 41.4 |
| 32 | 28.6 | 60.4 | 27.7 | 60.4 | 23.0 | 58.0 | 14.2 | 54.4 | 0.0 | 50.7 | | 45.3 | 41.4 |
| 33 | 28.0 | 60.4 | 27.1 | 60.4 | 22.4 | 58.0 | 13.2 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 34 | 27.5 | 60.4 | 26.7 | 60.4 | 21.8 | 58.0 | 12.4 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 35 | 27.0 | 60.4 | 26.2 | 60.4 | 21.2 | 58.0 | 11.4 | 54.4 | | 50.7 | | 45.3 | 41.4 |
| 36 | 25.6 | 60.4 | 26.2 | 60.4 | 21.2 | 58.0 | 11.3 | 54.4 | | 50.7 | | 45.3 | 41.4 |

Table A60. Longitudinal Moment Distribution at Critical Section for Three-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 54 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 53.0 | 77.1 | 54.0 | 77.1 | 50.1 | 74.0 | 43.1 | 69.4 | 35.5 | 64.8 | 28.3 | 57.8 | 50.2 |
| 1 | 50.9 | 77.1 | 54.7 | 77.1 | 50.7 | 74.0 | 44.2 | 69.4 | 36.8 | 64.8 | 28.2 | 57.8 | 50.2 |
| 2 | 51.7 | 77.1 | 52.3 | 77.1 | 48.3 | 74.0 | 41.6 | 69.4 | 33.9 | 64.8 | 25.9 | 57.8 | 50.2 |
| 3 | 51.2 | 77.1 | 51.1 | 77.1 | 47.0 | 74.0 | 40.4 | 69.4 | 32.6 | 64.8 | 24.5 | 57.8 | 50.2 |
| 4 | 50.9 | 77.1 | 50.8 | 77.1 | 46.7 | 74.0 | 39.9 | 69.4 | 32.1 | 64.8 | 23.9 | 57.8 | 50.2 |
| 5 | 50.9 | 77.1 | 50.8 | 77.1 | 46.7 | 74.0 | 39.8 | 69.4 | 32.0 | 64.8 | 23.8 | 57.8 | 50.2 |
| 6 | 51.1 | 77.1 | 51.6 | 77.1 | 47.4 | 74.0 | 40.5 | 69.4 | 32.5 | 64.8 | 24.4 | 57.8 | 50.2 |
| 7 | 50.4 | 77.1 | 54.2 | 77.1 | 49.9 | 74.0 | 43.1 | 69.4 | 35.2 | 64.8 | 26.5 | 57.8 | 50.2 |
| 8 | 50.9 | 77.1 | 51.5 | 77.1 | 47.2 | 74.0 | 40.1 | 69.4 | 32.0 | 64.8 | 23.8 | 57.8 | 50.2 |
| 9 | 50.7 | 77.1 | 50.7 | 77.1 | 46.3 | 74.0 | 39.2 | 69.4 | 31.1 | 64.8 | 22.7 | 57.8 | 50.2 |
| 10 | 50.5 | 77.1 | 51.0 | 77.1 | 46.6 | 74.0 | 39.3 | 69.4 | 31.1 | 64.8 | 22.8 | 57.8 | 50.2 |
| 11 | 49.5 | 77.1 | 53.3 | 77.1 | 48.8 | 74.0 | 41.6 | 69.4 | 33.4 | 64.8 | 24.5 | 57.8 | 50.2 |
| 12 | 49.7 | 77.1 | 50.2 | 77.1 | 45.7 | 74.0 | 38.2 | 69.4 | 29.8 | 64.8 | 21.4 | 57.8 | 50.2 |
| 13 | 49.2 | 77.1 | 49.0 | 77.1 | 44.4 | 74.0 | 36.9 | 69.4 | 28.4 | 64.8 | 19.8 | 57.8 | 50.2 |
| 14 | 48.7 | 77.1 | 48.4 | 77.1 | 43.8 | 74.0 | 36.2 | 69.4 | 27.6 | 64.8 | 18.9 | 57.8 | 50.2 |
| 15 | 48.6 | 77.1 | 48.4 | 77.1 | 43.7 | 74.0 | 36.0 | 69.4 | 27.2 | 64.8 | 18.5 | 57.8 | 50.2 |
| 16 | 48.6 | 77.1 | 49.0 | 77.1 | 44.2 | 74.0 | 36.4 | 69.4 | 27.5 | 64.8 | 18.8 | 57.8 | 50.2 |
| 17 | 47.8 | 77.1 | 51.5 | 77.1 | 46.7 | 74.0 | 38.9 | 69.4 | 30.0 | 64.8 | 20.6 | 57.8 | 50.2 |
| 18 | 48.2 | 77.1 | 48.6 | 77.1 | 43.8 | 74.0 | 35.7 | 69.4 | 26.5 | 64.8 | 17.6 | 57.8 | 50.2 |
| 19 | 47.8 | 77.1 | 47.7 | 77.1 | 42.8 | 74.0 | 34.6 | 69.4 | 25.3 | 64.8 | 16.2 | 57.8 | 50.2 |
| 20 | 47.5 | 77.1 | 47.9 | 77.1 | 42.9 | 74.0 | 34.6 | 69.4 | 25.1 | 64.8 | 15.9 | 57.8 | 50.2 |
| 21 | 46.3 | 77.1 | 49.9 | 77.1 | 44.9 | 74.0 | 36.7 | 69.4 | 27.0 | 64.8 | 17.1 | 57.8 | 50.2 |
| 22 | 46.4 | 77.1 | 46.7 | 77.1 | 41.6 | 74.0 | 33.0 | 69.4 | 23.1 | 64.8 | 13.5 | 57.8 | 50.2 |
| 23 | 45.6 | 77.1 | 45.3 | 77.1 | 40.2 | 74.0 | 31.4 | 69.4 | 21.3 | 64.8 | 11.4 | 57.8 | 50.2 |
| 24 | 45.0 | 77.1 | 44.5 | 77.1 | 39.4 | 74.0 | 30.5 | 69.4 | 20.1 | 64.8 | 9.8 | 57.8 | 50.2 |
| 25 | 44.6 | 77.1 | 44.2 | 77.1 | 39.0 | 74.0 | 30.0 | 69.4 | 19.2 | 64.8 | 8.5 | 57.8 | 50.2 |
| 26 | 44.3 | 77.1 | 44.5 | 77.1 | 39.3 | 74.0 | 30.0 | 69.4 | 18.9 | 64.8 | 7.5 | 57.8 | 50.2 |
| 27 | 43.2 | 77.1 | 46.7 | 77.1 | 41.4 | 74.0 | 32.1 | 69.4 | 20.7 | 64.8 | 6.1 | 57.8 | 50.2 |
| 28 | 43.2 | 77.1 | 43.3 | 77.1 | 38.0 | 74.0 | 28.4 | 69.4 | 16.5 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 42.3 | 77.1 | 41.8 | 77.1 | 36.4 | 74.0 | 26.6 | 69.4 | 14.2 | 64.8 | | 57.8 | 50.2 |
| 30 | 41.4 | 77.1 | 40.8 | 77.1 | 35.4 | 74.0 | 25.4 | 69.4 | 12.4 | 64.8 | | 57.8 | 50.2 |
| 31 | 40.7 | 77.1 | 40.0 | 77.1 | 34.5 | 74.0 | 24.4 | 69.4 | 10.6 | 64.8 | | 57.8 | 50.2 |
| 32 | 40.1 | 77.1 | 39.4 | 77.1 | 33.9 | 74.0 | 23.5 | 69.4 | 8.9 | 64.8 | | 57.8 | 50.2 |
| 33 | 39.7 | 77.1 | 38.9 | 77.1 | 33.3 | 74.0 | 22.8 | 69.4 | 7.1 | 64.8 | | 57.8 | 50.2 |
| 34 | 39.3 | 77.1 | 38.5 | 77.1 | 32.9 | 74.0 | 22.2 | 69.4 | 4.5 | 64.8 | | 57.8 | 50.2 |
| 35 | 38.9 | 77.1 | 38.1 | 77.1 | 32.5 | 74.0 | 21.4 | 69.4 | 2.6 | 64.8 | | 57.8 | 50.2 |
| 36 | 36.6 | 77.1 | 35.0 | 77.1 | 32.5 | 74.0 | 21.3 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |

Table A61. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 24 ft, Deck Width = 48 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|---------------------------|------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | | LRFD |
| 0 | 11.4 | 21.5 | 11.5 | 21.5 | 11.1 | 20.6 | 10.0 | 19.4 | 7.6 | 18.1 | 7.2 | 16.1 | 21.6 |
| 1 | 12.8 | 21.5 | 12.7 | 21.5 | 12.1 | 20.6 | 10.8 | 19.4 | 9.7 | 18.1 | 7.8 | 16.1 | 21.6 |
| 2 | 11.5 | 21.5 | 11.4 | 21.5 | 10.8 | 20.6 | 9.4 | 19.4 | 7.6 | 18.1 | 6.3 | 16.1 | 21.6 |
| 3 | 11.1 | 21.5 | 11.0 | 21.5 | 10.3 | 20.6 | 8.8 | 19.4 | 7.0 | 18.1 | 5.4 | 16.1 | 21.6 |
| 4 | 11.6 | 21.5 | 11.4 | 21.5 | 10.7 | 20.6 | 9.0 | 19.4 | 7.0 | 18.1 | 5.3 | 16.1 | 21.6 |
| 5 | 12.3 | 21.5 | 12.2 | 21.5 | 11.3 | 20.6 | 9.5 | 19.4 | 7.4 | 18.1 | 5.5 | 16.1 | 21.6 |
| 6 | 13.8 | 21.5 | 13.6 | 21.5 | 12.7 | 20.6 | 10.7 | 19.4 | 8.3 | 18.1 | 6.4 | 16.1 | 21.6 |
| 7 | 17.0 | 21.5 | 16.8 | 21.5 | 15.7 | 20.6 | 13.3 | 19.4 | 11.3 | 18.1 | 8.7 | 16.1 | 21.6 |
| 8 | 14.9 | 21.5 | 14.7 | 21.5 | 13.6 | 20.6 | 11.1 | 19.4 | 8.4 | 18.1 | 6.3 | 16.1 | 21.6 |
| 9 | 14.6 | 21.5 | 14.5 | 21.5 | 13.2 | 20.6 | 10.5 | 19.4 | 7.7 | 18.1 | 5.3 | 16.1 | 21.6 |
| 10 | 15.5 | 21.5 | 15.3 | 21.5 | 13.9 | 20.6 | 11.0 | 19.4 | 7.9 | 18.1 | 5.5 | 16.1 | 21.6 |
| 11 | 18.2 | 21.5 | 18.0 | 21.5 | 16.3 | 20.6 | 13.1 | 19.4 | 10.2 | 18.1 | 7.1 | 16.1 | 21.6 |
| 12 | 15.6 | 21.5 | 15.4 | 21.5 | 13.7 | 20.6 | 10.4 | 19.4 | 6.7 | 18.1 | 4.0 | 16.1 | 21.6 |
| 13 | 14.9 | 21.5 | 14.6 | 21.5 | 12.7 | 20.6 | 9.1 | 19.4 | 5.2 | 18.1 | 2.6 | 16.1 | 21.6 |
| 14 | 14.8 | 21.5 | 14.6 | 21.5 | 12.5 | 20.6 | 8.6 | 19.4 | 4.3 | 18.1 | 1.2 | 16.1 | 21.6 |
| 15 | 15.2 | 21.5 | 14.9 | 21.5 | 12.6 | 20.6 | 8.4 | 19.4 | 3.7 | 18.1 | 0.0 | 16.1 | 21.6 |
| 16 | 16.2 | 21.5 | 16.0 | 21.5 | 13.5 | 20.6 | 9.0 | 19.4 | 3.6 | 18.1 | | 16.1 | 21.6 |
| 17 | 19.1 | 21.5 | 18.8 | 21.5 | 16.0 | 20.6 | 11.1 | 19.4 | 5.7 | 18.1 | | 16.1 | 21.6 |
| 18 | 16.7 | 21.5 | 16.4 | 21.5 | 13.5 | 20.6 | 8.3 | 19.4 | 1.6 | 18.1 | | 16.1 | 21.6 |
| 19 | 16.1 | 21.5 | 15.8 | 21.5 | 12.7 | 20.6 | 7.1 | 19.4 | 0.0 | 18.1 | | 16.1 | 21.6 |
| 20 | 16.7 | 21.5 | 16.4 | 21.5 | 13.0 | 20.6 | 7.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 21 | 19.2 | 21.5 | 18.8 | 21.5 | 15.1 | 20.6 | 8.5 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 22 | 16.3 | 21.5 | 15.9 | 21.5 | 12.1 | 20.6 | 5.1 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 23 | 15.3 | 21.5 | 14.9 | 21.5 | 10.7 | 20.6 | 3.4 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 24 | 14.9 | 21.5 | 14.5 | 21.5 | 10.1 | 20.6 | 1.9 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 25 | 15.0 | 21.5 | 14.6 | 21.5 | 9.9 | 20.6 | 0.0 | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 26 | 15.8 | 21.5 | 15.4 | 21.5 | 10.4 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 27 | 18.5 | 21.5 | 17.9 | 21.5 | 12.5 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 28 | 15.7 | 21.5 | 15.2 | 21.5 | 9.6 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 29 | 14.9 | 21.5 | 14.4 | 21.5 | 8.5 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 30 | 15.2 | 21.5 | 14.7 | 21.5 | 8.5 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 31 | 17.3 | 21.5 | 16.7 | 21.5 | 10.2 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 32 | 14.1 | 21.5 | 13.6 | 21.5 | 6.9 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 33 | 12.7 | 21.5 | 12.2 | 21.5 | 5.1 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 34 | 12.0 | 21.5 | 11.5 | 21.5 | 4.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 35 | 11.7 | 21.5 | 11.1 | 21.5 | 3.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 36 | 12.0 | 21.5 | 11.5 | 21.5 | 2.3 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 37 | 14.1 | 21.5 | 13.5 | 21.5 | 1.7 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 38 | 10.7 | 21.5 | 10.2 | 21.5 | 0.0 | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 39 | 9.1 | 21.5 | 8.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 40 | 8.0 | 21.5 | 7.4 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 41 | 7.1 | 21.5 | 6.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 42 | 6.3 | 21.5 | 5.7 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 43 | 5.6 | 21.5 | 5.0 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 44 | 5.0 | 21.5 | 4.4 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 45 | 4.5 | 21.5 | 3.8 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 46 | 4.0 | 21.5 | 3.3 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 47 | 3.5 | 21.5 | 2.7 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |
| 48 | 3.3 | 21.5 | 2.5 | 21.5 | | 20.6 | | 19.4 | | 18.1 | | 16.1 | 21.6 |

Table A62. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 36 ft, Deck Width = 48 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 27.0 | 40.0 | 26.9 | 40.0 | 25.0 | 38.4 | 22.0 | 36.0 | 16.9 | 33.6 | 13.9 | 30.0 | 32.4 |
| 1 | 28.0 | 40.0 | 27.9 | 40.0 | 25.9 | 38.4 | 22.2 | 36.0 | 18.4 | 33.6 | 14.1 | 30.0 | 32.4 |
| 2 | 26.3 | 40.0 | 26.2 | 40.0 | 24.2 | 38.4 | 20.7 | 36.0 | 16.1 | 33.6 | 12.3 | 30.0 | 32.4 |
| 3 | 25.7 | 40.0 | 25.6 | 40.0 | 23.4 | 38.4 | 19.7 | 36.0 | 15.2 | 33.6 | 11.2 | 30.0 | 32.4 |
| 4 | 25.9 | 40.0 | 25.7 | 40.0 | 23.5 | 38.4 | 19.7 | 36.0 | 15.0 | 33.6 | 10.9 | 30.0 | 32.4 |
| 5 | 26.4 | 40.0 | 26.3 | 40.0 | 24.0 | 38.4 | 20.0 | 36.0 | 15.2 | 33.6 | 11.0 | 30.0 | 32.4 |
| 6 | 27.6 | 40.0 | 27.5 | 40.0 | 25.1 | 38.4 | 21.0 | 36.0 | 16.0 | 33.6 | 11.8 | 30.0 | 32.4 |
| 7 | 30.7 | 40.0 | 30.5 | 40.0 | 28.1 | 38.4 | 23.5 | 36.0 | 18.9 | 33.6 | 14.1 | 30.0 | 32.4 |
| 8 | 28.4 | 40.0 | 28.2 | 40.0 | 25.7 | 38.4 | 21.2 | 36.0 | 15.9 | 33.6 | 11.6 | 30.0 | 32.4 |
| 9 | 28.0 | 40.0 | 27.8 | 40.0 | 25.2 | 38.4 | 20.6 | 36.0 | 15.1 | 33.6 | 10.6 | 30.0 | 32.4 |
| 10 | 28.7 | 40.0 | 28.5 | 40.0 | 25.8 | 38.4 | 21.0 | 36.0 | 15.3 | 33.6 | 10.7 | 30.0 | 32.4 |
| 11 | 31.4 | 40.0 | 31.1 | 40.0 | 28.3 | 38.4 | 23.1 | 36.0 | 17.7 | 33.6 | 12.4 | 30.0 | 32.4 |
| 12 | 28.6 | 40.0 | 28.4 | 40.0 | 25.5 | 38.4 | 20.4 | 36.0 | 14.3 | 33.6 | 9.3 | 30.0 | 32.4 |
| 13 | 27.8 | 40.0 | 27.5 | 40.0 | 24.5 | 38.4 | 19.1 | 36.0 | 12.9 | 33.6 | 7.7 | 30.0 | 32.4 |
| 14 | 27.6 | 40.0 | 27.3 | 40.0 | 24.2 | 38.4 | 18.6 | 36.0 | 12.2 | 33.6 | 6.7 | 30.0 | 32.4 |
| 15 | 27.9 | 40.0 | 27.6 | 40.0 | 24.4 | 38.4 | 18.6 | 36.0 | 11.9 | 33.6 | 6.1 | 30.0 | 32.4 |
| 16 | 28.8 | 40.0 | 28.5 | 40.0 | 25.2 | 38.4 | 19.2 | 36.0 | 12.2 | 33.6 | 6.1 | 30.0 | 32.4 |
| 17 | 31.6 | 40.0 | 31.3 | 40.0 | 27.9 | 38.4 | 21.5 | 36.0 | 14.6 | 33.6 | 7.6 | 30.0 | 32.4 |
| 18 | 29.1 | 40.0 | 28.7 | 40.0 | 25.2 | 38.4 | 18.8 | 36.0 | 11.1 | 33.6 | 4.6 | 30.0 | 32.4 |
| 19 | 28.4 | 40.0 | 28.1 | 40.0 | 24.5 | 38.4 | 17.8 | 36.0 | 9.8 | 33.6 | 2.1 | 30.0 | 32.4 |
| 20 | 28.9 | 40.0 | 28.5 | 40.0 | 24.8 | 38.4 | 17.9 | 36.0 | 9.5 | 33.6 | 0.0 | 30.0 | 32.4 |
| 21 | 31.2 | 40.0 | 30.8 | 40.0 | 27.1 | 38.4 | 19.7 | 36.0 | 11.4 | 33.6 | | 30.0 | 32.4 |
| 22 | 28.3 | 40.0 | 27.9 | 40.0 | 24.0 | 38.4 | 16.5 | 36.0 | 7.4 | 33.6 | | 30.0 | 32.4 |
| 23 | 27.1 | 40.0 | 26.7 | 40.0 | 22.7 | 38.4 | 15.0 | 36.0 | 5.3 | 33.6 | | 30.0 | 32.4 |
| 24 | 26.7 | 40.0 | 26.2 | 40.0 | 22.2 | 38.4 | 14.1 | 36.0 | 4.1 | 33.6 | | 30.0 | 32.4 |
| 25 | 26.6 | 40.0 | 26.2 | 40.0 | 22.1 | 38.4 | 13.7 | 36.0 | 2.4 | 33.6 | | 30.0 | 32.4 |
| 26 | 27.3 | 40.0 | 26.8 | 40.0 | 22.6 | 38.4 | 14.0 | 36.0 | 0.0 | 33.6 | | 30.0 | 32.4 |
| 27 | 29.8 | 40.0 | 29.3 | 40.0 | 25.0 | 38.4 | 15.8 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 28 | 26.9 | 40.0 | 26.5 | 40.0 | 22.1 | 38.4 | 12.7 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 29 | 26.0 | 40.0 | 25.5 | 40.0 | 21.1 | 38.4 | 11.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 30 | 26.1 | 40.0 | 25.6 | 40.0 | 21.1 | 38.4 | 11.1 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 31 | 28.1 | 40.0 | 27.6 | 40.0 | 23.1 | 38.4 | 12.4 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 32 | 24.8 | 40.0 | 24.3 | 40.0 | 19.7 | 38.4 | 8.8 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 33 | 23.3 | 40.0 | 22.8 | 40.0 | 18.1 | 38.4 | 6.9 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 34 | 22.5 | 40.0 | 21.9 | 40.0 | 17.2 | 38.4 | 5.3 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 35 | 22.0 | 40.0 | 21.5 | 40.0 | 16.6 | 38.4 | 3.7 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 36 | 22.3 | 40.0 | 21.7 | 40.0 | 16.8 | 38.4 | 0.0 | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 37 | 24.2 | 40.0 | 23.6 | 40.0 | 18.6 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 38 | 20.7 | 40.0 | 20.1 | 40.0 | 15.1 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 39 | 19.0 | 40.0 | 18.3 | 40.0 | 13.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 40 | 17.8 | 40.0 | 17.1 | 40.0 | 11.9 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 41 | 16.8 | 40.0 | 16.1 | 40.0 | 10.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 42 | 16.0 | 40.0 | 15.2 | 40.0 | 9.8 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 43 | 15.2 | 40.0 | 14.5 | 40.0 | 8.9 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 44 | 14.6 | 40.0 | 13.8 | 40.0 | 8.0 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 45 | 14.0 | 40.0 | 13.1 | 40.0 | 7.2 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 46 | 13.5 | 40.0 | 12.5 | 40.0 | 6.3 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 47 | 12.9 | 40.0 | 11.9 | 40.0 | 5.0 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |
| 48 | 12.2 | 40.0 | 11.8 | 40.0 | 4.6 | 38.4 | | 36.0 | | 33.6 | | 30.0 | 32.4 |

Table A63. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 48 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 44.3 | 59.8 | 43.5 | 59.8 | 40.3 | 57.3 | 35.0 | 53.8 | 27.0 | 50.2 | 21.3 | 44.8 | 41.4 |
| 1 | 45.1 | 59.8 | 44.5 | 59.8 | 40.9 | 57.3 | 35.0 | 53.8 | 28.4 | 50.2 | 21.2 | 44.8 | 41.4 |
| 2 | 43.0 | 59.8 | 42.4 | 59.8 | 38.8 | 57.3 | 33.1 | 53.8 | 25.7 | 50.2 | 19.2 | 44.8 | 41.4 |
| 3 | 42.1 | 59.8 | 41.4 | 59.8 | 37.8 | 57.3 | 31.9 | 53.8 | 24.6 | 50.2 | 17.9 | 44.8 | 41.4 |
| 4 | 42.0 | 59.8 | 41.3 | 59.8 | 37.6 | 57.3 | 31.6 | 53.8 | 24.3 | 50.2 | 17.4 | 44.8 | 41.4 |
| 5 | 42.3 | 59.8 | 41.6 | 59.8 | 37.8 | 57.3 | 31.7 | 53.8 | 24.3 | 50.2 | 17.4 | 44.8 | 41.4 |
| 6 | 43.3 | 59.8 | 42.6 | 59.8 | 38.7 | 57.3 | 32.6 | 53.8 | 24.9 | 50.2 | 18.0 | 44.8 | 41.4 |
| 7 | 46.1 | 59.8 | 45.5 | 59.8 | 41.4 | 57.3 | 34.9 | 53.8 | 27.7 | 50.2 | 20.2 | 44.8 | 41.4 |
| 8 | 43.6 | 59.8 | 42.8 | 59.8 | 38.8 | 57.3 | 32.5 | 53.8 | 24.6 | 50.2 | 17.6 | 44.8 | 41.4 |
| 9 | 43.0 | 59.8 | 42.3 | 59.8 | 38.1 | 57.3 | 31.7 | 53.8 | 23.7 | 50.2 | 16.5 | 44.8 | 41.4 |
| 10 | 43.6 | 59.8 | 42.7 | 59.8 | 38.6 | 57.3 | 32.0 | 53.8 | 23.9 | 50.2 | 16.6 | 44.8 | 41.4 |
| 11 | 46.0 | 59.8 | 45.3 | 59.8 | 40.9 | 57.3 | 34.0 | 53.8 | 26.2 | 50.2 | 18.2 | 44.8 | 41.4 |
| 12 | 43.1 | 59.8 | 42.2 | 59.8 | 37.9 | 57.3 | 31.1 | 53.8 | 22.7 | 50.2 | 15.1 | 44.8 | 41.4 |
| 13 | 42.1 | 59.8 | 41.2 | 59.8 | 36.8 | 57.3 | 29.9 | 53.8 | 21.3 | 50.2 | 13.5 | 44.8 | 41.4 |
| 14 | 41.7 | 59.8 | 40.9 | 59.8 | 36.3 | 57.3 | 29.3 | 53.8 | 20.6 | 50.2 | 12.5 | 44.8 | 41.4 |
| 15 | 41.8 | 59.8 | 40.9 | 59.8 | 36.3 | 57.3 | 29.2 | 53.8 | 20.3 | 50.2 | 11.9 | 44.8 | 41.4 |
| 16 | 42.6 | 59.8 | 41.7 | 59.8 | 37.1 | 57.3 | 29.8 | 53.8 | 20.6 | 50.2 | 12.1 | 44.8 | 41.4 |
| 17 | 45.3 | 59.8 | 44.4 | 59.8 | 39.6 | 57.3 | 32.0 | 53.8 | 23.1 | 50.2 | 13.6 | 44.8 | 41.4 |
| 18 | 42.6 | 59.8 | 41.6 | 59.8 | 36.9 | 57.3 | 29.4 | 53.8 | 19.7 | 50.2 | 10.3 | 44.8 | 41.4 |
| 19 | 41.9 | 59.8 | 40.9 | 59.8 | 36.0 | 57.3 | 28.3 | 53.8 | 18.5 | 50.2 | 8.3 | 44.8 | 41.4 |
| 20 | 42.2 | 59.8 | 41.2 | 59.8 | 36.2 | 57.3 | 28.5 | 53.8 | 18.3 | 50.2 | 7.0 | 44.8 | 41.4 |
| 21 | 44.4 | 59.8 | 43.5 | 59.8 | 38.4 | 57.3 | 30.3 | 53.8 | 20.3 | 50.2 | 5.8 | 44.8 | 41.4 |
| 22 | 41.4 | 59.8 | 40.3 | 59.8 | 35.2 | 57.3 | 27.2 | 53.8 | 16.3 | 50.2 | 4.9 | 44.8 | 41.4 |
| 23 | 40.1 | 59.8 | 39.1 | 59.8 | 33.9 | 57.3 | 25.7 | 53.8 | 14.5 | 50.2 | 3.7 | 44.8 | 41.4 |
| 24 | 39.6 | 59.8 | 38.5 | 59.8 | 33.3 | 57.3 | 24.9 | 53.8 | 13.4 | 50.2 | 0.0 | 44.8 | 41.4 |
| 25 | 39.5 | 59.8 | 38.4 | 59.8 | 33.0 | 57.3 | 24.5 | 53.8 | 12.5 | 50.2 | | 44.8 | 41.4 |
| 26 | 40.1 | 59.8 | 39.0 | 59.8 | 33.5 | 57.3 | 24.9 | 53.8 | 12.3 | 50.2 | | 44.8 | 41.4 |
| 27 | 42.5 | 59.8 | 41.5 | 59.8 | 35.9 | 57.3 | 26.8 | 53.8 | 14.2 | 50.2 | | 44.8 | 41.4 |
| 28 | 39.6 | 59.8 | 38.4 | 59.8 | 32.9 | 57.3 | 23.9 | 53.8 | 10.2 | 50.2 | | 44.8 | 41.4 |
| 29 | 38.6 | 59.8 | 37.4 | 59.8 | 31.7 | 57.3 | 22.5 | 53.8 | 8.1 | 50.2 | | 44.8 | 41.4 |
| 30 | 38.7 | 59.8 | 37.5 | 59.8 | 31.7 | 57.3 | 22.4 | 53.8 | 6.7 | 50.2 | | 44.8 | 41.4 |
| 31 | 40.6 | 59.8 | 39.6 | 59.8 | 33.6 | 57.3 | 23.8 | 53.8 | 5.0 | 50.2 | | 44.8 | 41.4 |
| 32 | 37.3 | 59.8 | 36.1 | 59.8 | 30.1 | 57.3 | 20.4 | 53.8 | 0.0 | 50.2 | | 44.8 | 41.4 |
| 33 | 35.8 | 59.8 | 34.6 | 59.8 | 28.5 | 57.3 | 18.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 34 | 34.9 | 59.8 | 33.7 | 59.8 | 27.5 | 57.3 | 17.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 35 | 34.5 | 59.8 | 33.2 | 59.8 | 26.9 | 57.3 | 16.6 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 36 | 34.7 | 59.8 | 33.4 | 59.8 | 26.9 | 57.3 | 16.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 37 | 36.7 | 59.8 | 35.5 | 59.8 | 28.7 | 57.3 | 17.8 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 38 | 33.2 | 59.8 | 31.9 | 59.8 | 25.1 | 57.3 | 14.3 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 39 | 31.5 | 59.8 | 30.1 | 59.8 | 23.2 | 57.3 | 12.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 40 | 30.3 | 59.8 | 29.0 | 59.8 | 21.9 | 57.3 | 10.5 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 41 | 29.4 | 59.8 | 28.0 | 59.8 | 20.7 | 57.3 | 9.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 42 | 28.6 | 59.8 | 27.2 | 59.8 | 19.7 | 57.3 | 7.8 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 43 | 27.9 | 59.8 | 26.5 | 59.8 | 18.8 | 57.3 | 6.6 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 44 | 27.3 | 59.8 | 25.8 | 59.8 | 18.0 | 57.3 | 5.1 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 45 | 26.7 | 59.8 | 25.3 | 59.8 | 17.2 | 57.3 | 0.0 | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 46 | 26.3 | 59.8 | 24.8 | 59.8 | 16.5 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 47 | 25.8 | 59.8 | 24.2 | 59.8 | 15.7 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |
| 48 | 24.5 | 59.8 | 24.2 | 59.8 | 15.6 | 57.3 | | 53.8 | | 50.2 | | 44.8 | 41.4 |

Table A64. Longitudinal Moment Distribution at Critical Section for Four-Lane Single Span Bridge – Deck Span = 46 ft, Deck Width = 54 ft, Two Railings with Edge Loading E1.

| Longitudinal Moment at Critical Section (Kip-ft/ft) | | | | | | | | | | | | | |
|---|-------------------|------|------------|------|------------|------|------------|------|------------|------|------------|------|---------------------------|
| Location (ft) | Angle of Skewness | | | | | | | | | | | | AASHTO Moment (Kip-ft/ft) |
| | 0 Degrees | | 10 Degrees | | 20 Degrees | | 30 Degrees | | 40 Degrees | | 50 Degrees | | |
| | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | FEA | LRFD | |
| 0 | 58.7 | 77.1 | 57.7 | 77.1 | 53.1 | 74.0 | 45.2 | 69.4 | 36.3 | 64.8 | 28.4 | 57.8 | 50.2 |
| 1 | 59.4 | 77.1 | 58.4 | 77.1 | 53.7 | 74.0 | 46.2 | 69.4 | 37.6 | 64.8 | 28.2 | 57.8 | 50.2 |
| 2 | 57.1 | 77.1 | 56.0 | 77.1 | 51.2 | 74.0 | 43.6 | 69.4 | 34.7 | 64.8 | 26.0 | 57.8 | 50.2 |
| 3 | 55.9 | 77.1 | 54.9 | 77.1 | 50.0 | 74.0 | 42.4 | 69.4 | 33.5 | 64.8 | 24.6 | 57.8 | 50.2 |
| 4 | 55.6 | 77.1 | 54.6 | 77.1 | 49.7 | 74.0 | 41.9 | 69.4 | 33.0 | 64.8 | 24.0 | 57.8 | 50.2 |
| 5 | 55.8 | 77.1 | 54.7 | 77.1 | 49.7 | 74.0 | 41.9 | 69.4 | 32.8 | 64.8 | 23.9 | 57.8 | 50.2 |
| 6 | 56.6 | 77.1 | 55.5 | 77.1 | 50.4 | 74.0 | 42.5 | 69.4 | 33.4 | 64.8 | 24.5 | 57.8 | 50.2 |
| 7 | 59.3 | 77.1 | 58.1 | 77.1 | 53.0 | 74.0 | 45.1 | 69.4 | 36.1 | 64.8 | 26.6 | 57.8 | 50.2 |
| 8 | 56.6 | 77.1 | 55.4 | 77.1 | 50.3 | 74.0 | 42.2 | 69.4 | 32.9 | 64.8 | 23.9 | 57.8 | 50.2 |
| 9 | 55.9 | 77.1 | 54.7 | 77.1 | 49.5 | 74.0 | 41.3 | 69.4 | 31.9 | 64.8 | 22.8 | 57.8 | 50.2 |
| 10 | 56.3 | 77.1 | 55.1 | 77.1 | 49.8 | 74.0 | 41.4 | 69.4 | 32.0 | 64.8 | 22.9 | 57.8 | 50.2 |
| 11 | 58.6 | 77.1 | 57.4 | 77.1 | 52.0 | 74.0 | 43.7 | 69.4 | 34.3 | 64.8 | 24.6 | 57.8 | 50.2 |
| 12 | 55.6 | 77.1 | 54.3 | 77.1 | 48.9 | 74.0 | 40.4 | 69.4 | 30.7 | 64.8 | 21.5 | 57.8 | 50.2 |
| 13 | 54.4 | 77.1 | 53.1 | 77.1 | 47.6 | 74.0 | 39.1 | 69.4 | 29.3 | 64.8 | 19.9 | 57.8 | 50.2 |
| 14 | 54.0 | 77.1 | 52.7 | 77.1 | 47.1 | 74.0 | 38.4 | 69.4 | 28.6 | 64.8 | 19.0 | 57.8 | 50.2 |
| 15 | 54.0 | 77.1 | 52.7 | 77.1 | 47.0 | 74.0 | 38.2 | 69.4 | 28.2 | 64.8 | 18.6 | 57.8 | 50.2 |
| 16 | 54.7 | 77.1 | 53.4 | 77.1 | 47.6 | 74.0 | 38.7 | 69.4 | 28.6 | 64.8 | 18.9 | 57.8 | 50.2 |
| 17 | 57.3 | 77.1 | 55.9 | 77.1 | 50.1 | 74.0 | 41.3 | 69.4 | 31.1 | 64.8 | 20.7 | 57.8 | 50.2 |
| 18 | 54.5 | 77.1 | 53.1 | 77.1 | 47.3 | 74.0 | 38.1 | 69.4 | 27.7 | 64.8 | 17.7 | 57.8 | 50.2 |
| 19 | 53.7 | 77.1 | 52.3 | 77.1 | 46.3 | 74.0 | 37.1 | 69.4 | 26.5 | 64.8 | 16.3 | 57.8 | 50.2 |
| 20 | 53.9 | 77.1 | 52.5 | 77.1 | 46.5 | 74.0 | 37.1 | 69.4 | 26.3 | 64.8 | 16.0 | 57.8 | 50.2 |
| 21 | 56.1 | 77.1 | 54.7 | 77.1 | 48.6 | 74.0 | 39.3 | 69.4 | 28.4 | 64.8 | 17.2 | 57.8 | 50.2 |
| 22 | 53.0 | 77.1 | 51.6 | 77.1 | 45.4 | 74.0 | 35.7 | 69.4 | 24.5 | 64.8 | 13.6 | 57.8 | 50.2 |
| 23 | 51.7 | 77.1 | 50.2 | 77.1 | 44.0 | 74.0 | 34.3 | 69.4 | 22.9 | 64.8 | 11.5 | 57.8 | 50.2 |
| 24 | 51.1 | 77.1 | 49.6 | 77.1 | 43.3 | 74.0 | 33.4 | 69.4 | 21.8 | 64.8 | 10.0 | 57.8 | 50.2 |
| 25 | 50.9 | 77.1 | 49.5 | 77.1 | 43.0 | 74.0 | 33.0 | 69.4 | 21.2 | 64.8 | 8.6 | 57.8 | 50.2 |
| 26 | 51.5 | 77.1 | 50.0 | 77.1 | 43.5 | 74.0 | 33.3 | 69.4 | 21.1 | 64.8 | 7.6 | 57.8 | 50.2 |
| 27 | 53.9 | 77.1 | 52.4 | 77.1 | 45.8 | 74.0 | 35.6 | 69.4 | 23.3 | 64.8 | 6.2 | 57.8 | 50.2 |
| 28 | 51.0 | 77.1 | 49.5 | 77.1 | 42.7 | 74.0 | 32.2 | 69.4 | 19.5 | 64.8 | 0.0 | 57.8 | 50.2 |
| 29 | 50.0 | 77.1 | 48.4 | 77.1 | 41.6 | 74.0 | 30.9 | 69.4 | 18.0 | 64.8 | | 57.8 | 50.2 |
| 30 | 50.0 | 77.1 | 48.5 | 77.1 | 41.6 | 74.0 | 30.6 | 69.4 | 17.4 | 64.8 | | 57.8 | 50.2 |
| 31 | 52.0 | 77.1 | 50.5 | 77.1 | 43.4 | 74.0 | 32.5 | 69.4 | 19.0 | 64.8 | | 57.8 | 50.2 |
| 32 | 48.7 | 77.1 | 47.1 | 77.1 | 39.9 | 74.0 | 28.6 | 69.4 | 14.7 | 64.8 | | 57.8 | 50.2 |
| 33 | 47.2 | 77.1 | 45.6 | 77.1 | 38.3 | 74.0 | 26.7 | 69.4 | 12.5 | 64.8 | | 57.8 | 50.2 |
| 34 | 46.3 | 77.1 | 44.7 | 77.1 | 37.3 | 74.0 | 25.5 | 69.4 | 10.7 | 64.8 | | 57.8 | 50.2 |
| 35 | 45.9 | 77.1 | 44.3 | 77.1 | 36.8 | 74.0 | 24.7 | 69.4 | 9.4 | 64.8 | | 57.8 | 50.2 |
| 36 | 46.1 | 77.1 | 44.5 | 77.1 | 36.8 | 74.0 | 24.4 | 69.4 | 7.5 | 64.8 | | 57.8 | 50.2 |
| 37 | 48.1 | 77.1 | 46.5 | 77.1 | 38.7 | 74.0 | 26.1 | 69.4 | 0.0 | 64.8 | | 57.8 | 50.2 |
| 38 | 44.7 | 77.1 | 43.0 | 77.1 | 35.1 | 74.0 | 22.0 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 39 | 43.0 | 77.1 | 41.3 | 77.1 | 33.3 | 74.0 | 19.8 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 40 | 41.9 | 77.1 | 40.2 | 77.1 | 32.0 | 74.0 | 18.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 41 | 41.0 | 77.1 | 39.3 | 77.1 | 31.0 | 74.0 | 16.6 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 42 | 40.3 | 77.1 | 38.5 | 77.1 | 30.1 | 74.0 | 15.1 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 43 | 39.7 | 77.1 | 37.9 | 77.1 | 29.3 | 74.0 | 13.7 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 44 | 39.1 | 77.1 | 37.4 | 77.1 | 28.6 | 74.0 | 12.4 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 45 | 38.7 | 77.1 | 36.9 | 77.1 | 28.0 | 74.0 | 10.9 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 46 | 38.3 | 77.1 | 36.5 | 77.1 | 27.5 | 74.0 | 9.6 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 47 | 37.9 | 77.1 | 36.4 | 77.1 | 26.9 | 74.0 | 7.5 | 69.4 | | 64.8 | | 57.8 | 50.2 |
| 48 | 36.5 | 77.1 | 36.1 | 77.1 | 26.8 | 74.0 | 6.7 | 69.4 | | 64.8 | | 57.8 | 50.2 |

APPENDIX 2

LONGITUDINAL BENDING MOMENT PLOTS

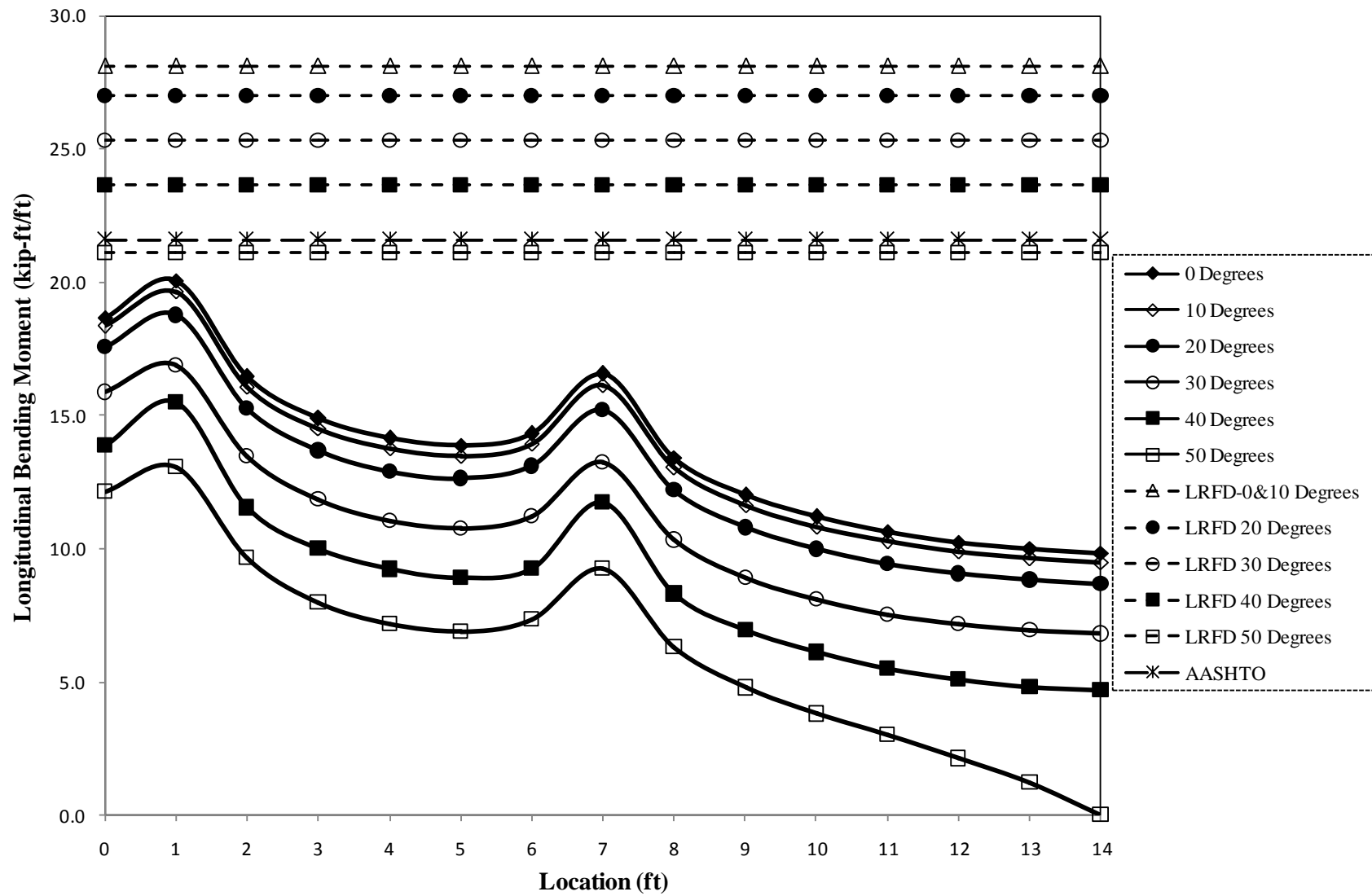


Fig. A1. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 1
No Railings with Edge Loading E1.

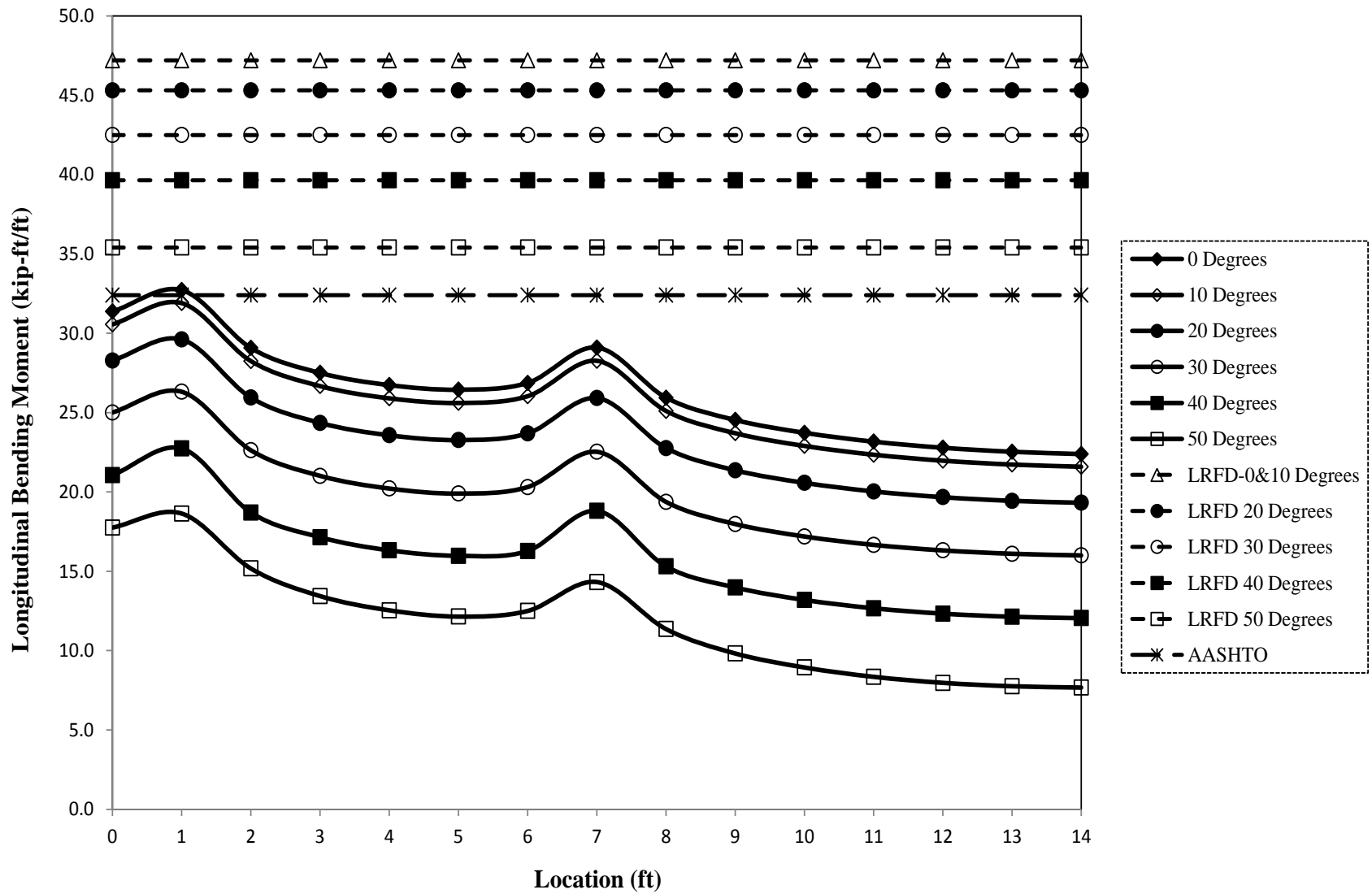


Fig. A2. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 1
No Railings with Edge Loading E1.

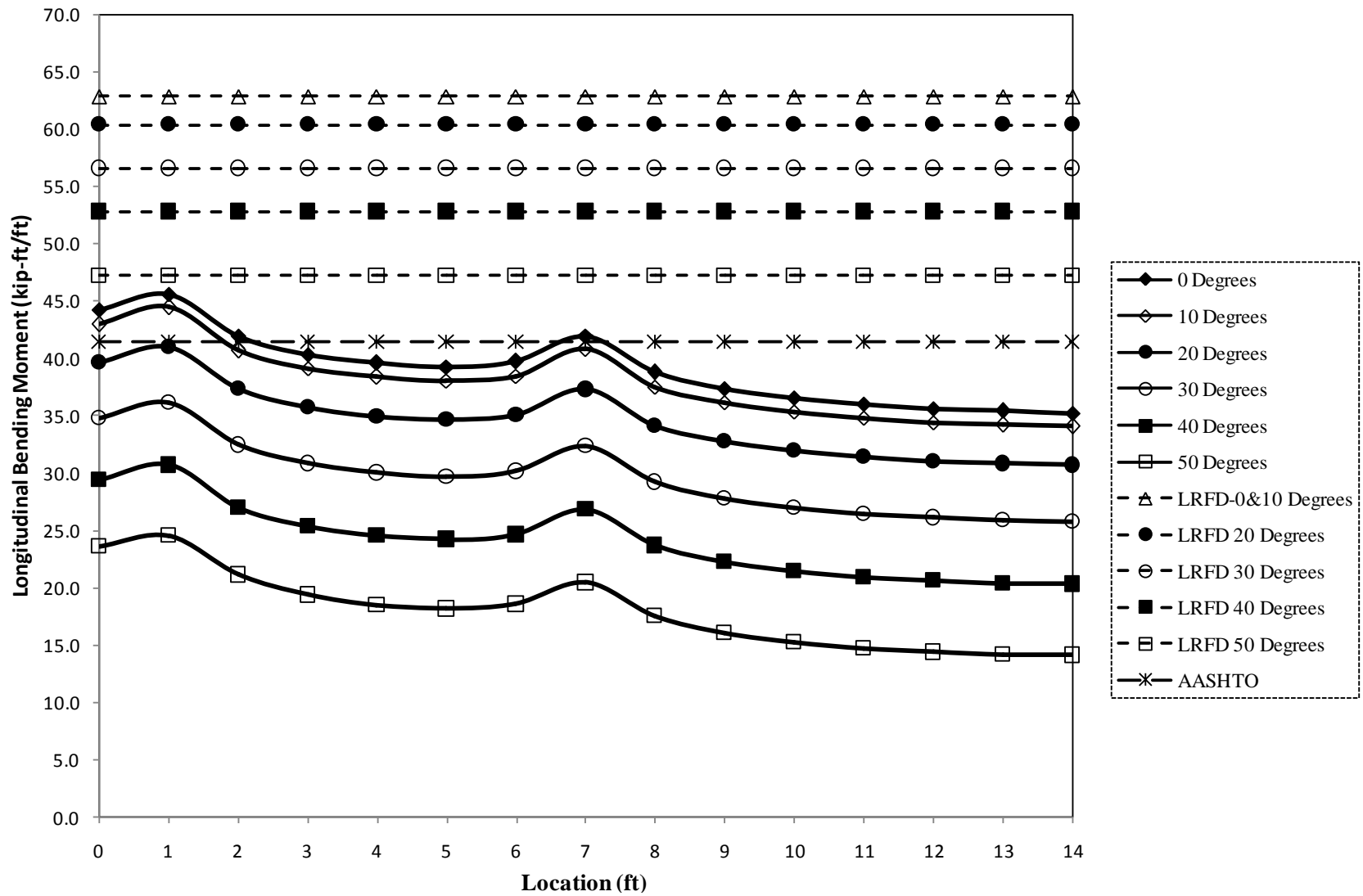


Fig. A3. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 1
No Railings with Edge Loading E1.

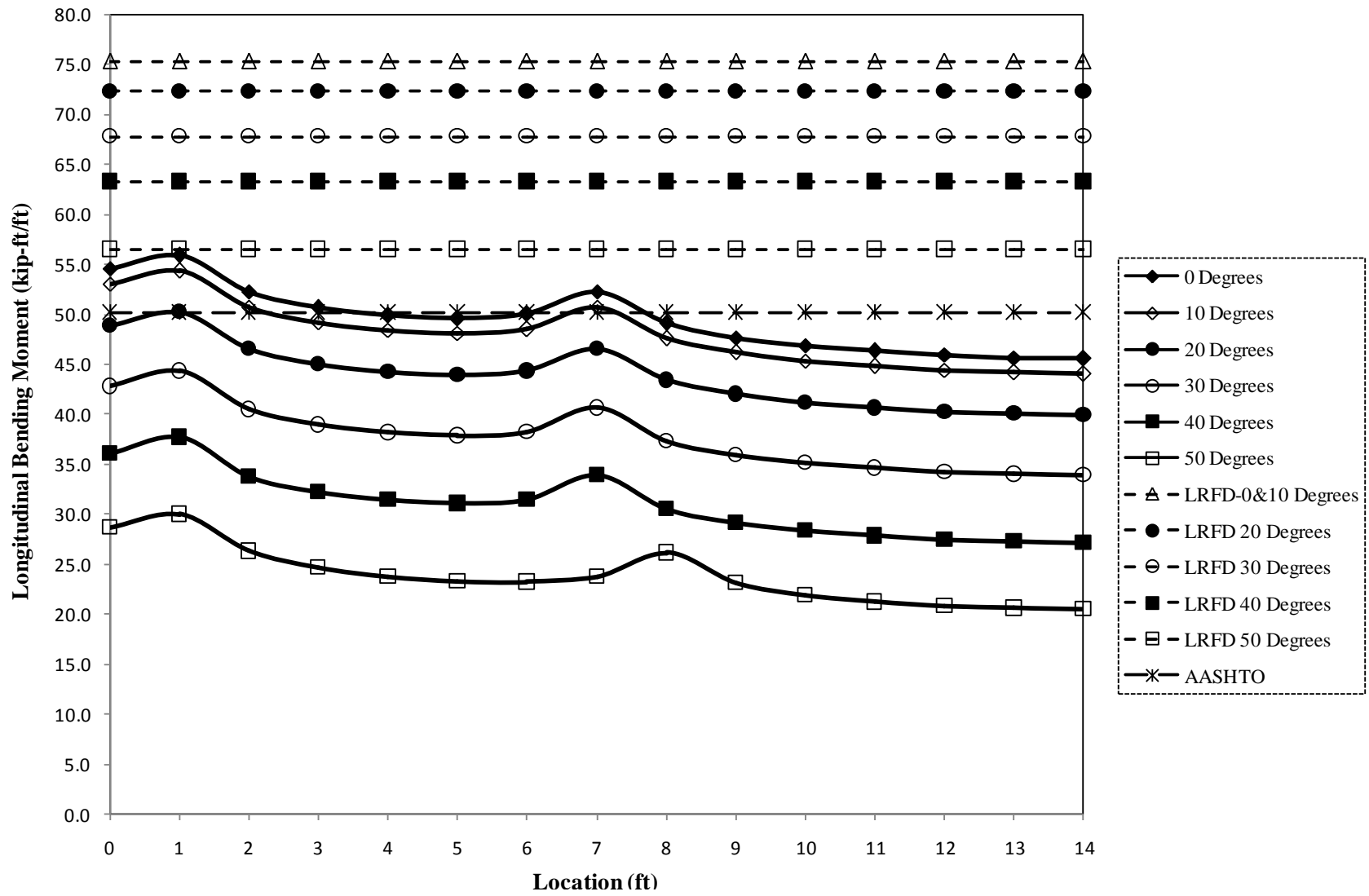


Fig. A4. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 1
No Railings with Edge Loading E1.

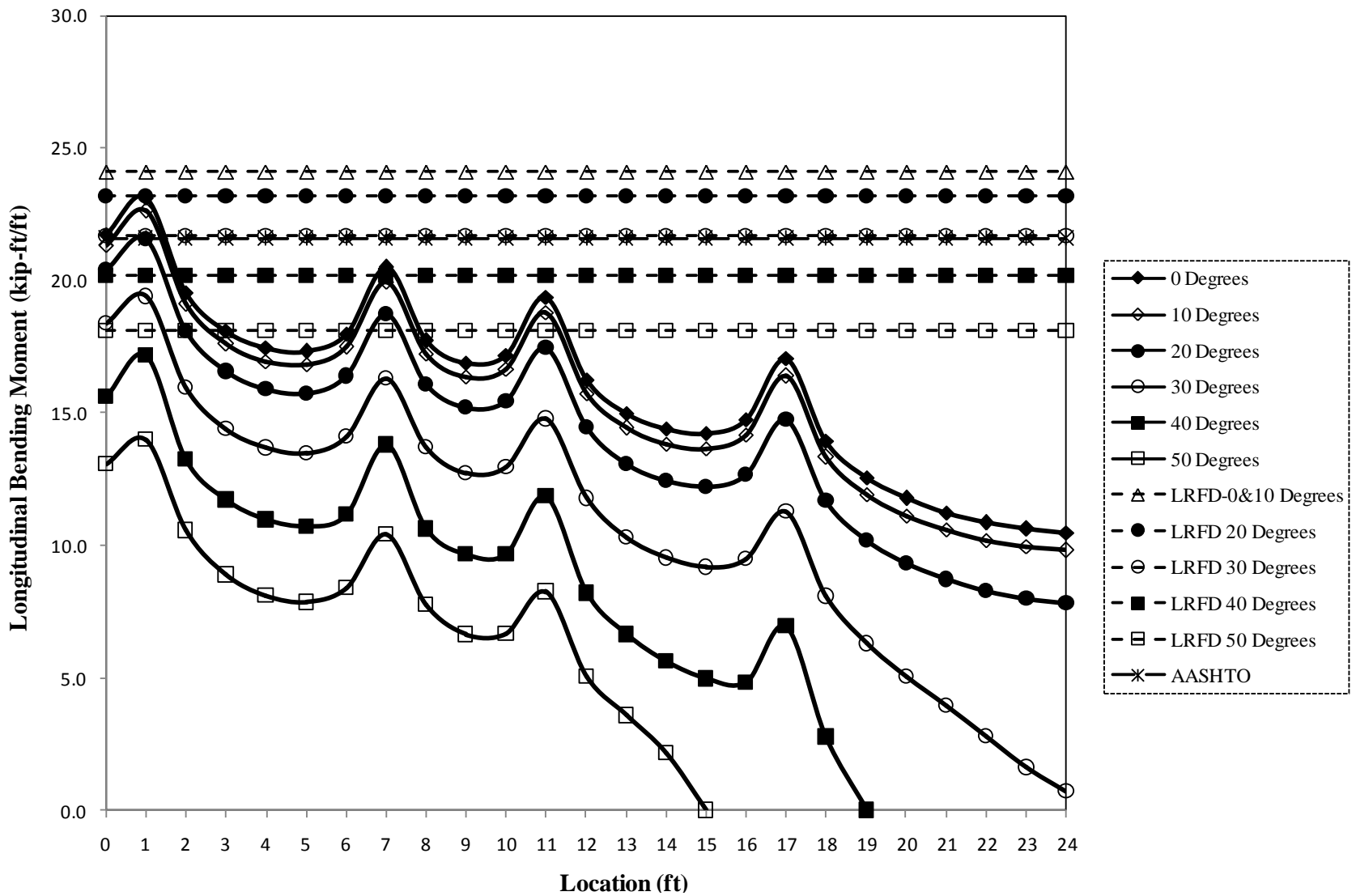


Fig. A5. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 2
No Railings with Edge Loading E1

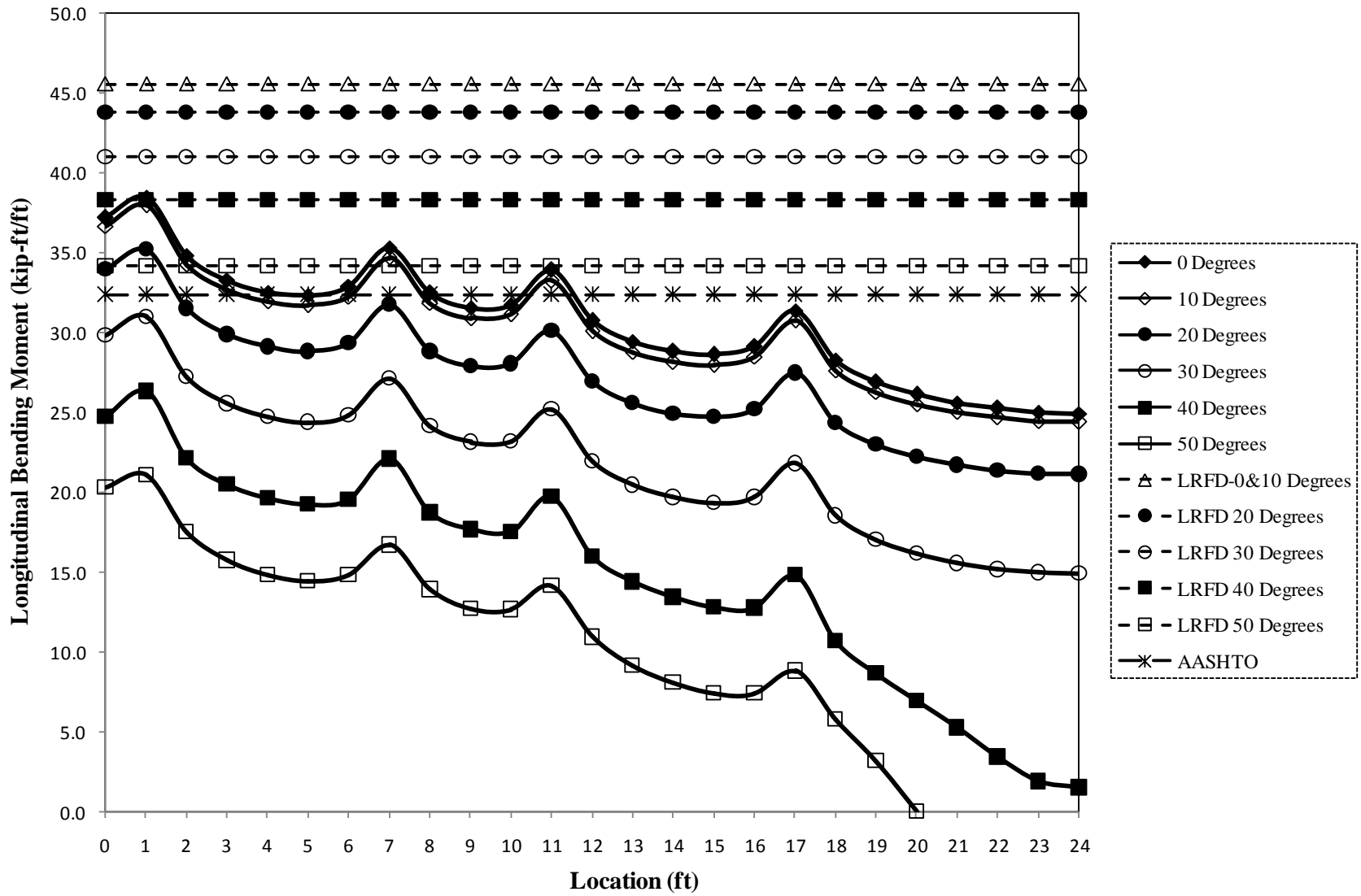


Fig. A6. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 2
No Railings with Edge Loading E1.

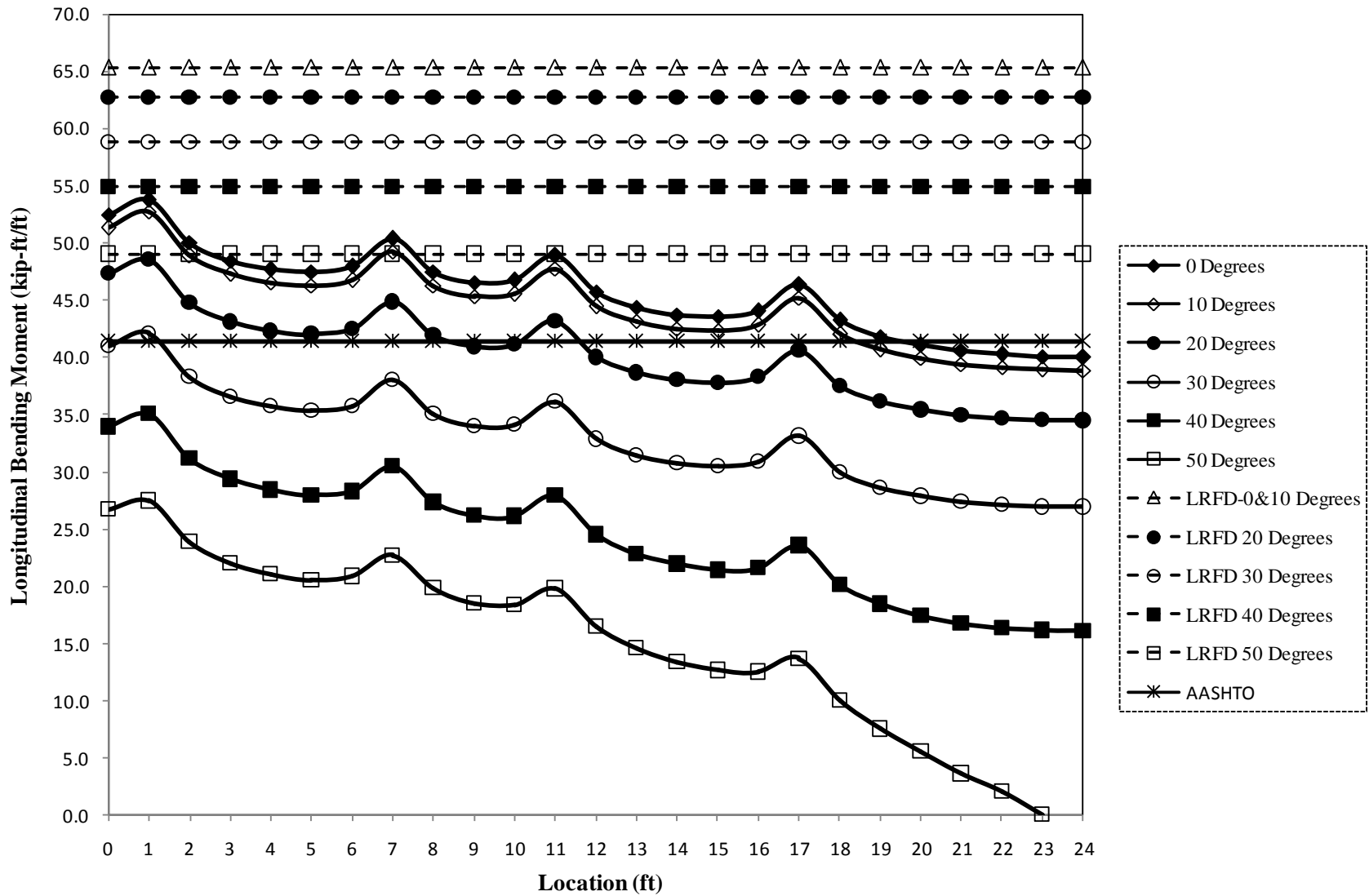


Fig. A7. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 2
No Railings with Edge Loading E1.

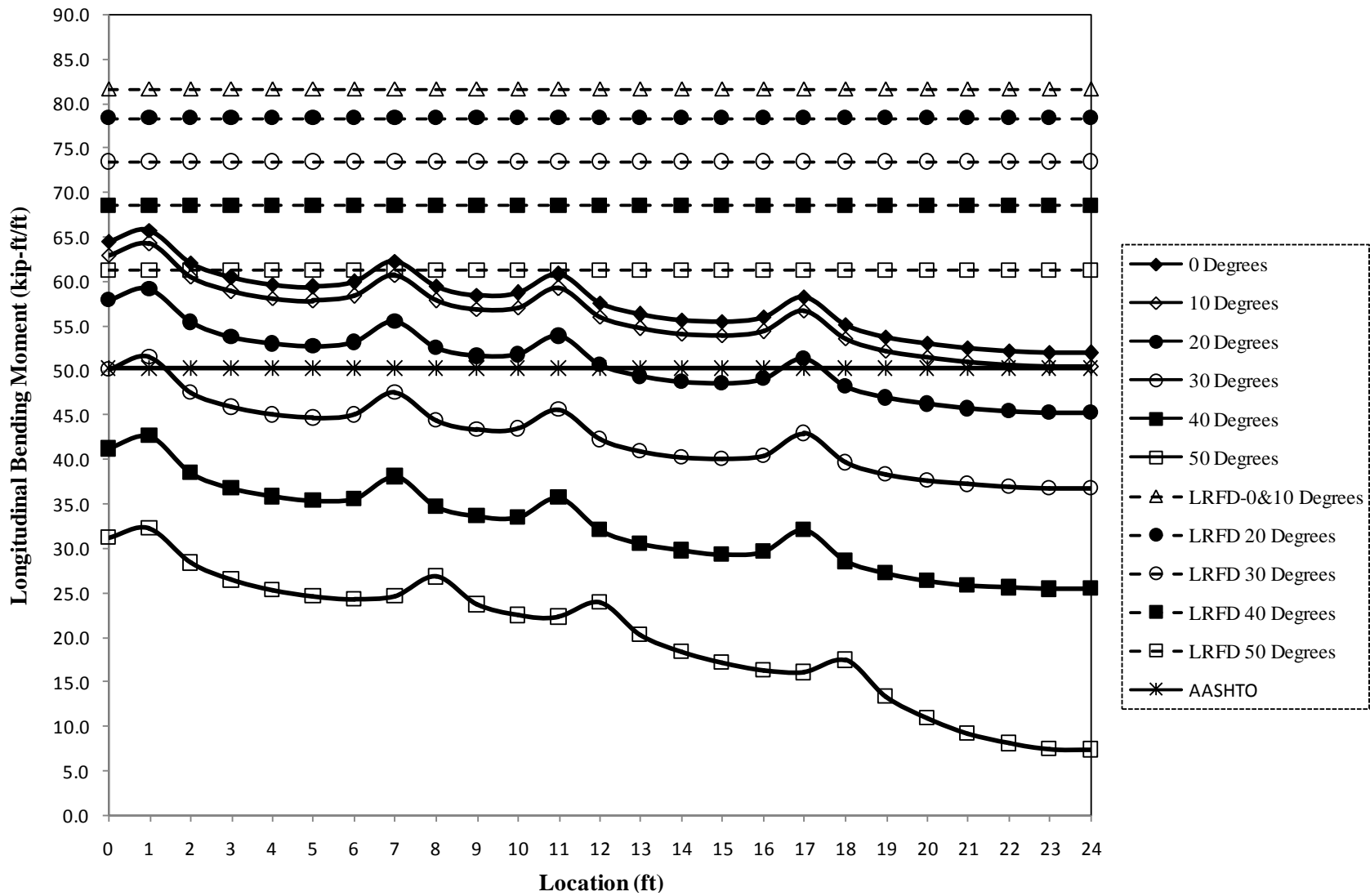


Fig. A8. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 2
No Railings with Edge Loading E1.

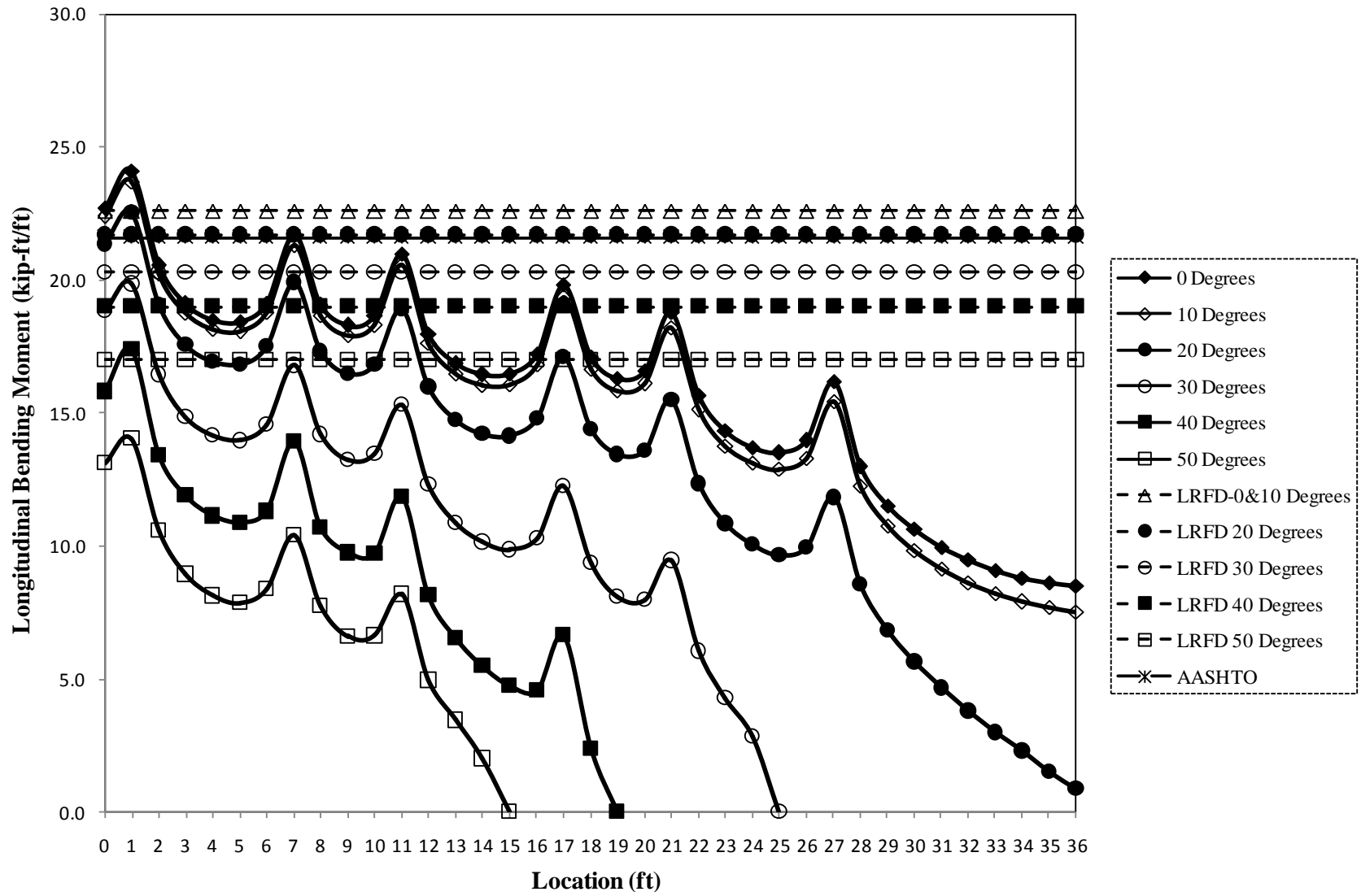


Fig. A9. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 3
No Railings with Edge Loading E1.

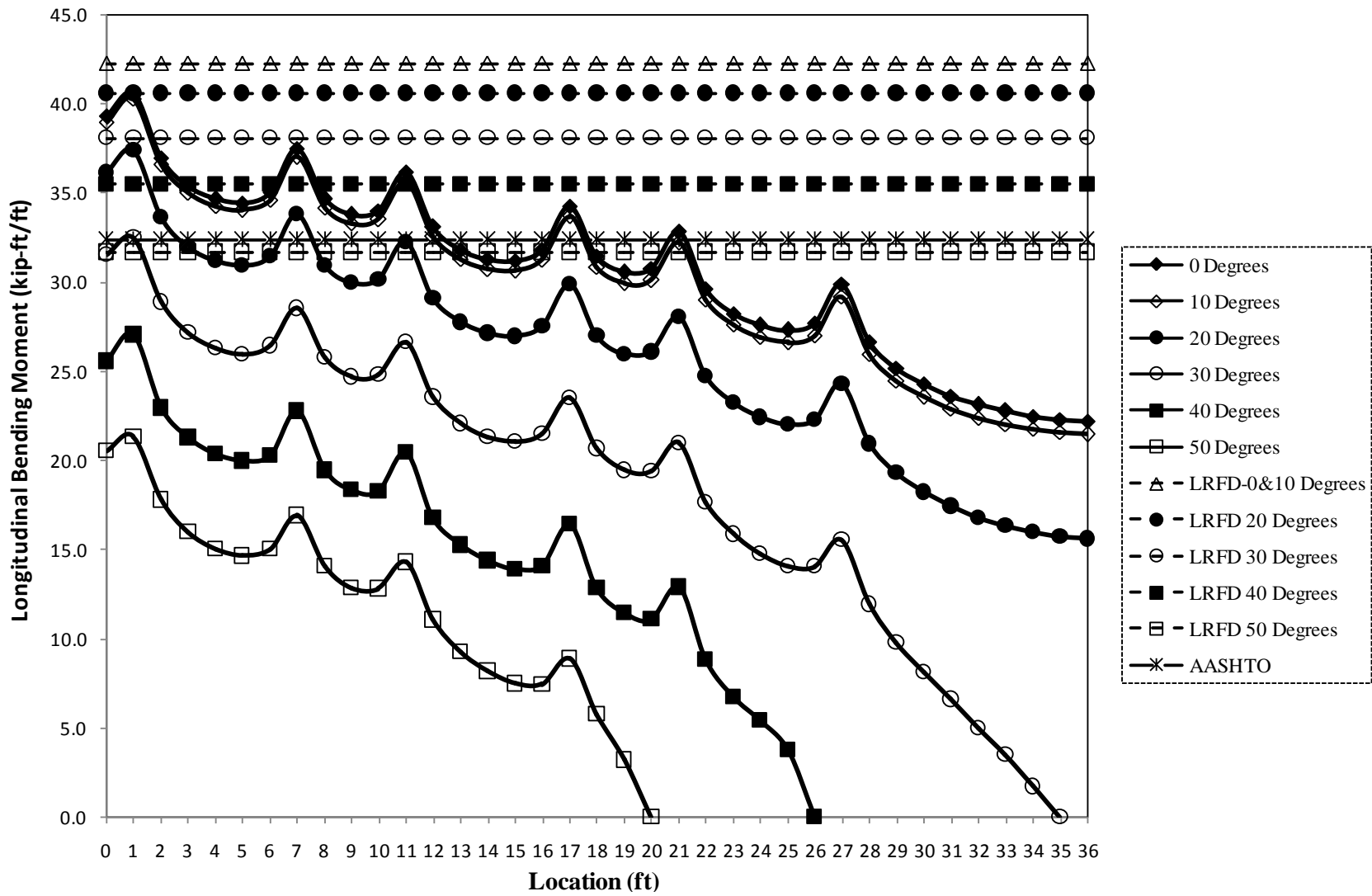


Fig. A10. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 3
No Railings with Edge Loading E1.

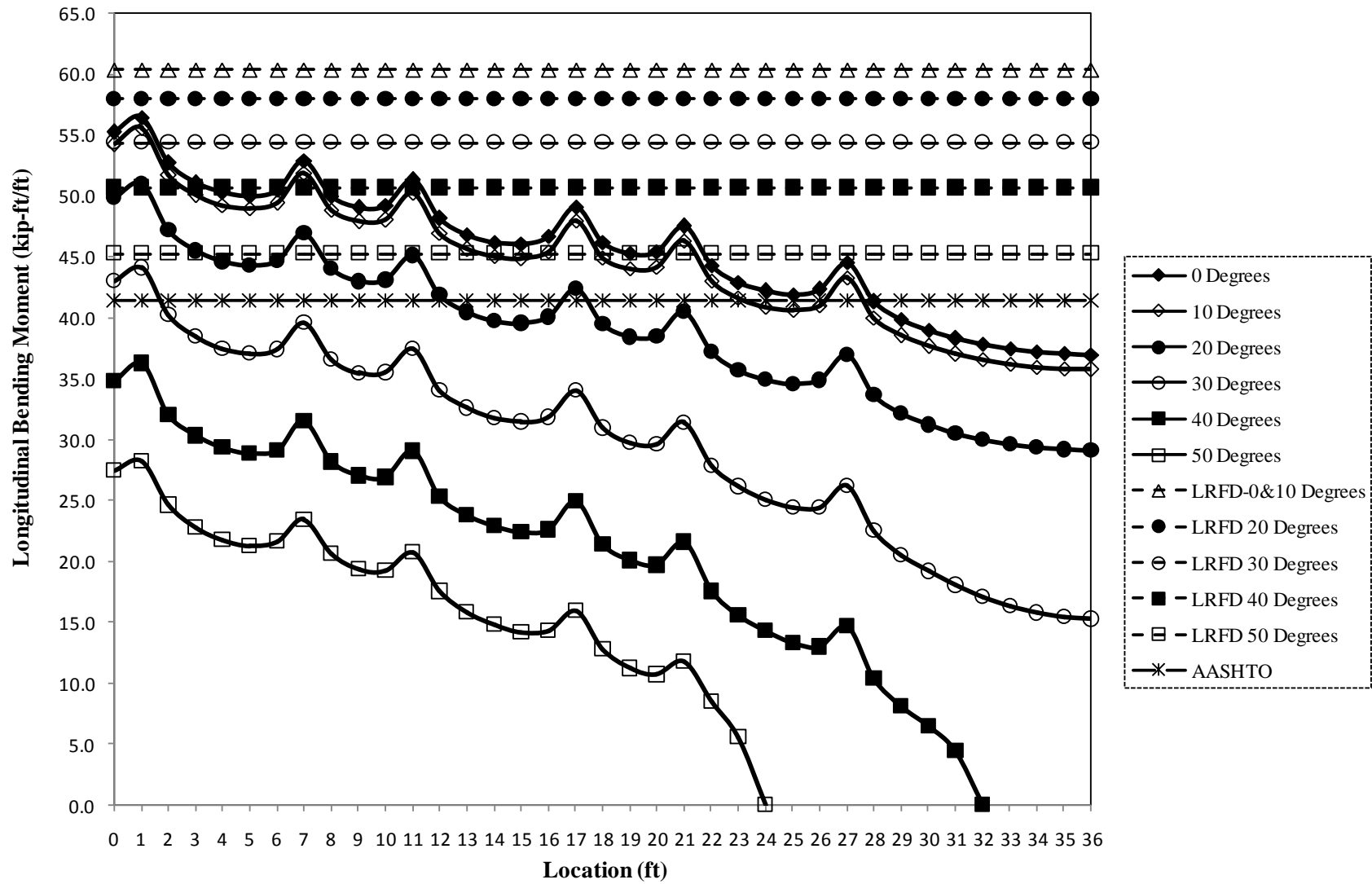


Fig. A11. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 3
No Railings with Edge Loading E1.

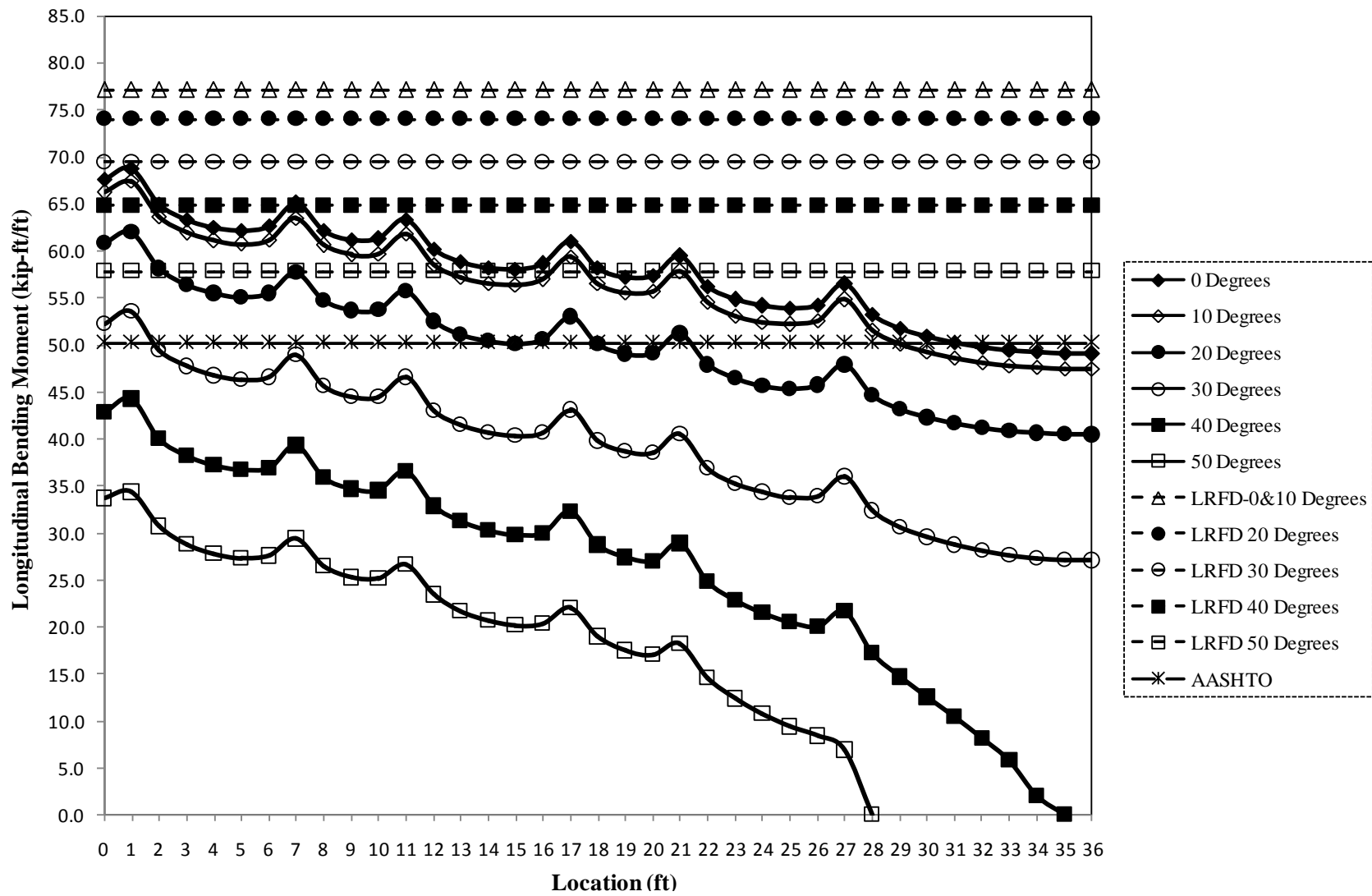


Fig. A12. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 3
No Railings with Edge Loading E1.

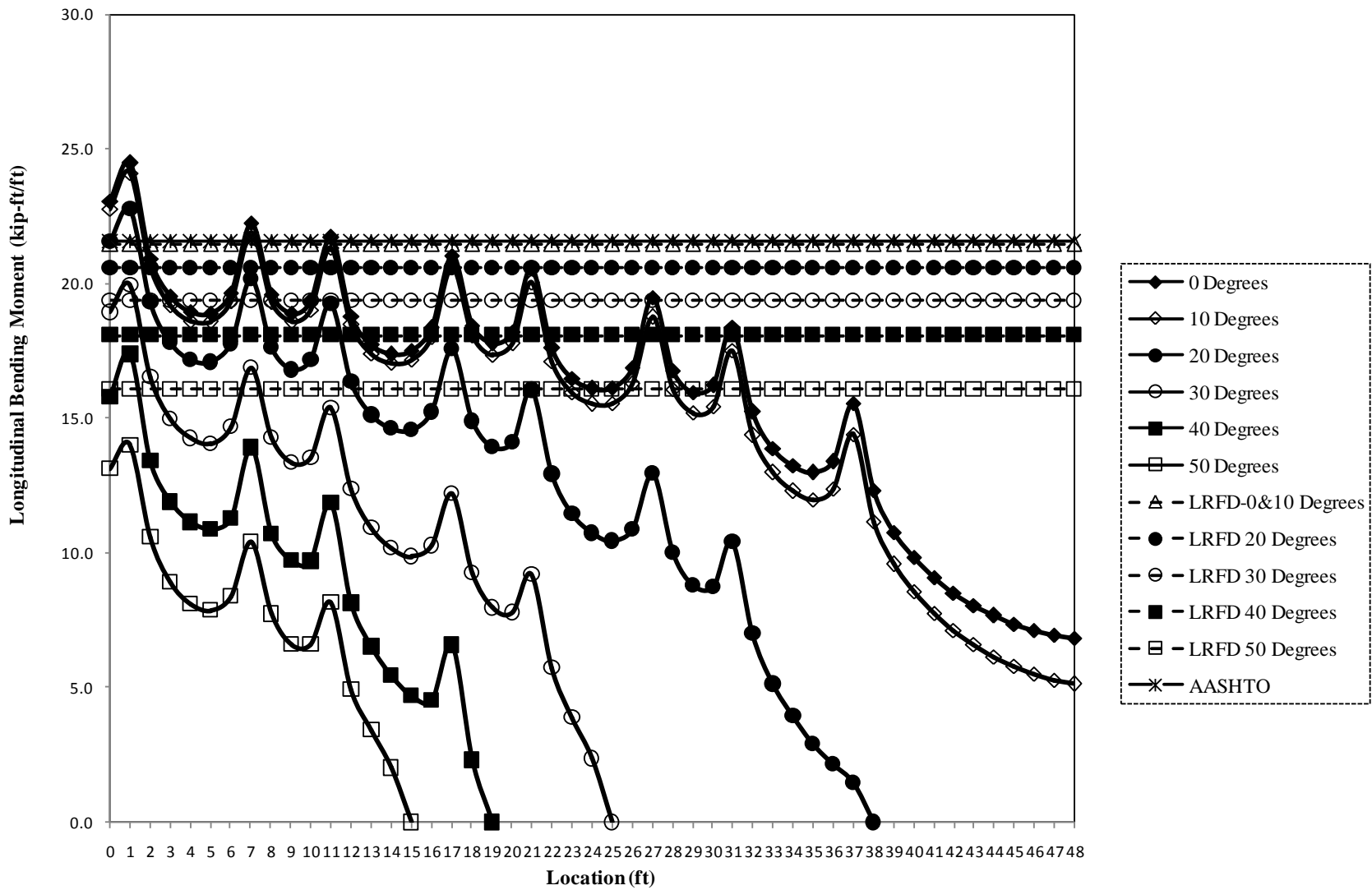


Fig. A13. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 4
No Railings with Edge Loading E1.

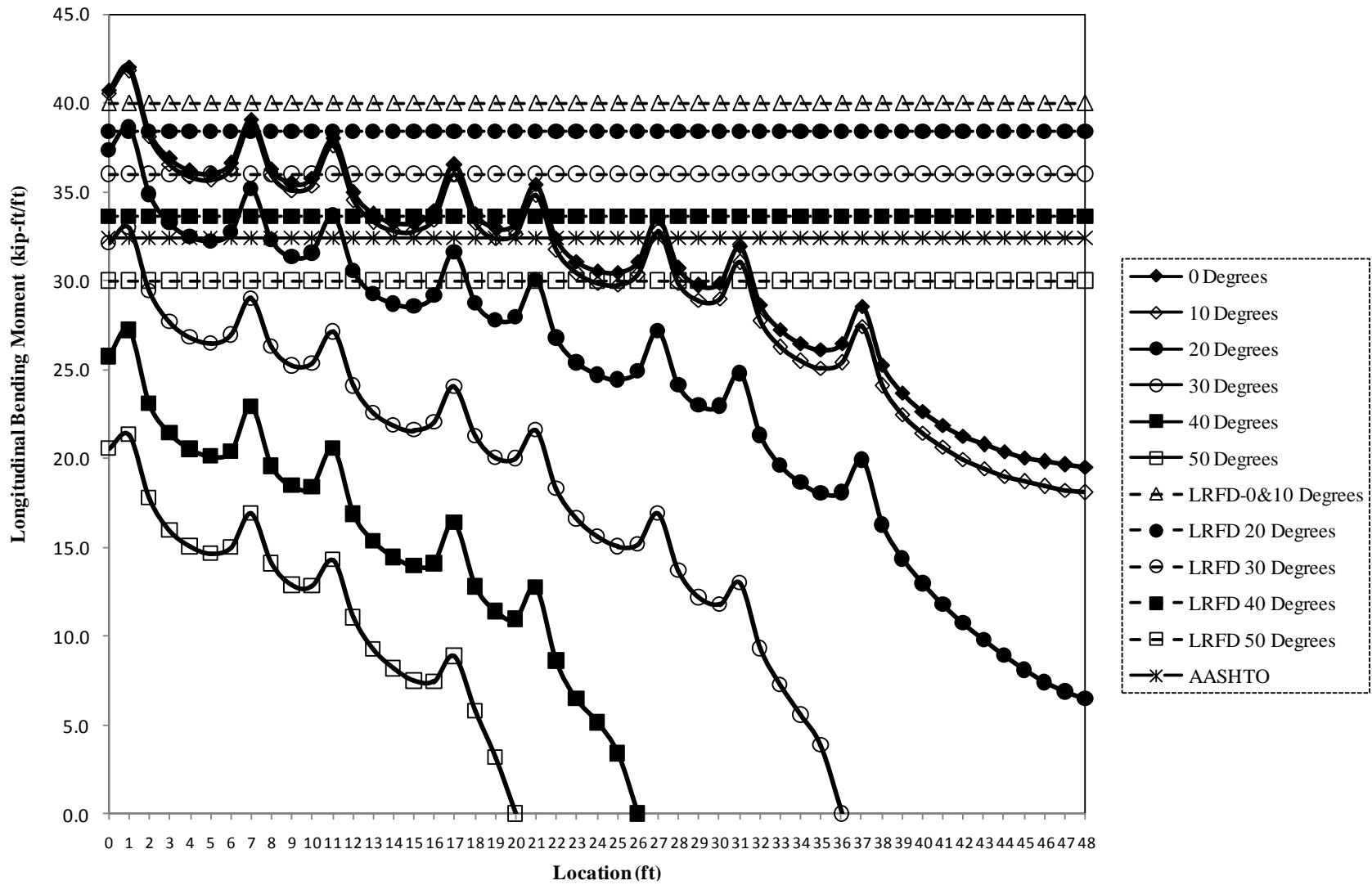


Fig. A14. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 4
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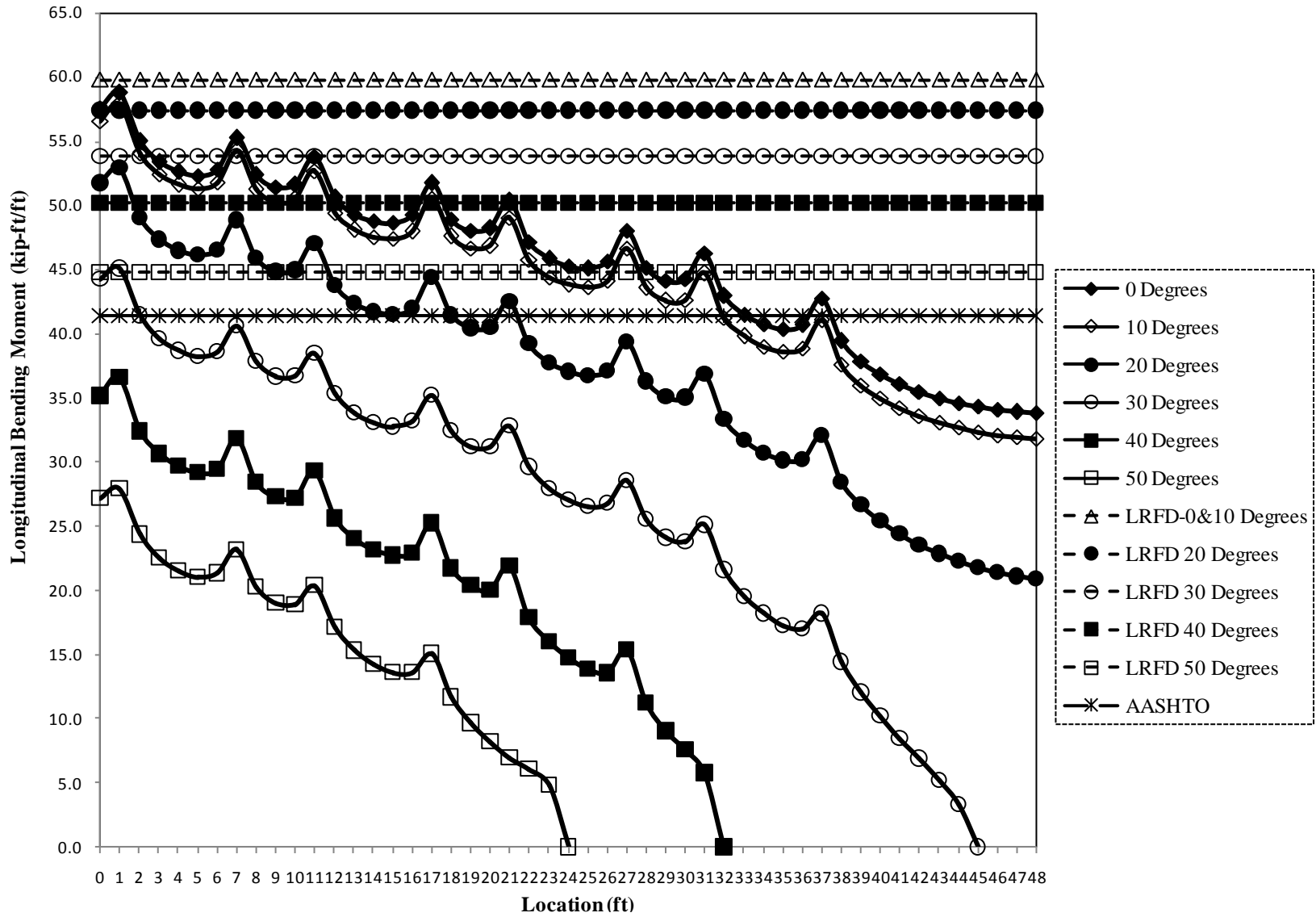


Fig. A15. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 4 No Railings with Edge Loading E1.

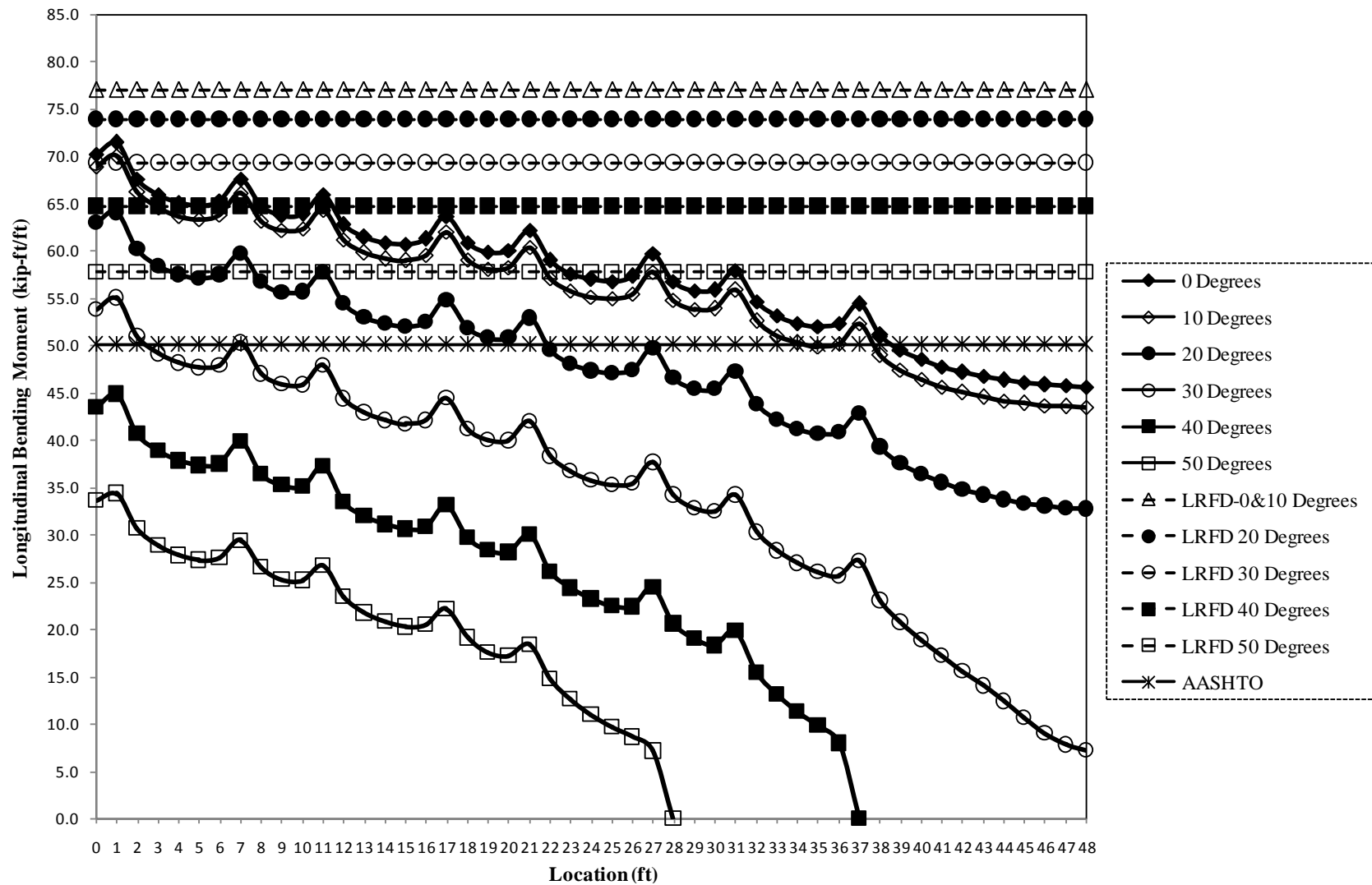


Fig. A16. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 4
No Railings with Edge Loading E1.

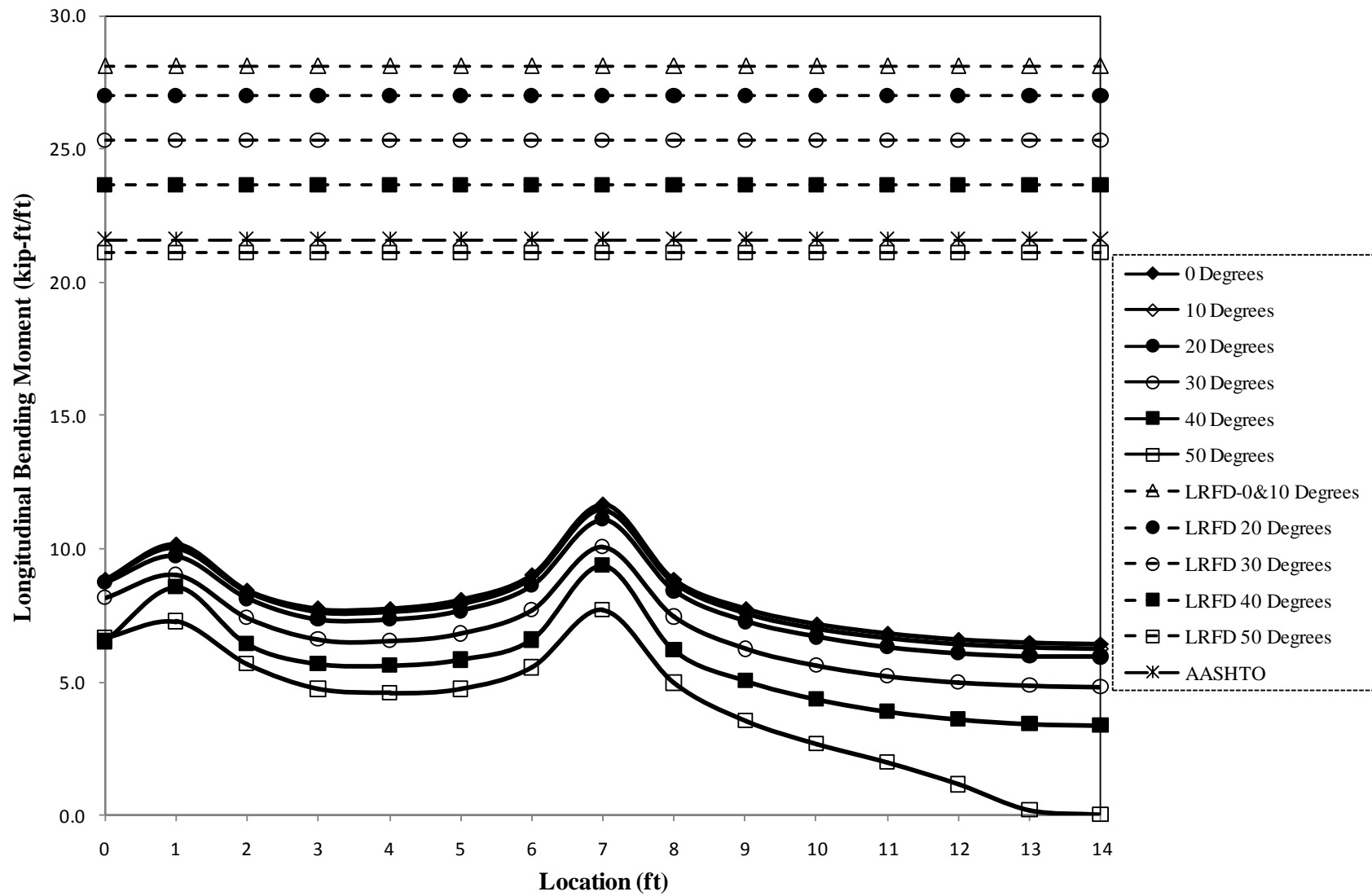


Fig. A17. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 1
One Railing with Edge Loading E1.

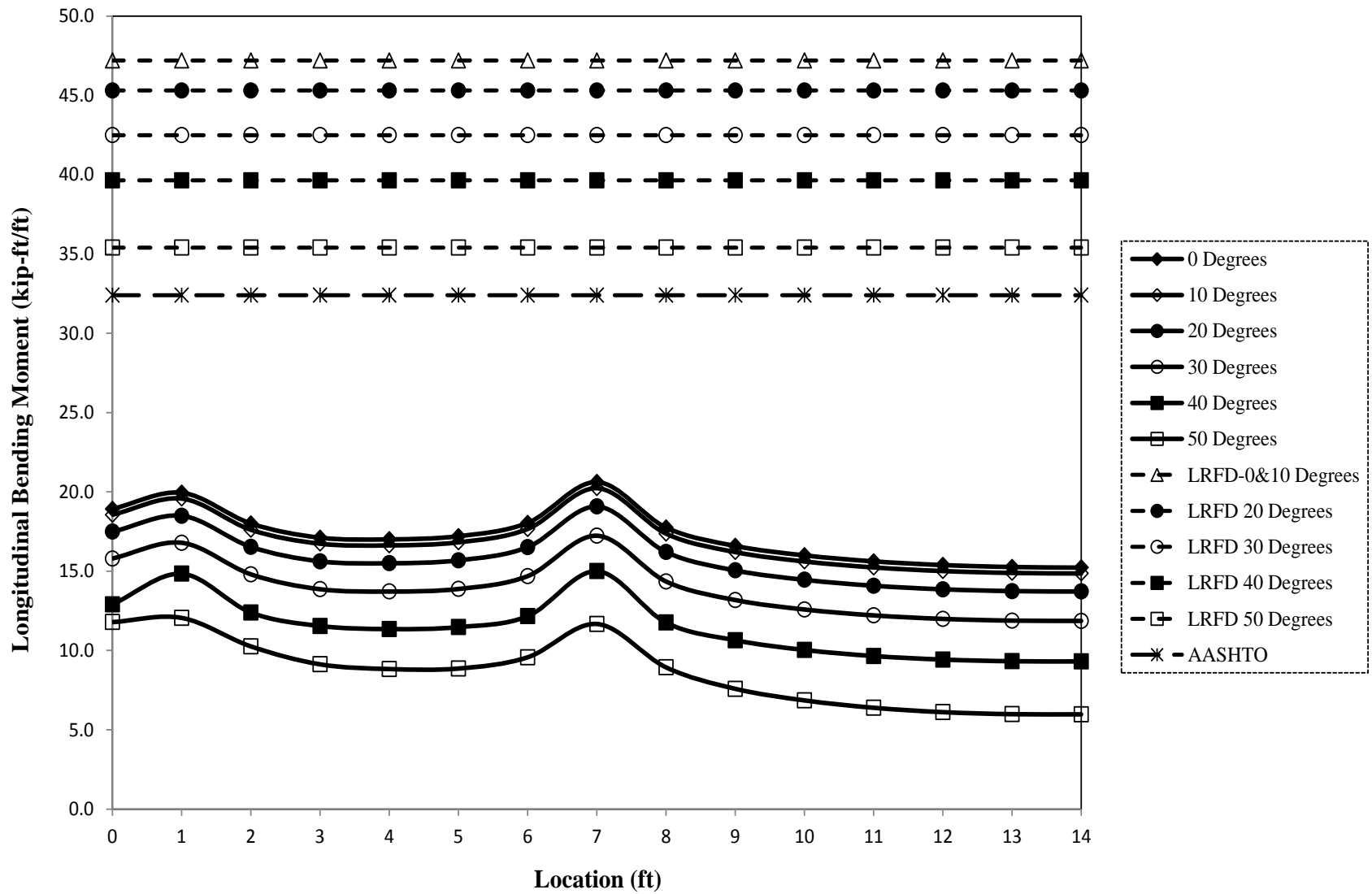


Fig. A18. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 1
One Railing with Edge Loading E1.

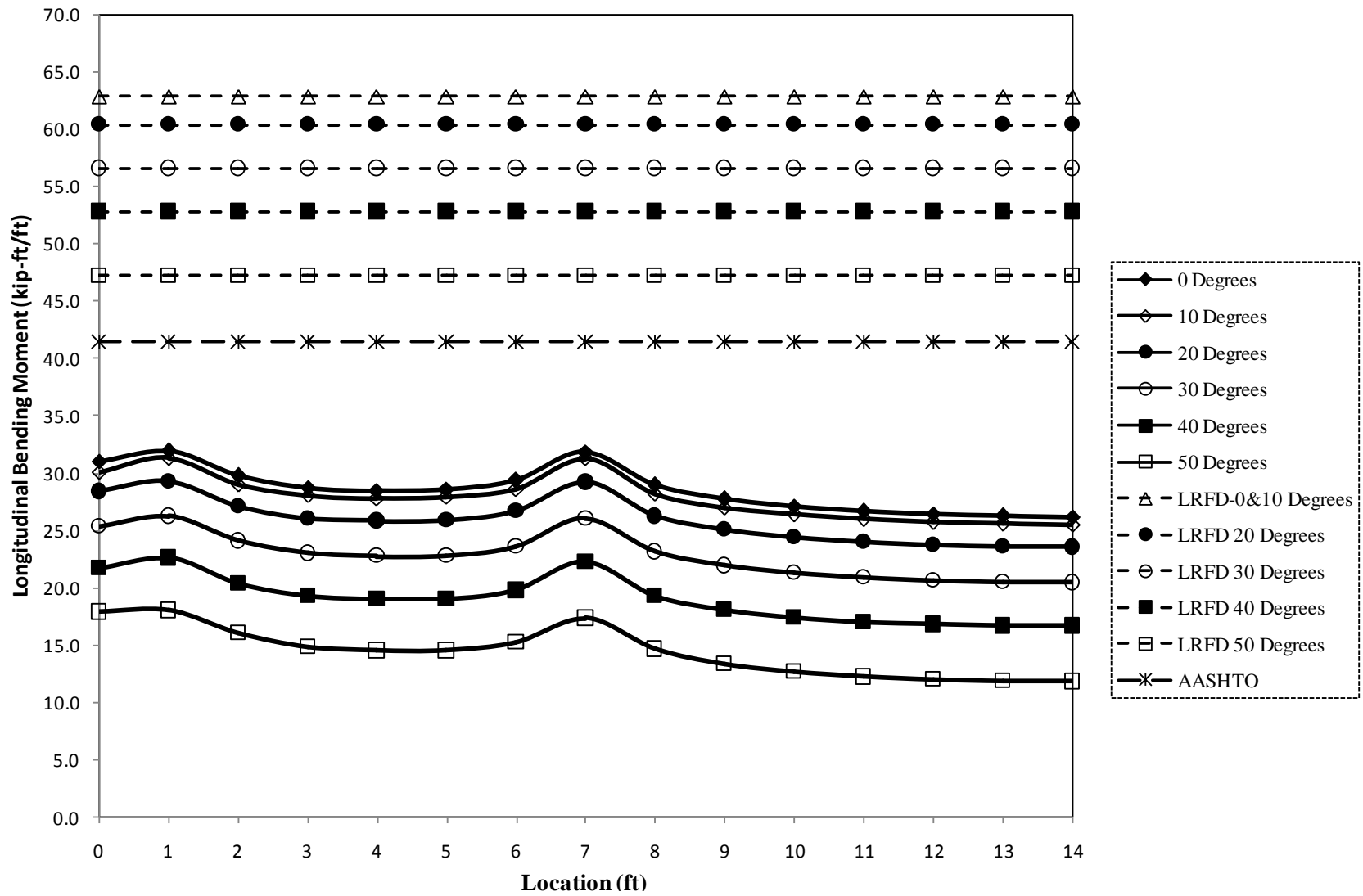


Fig. A19. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 1
One Railing with Edge Loading E1.

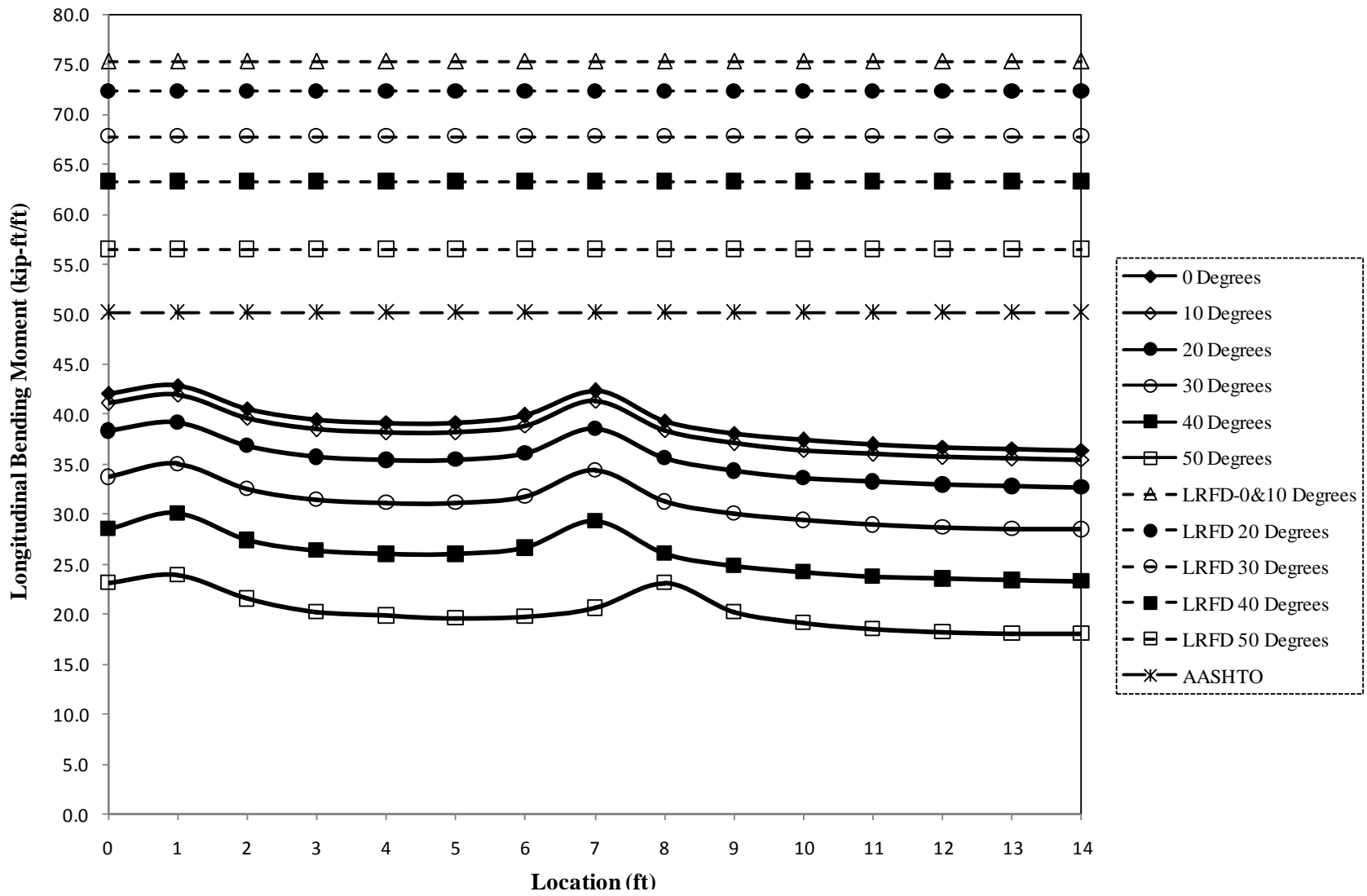


Fig. A20. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 1
One Railing with Edge Loading E1.

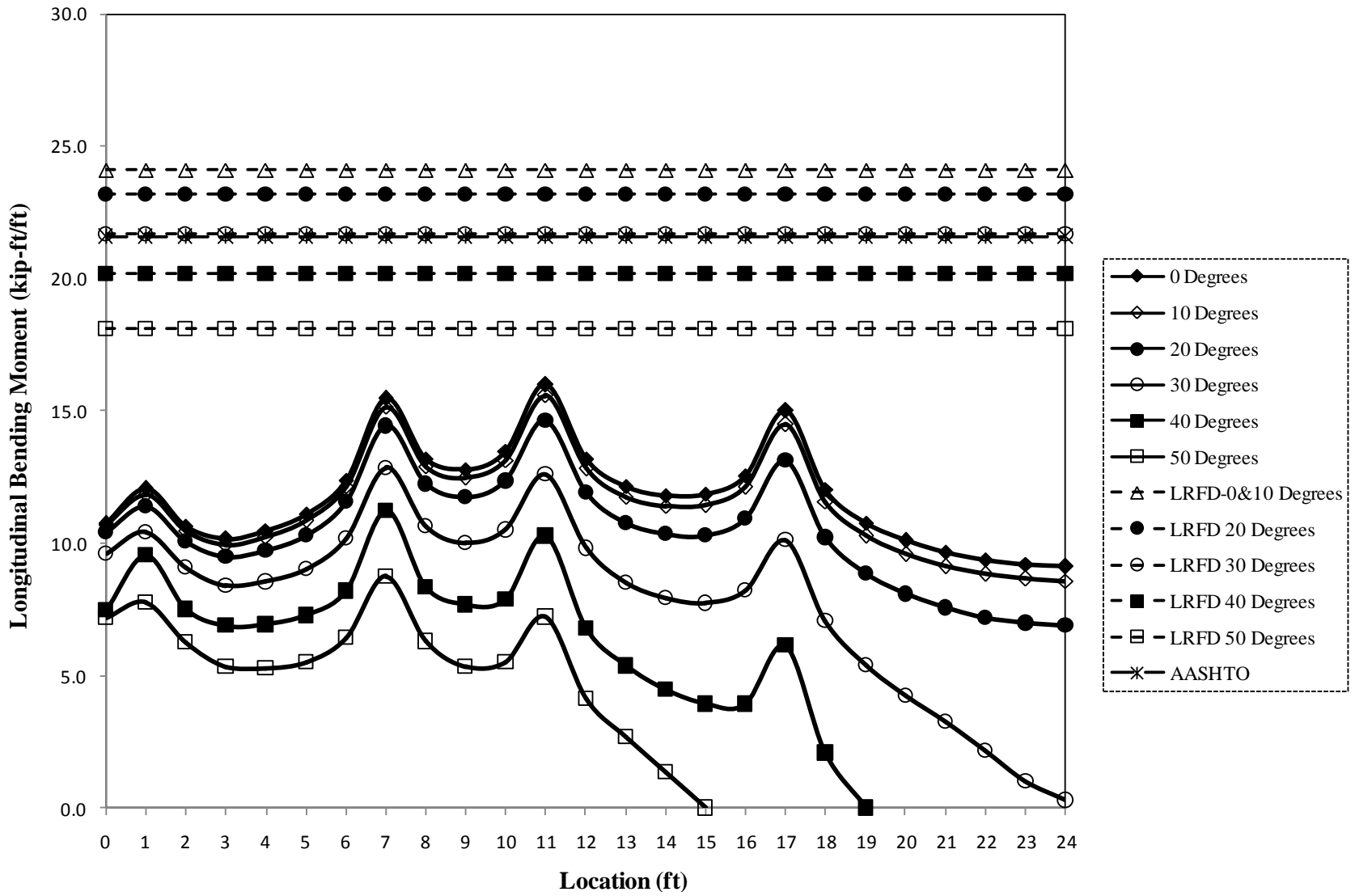


Fig. A21. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 2
One Railing with Edge Loading E1.

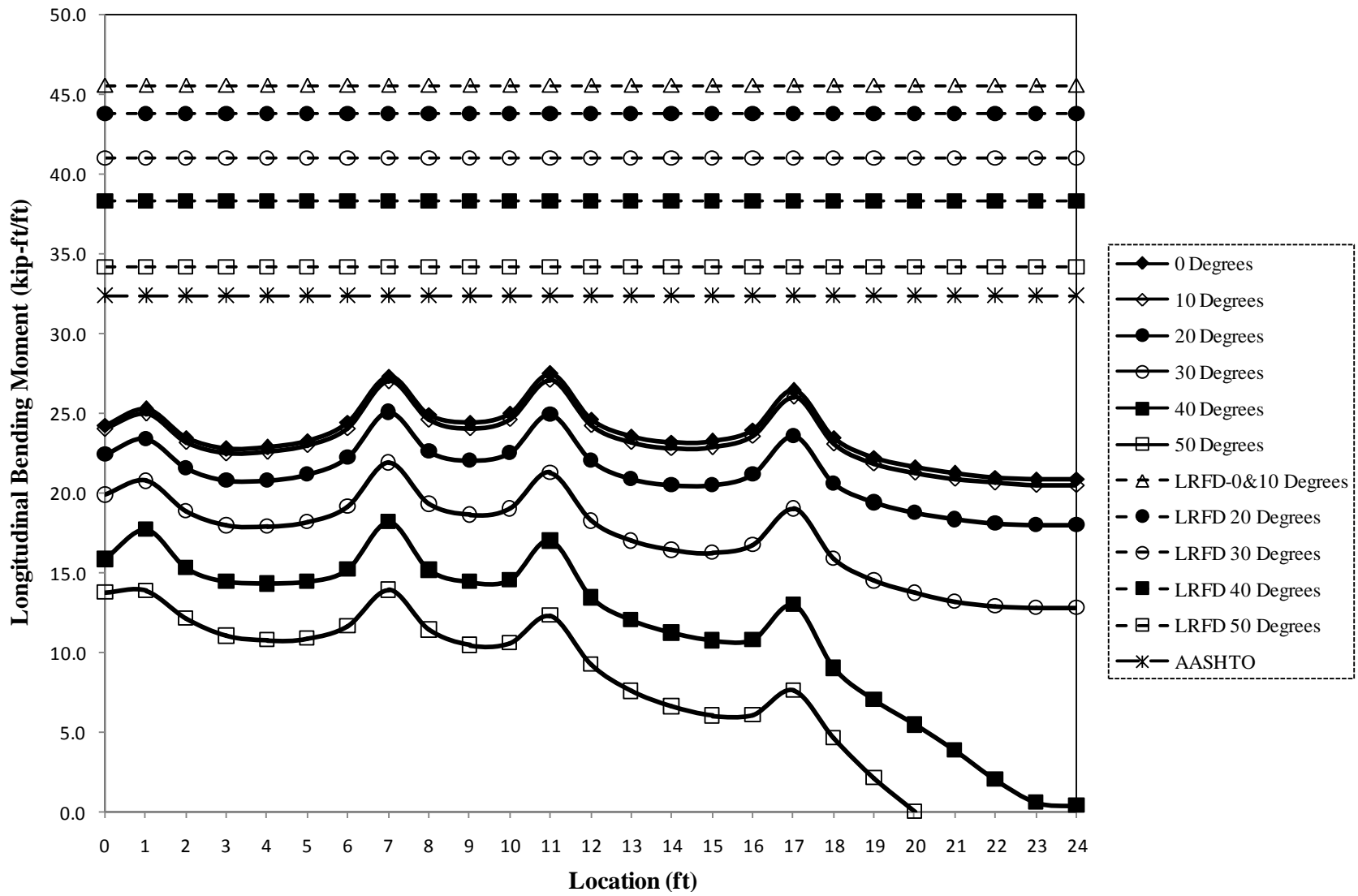


Fig. A22. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 2
One Railing with Edge Loading E1.

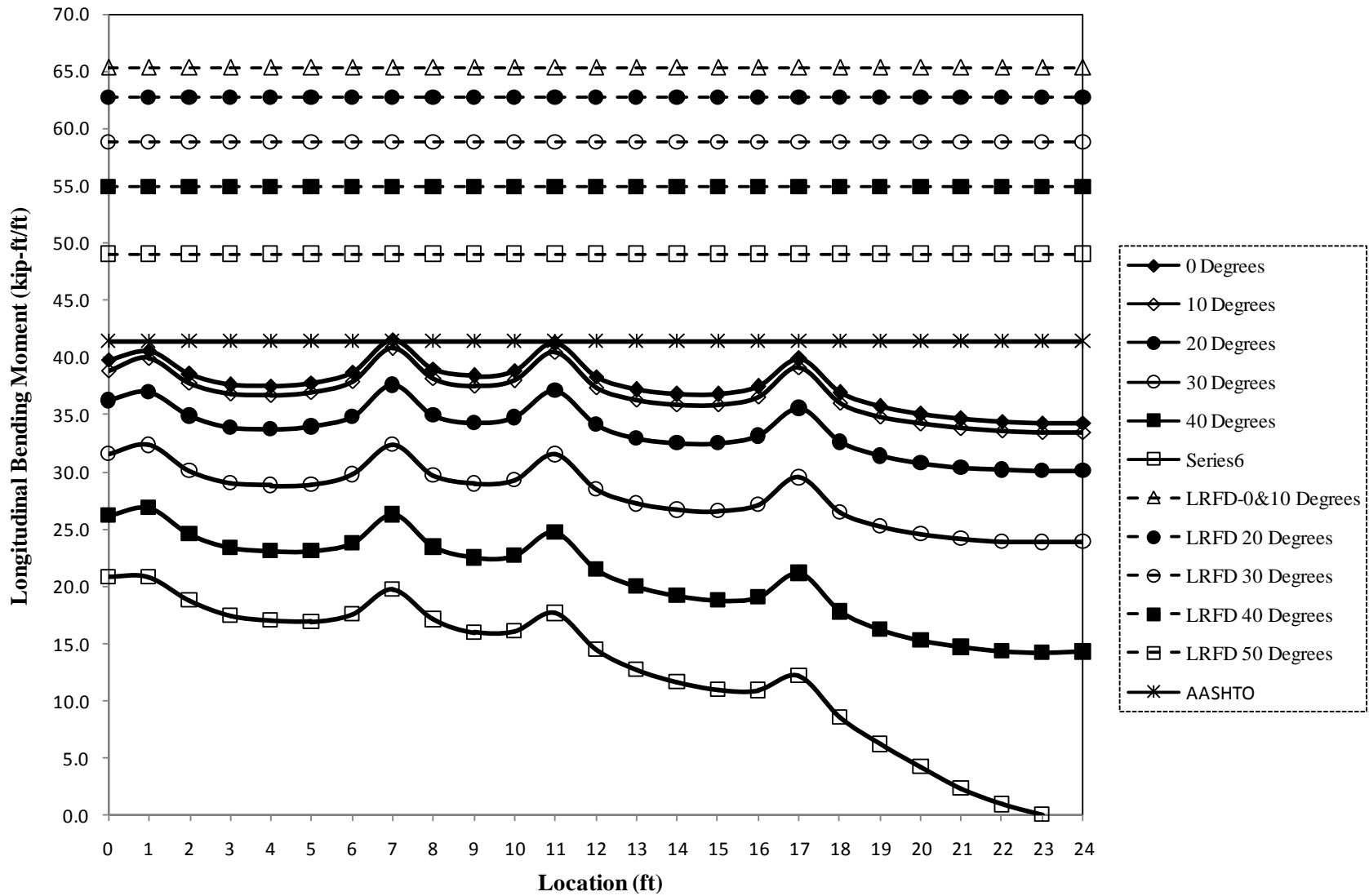


Fig. A23. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 2
One Railing with Edge Loading E1.

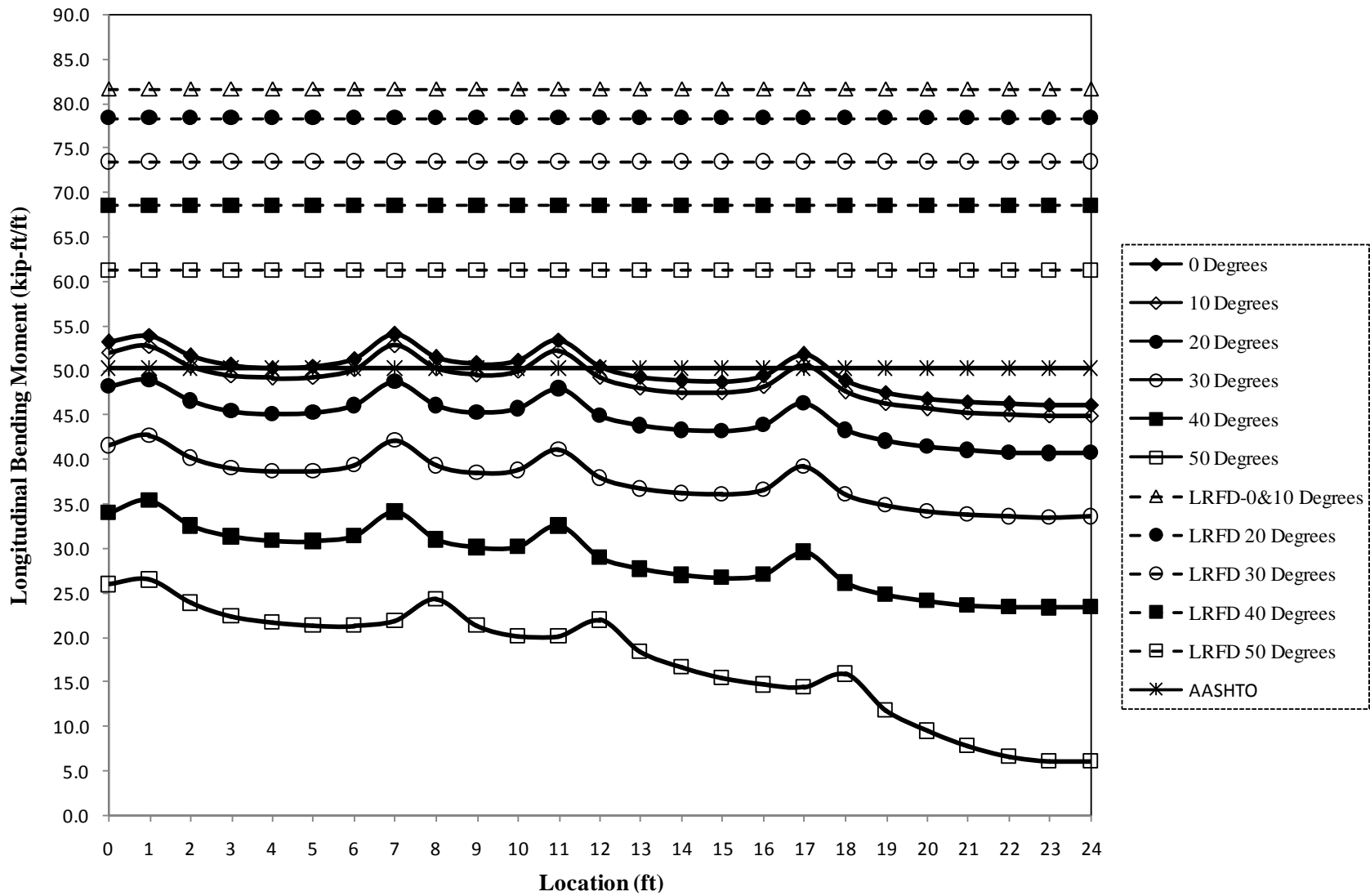


Fig. A24. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 2
One Railing with Edge Loading E1.

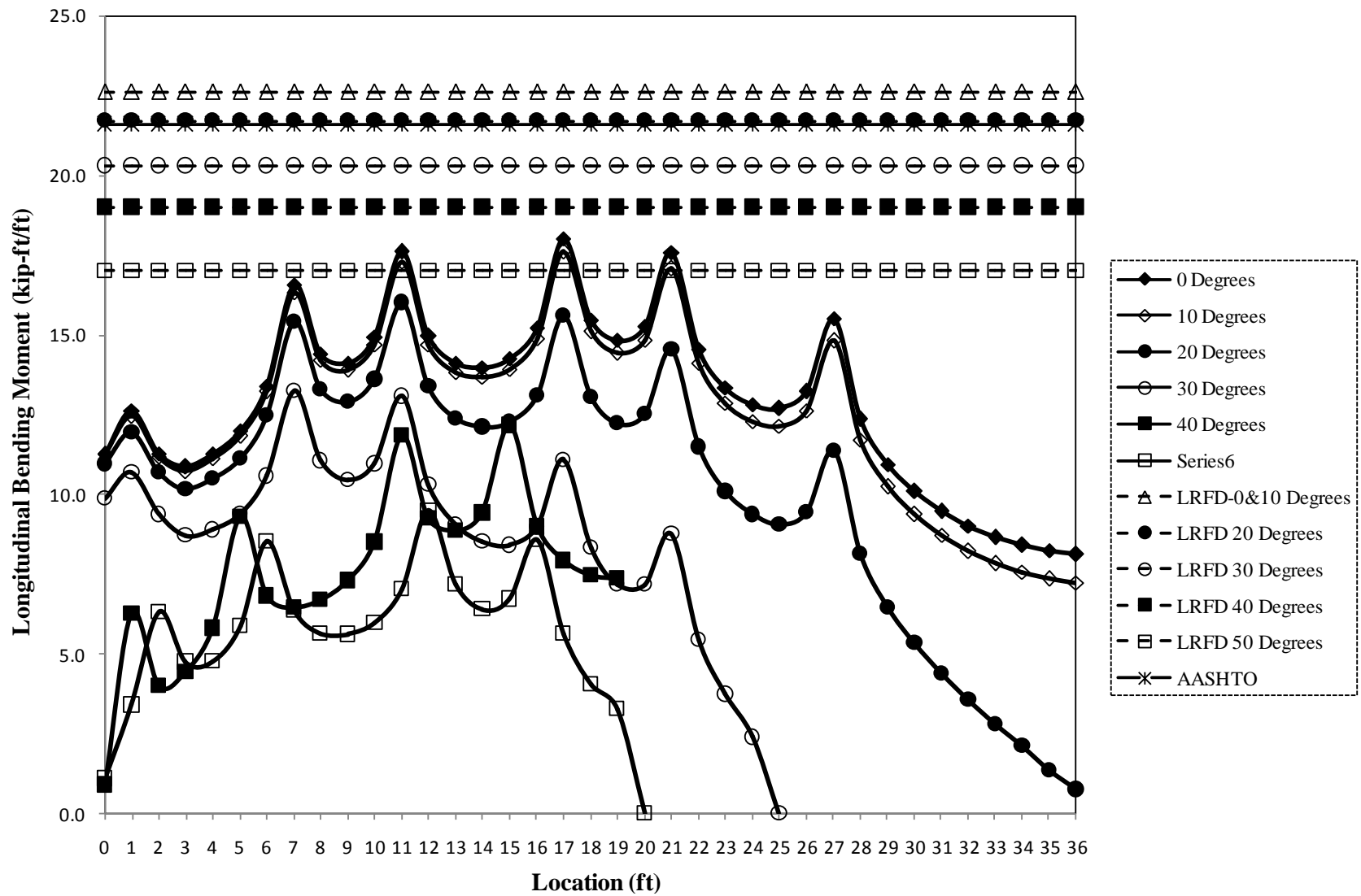


Fig. A25. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 3
One Railing with Edge Loading E1.

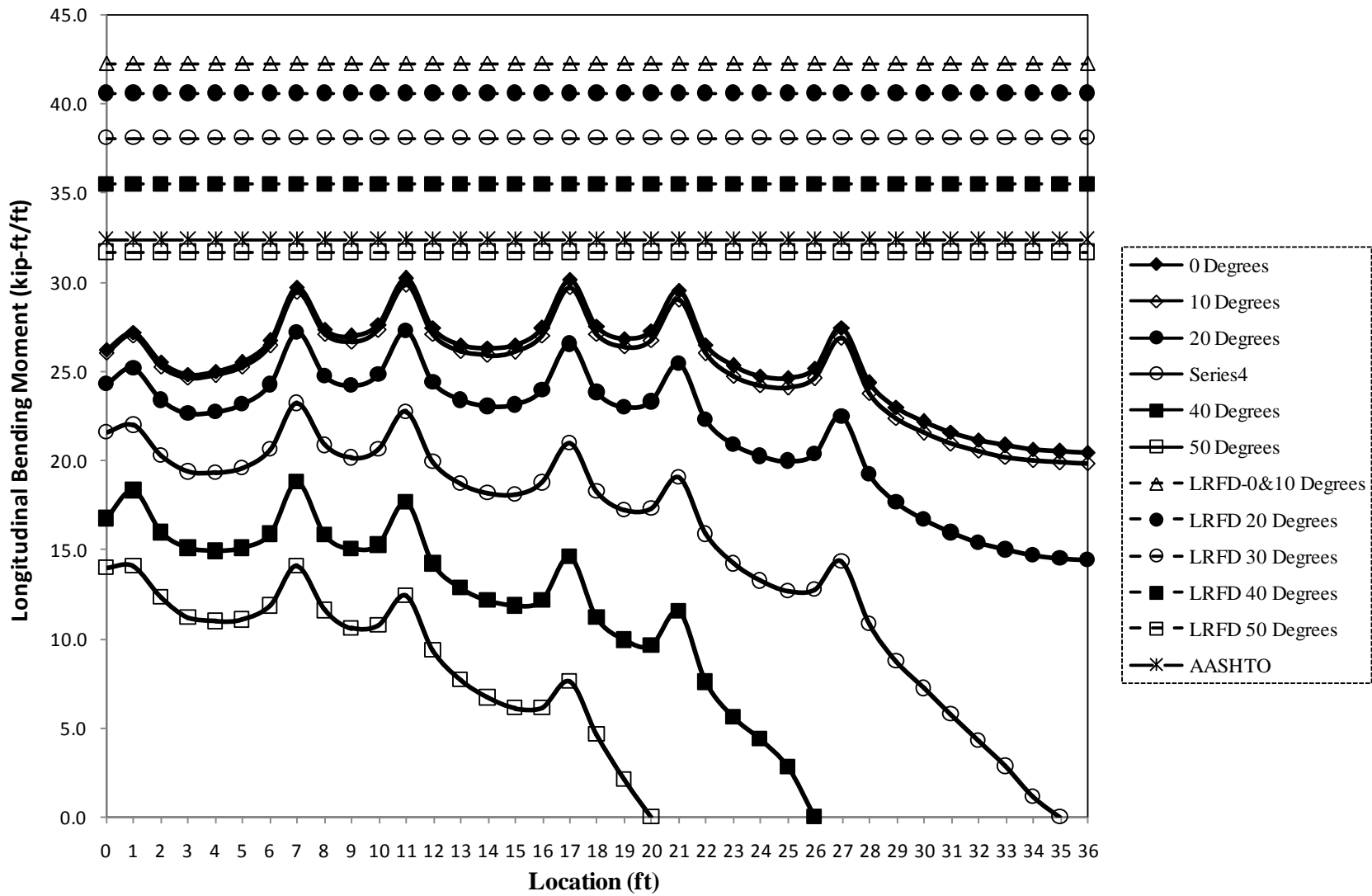


Fig. A26. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 3
One Railing with Edge Loading E1.

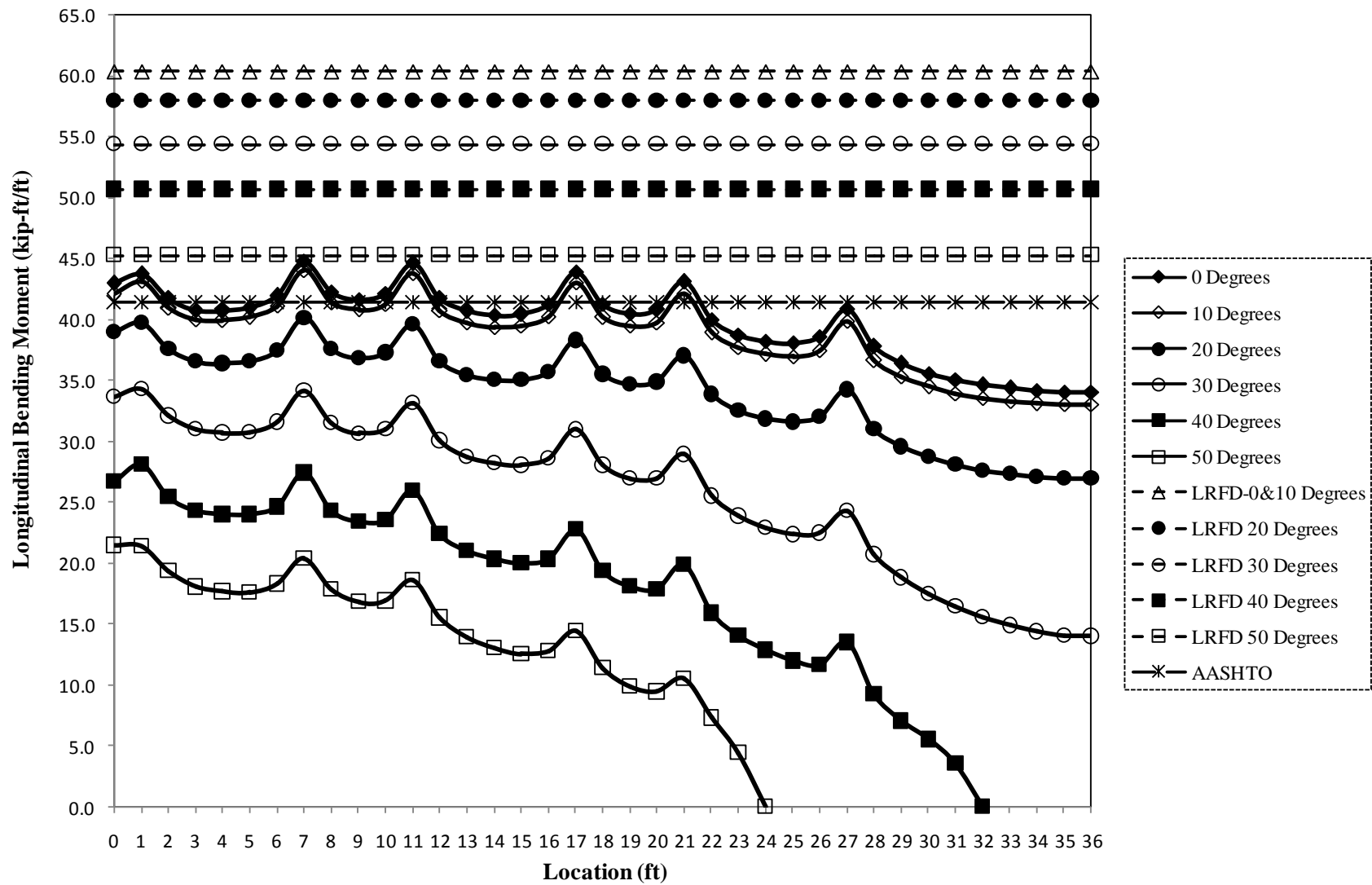


Fig. A27. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 3
One Railing with Edge Loading E1.

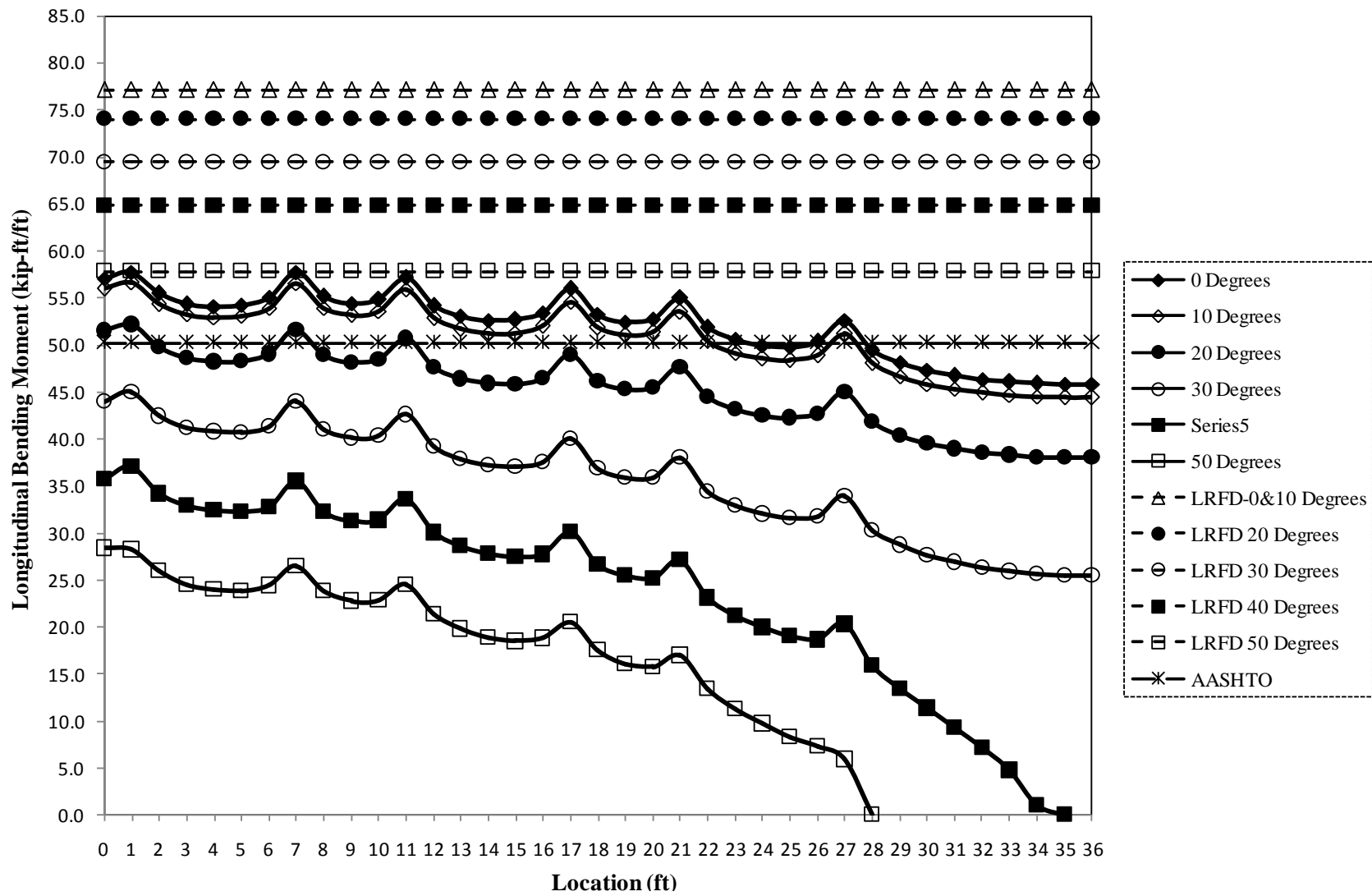


Fig. A28. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 3
One Railing with Edge Loading E1.

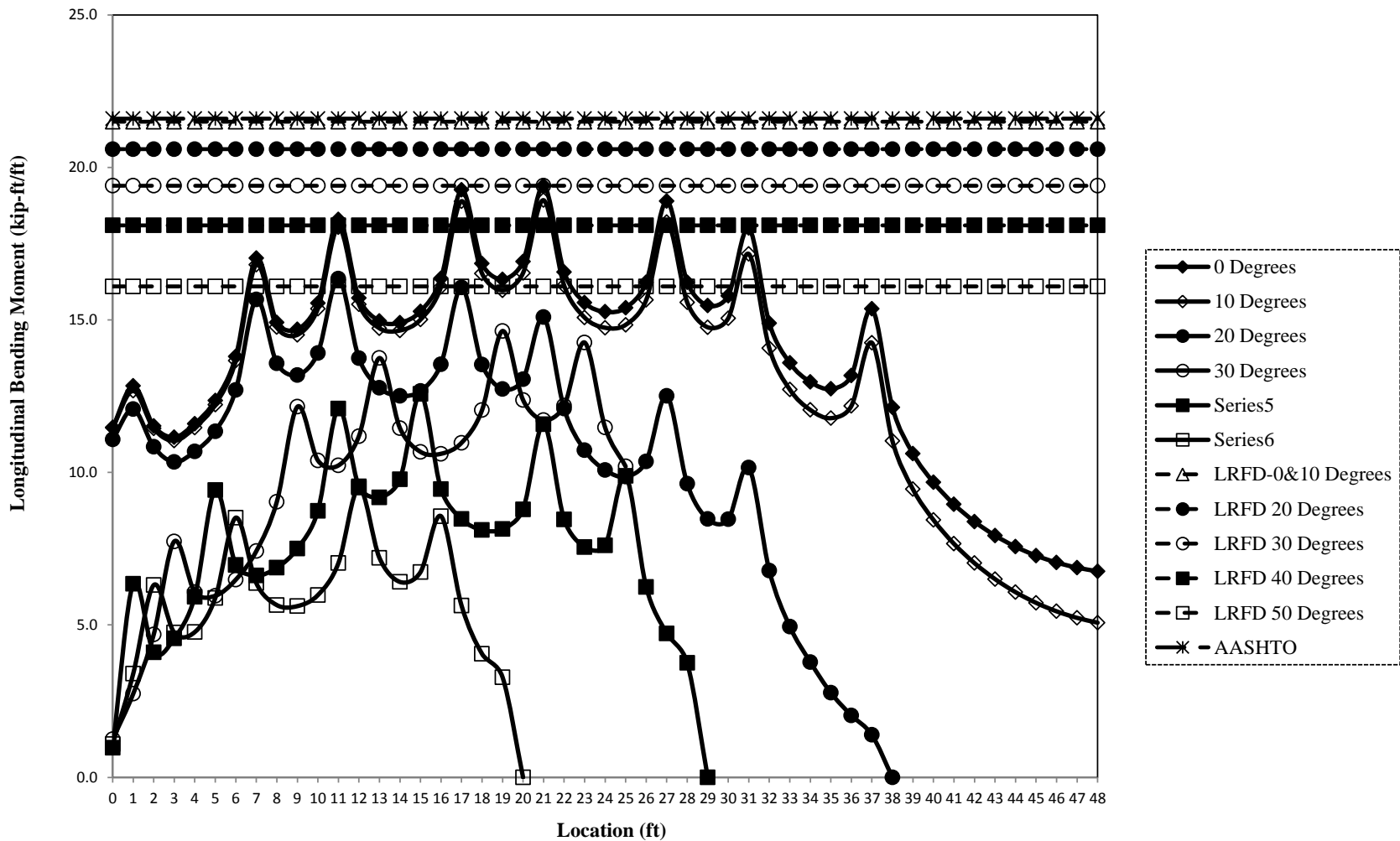


Fig. A29. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 4
One Railing with Edge Loading E1.

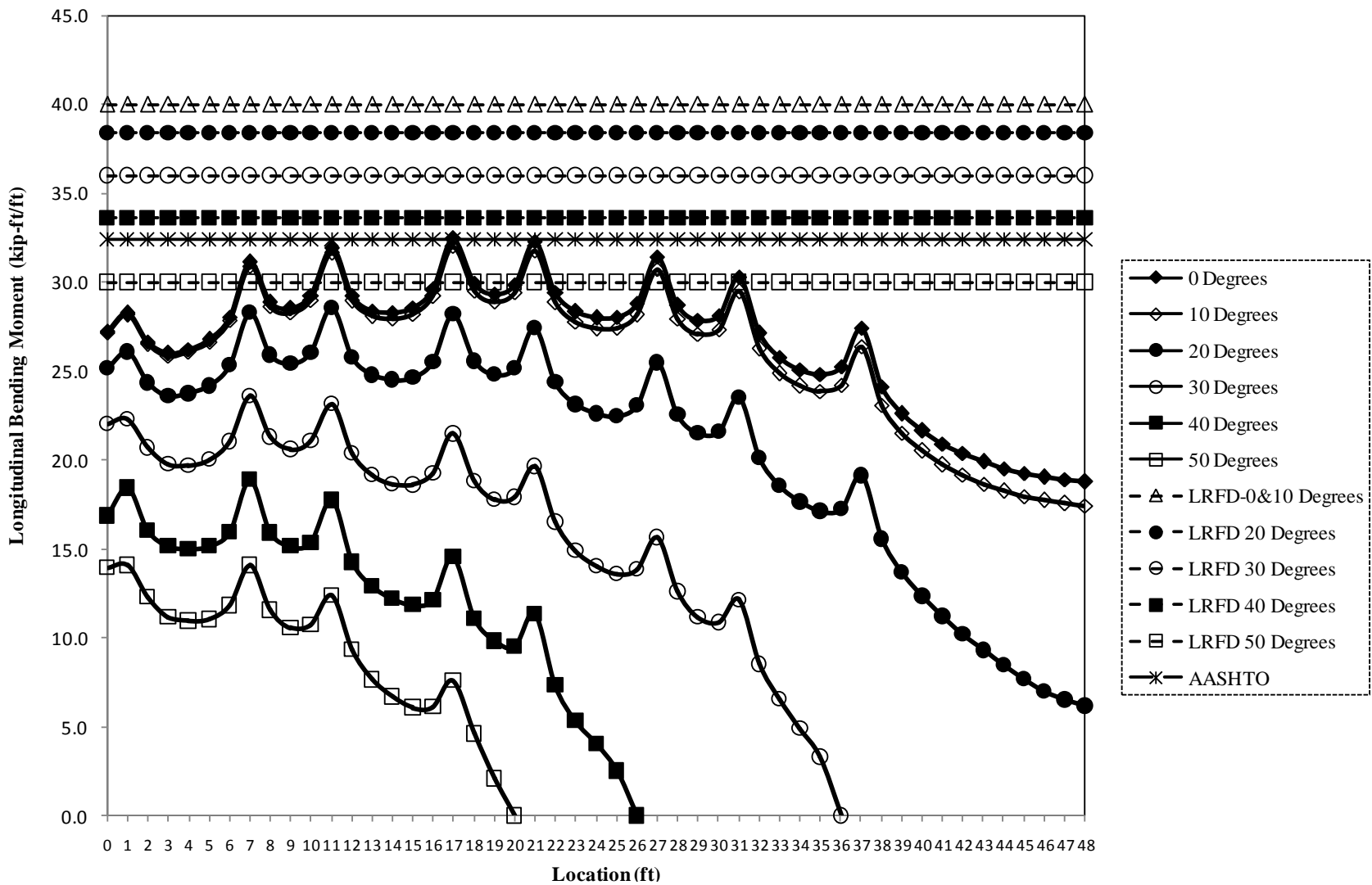


Fig. A30. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 4
One Railing with Edge Loading E1.

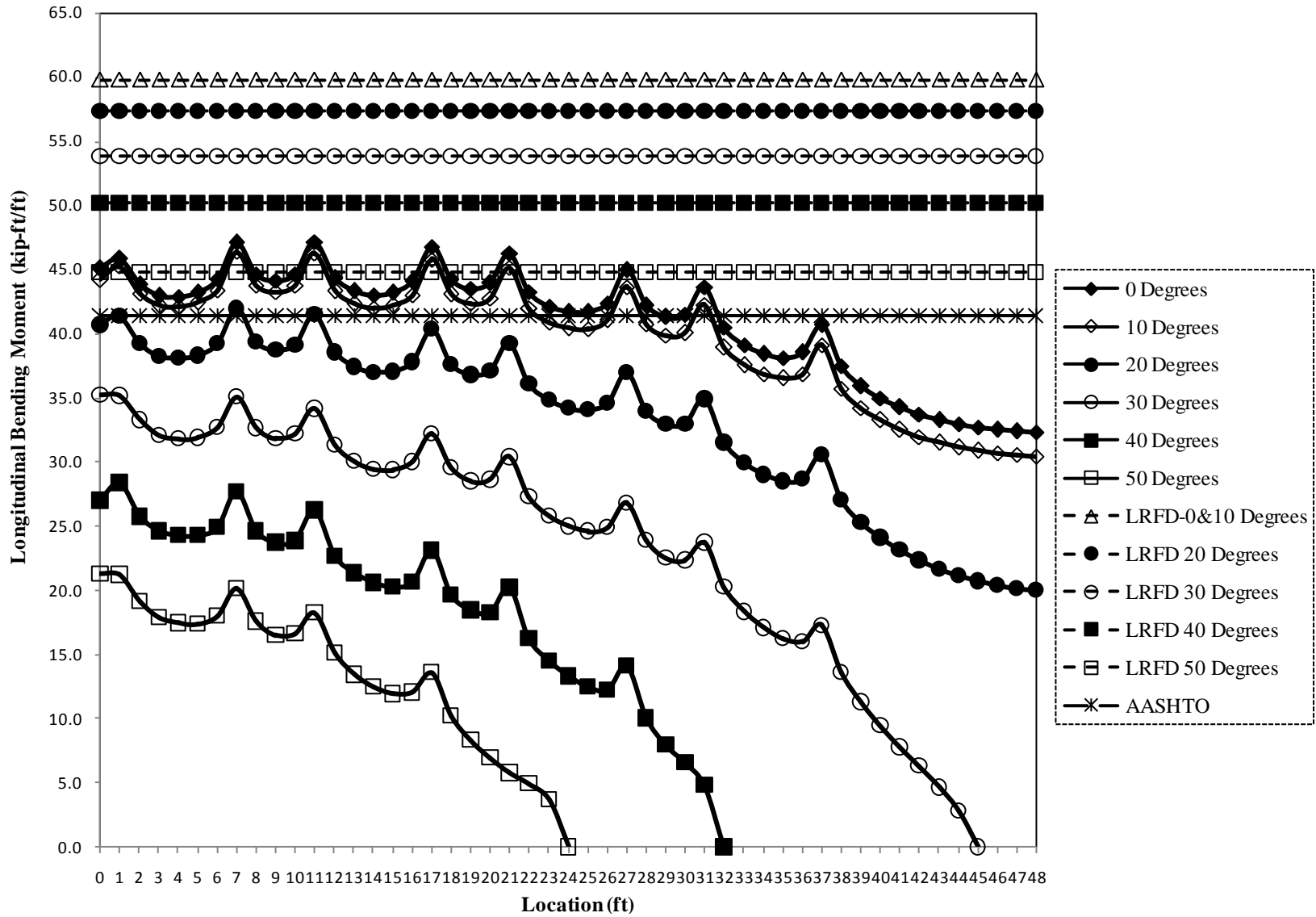


Fig. A31. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 4 One Railing with Edge Loading E1.

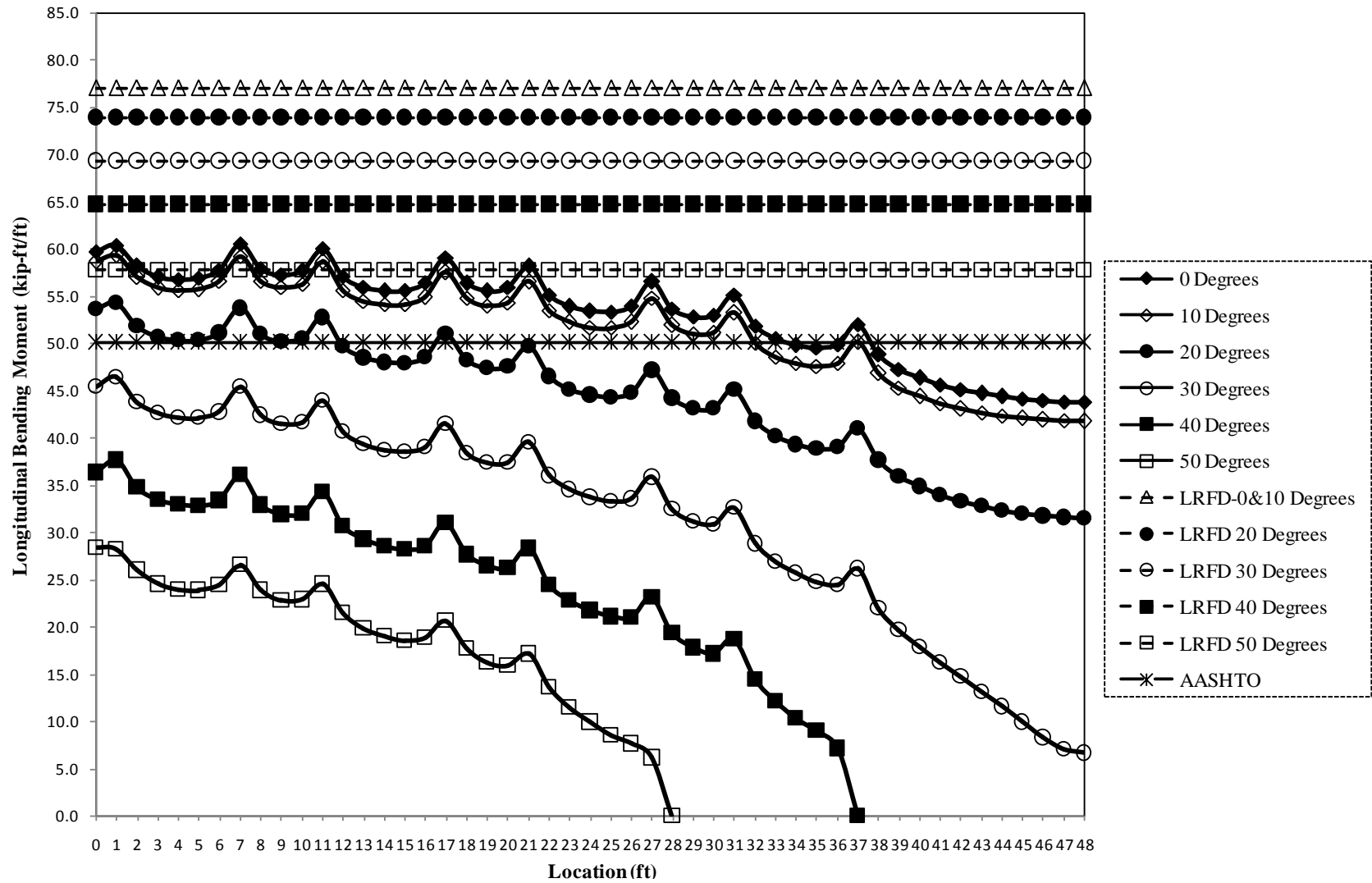


Fig. A32. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 4
One Railing with Edge Loading E1.

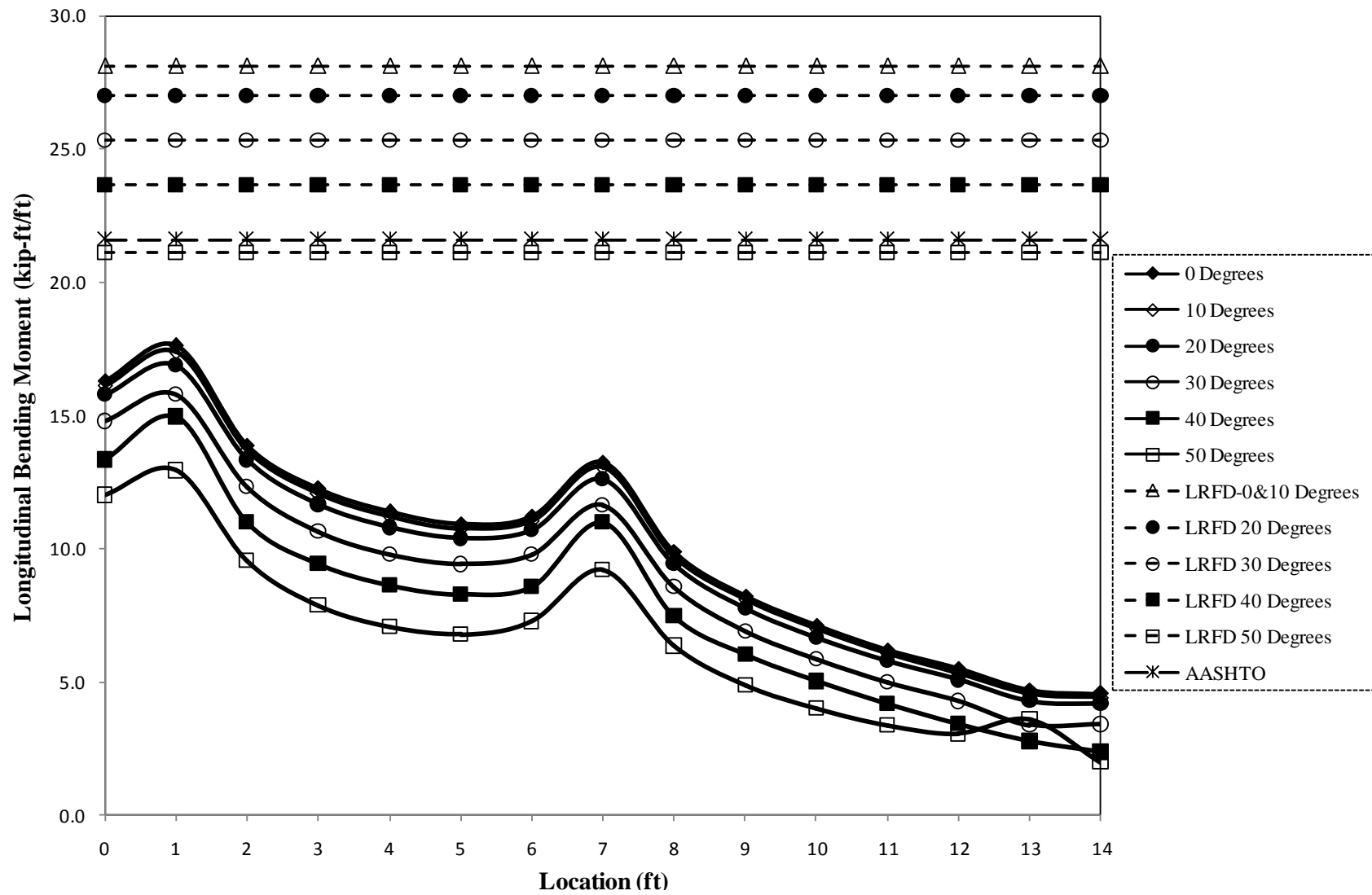


Fig. A33. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 1
One Railing with Edge Loading E2.

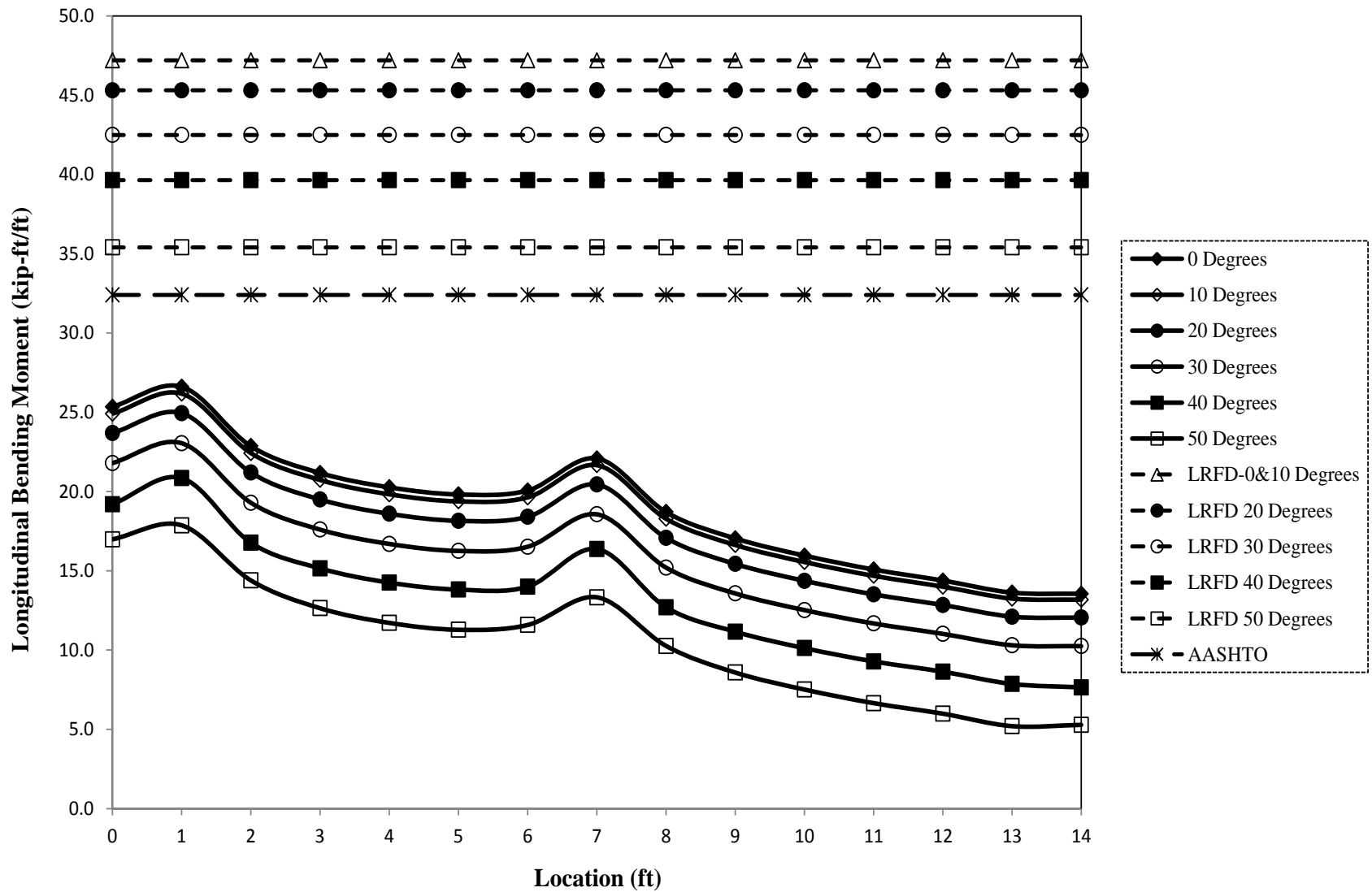


Fig. A34. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 1
One Railing with Edge Loading E2.

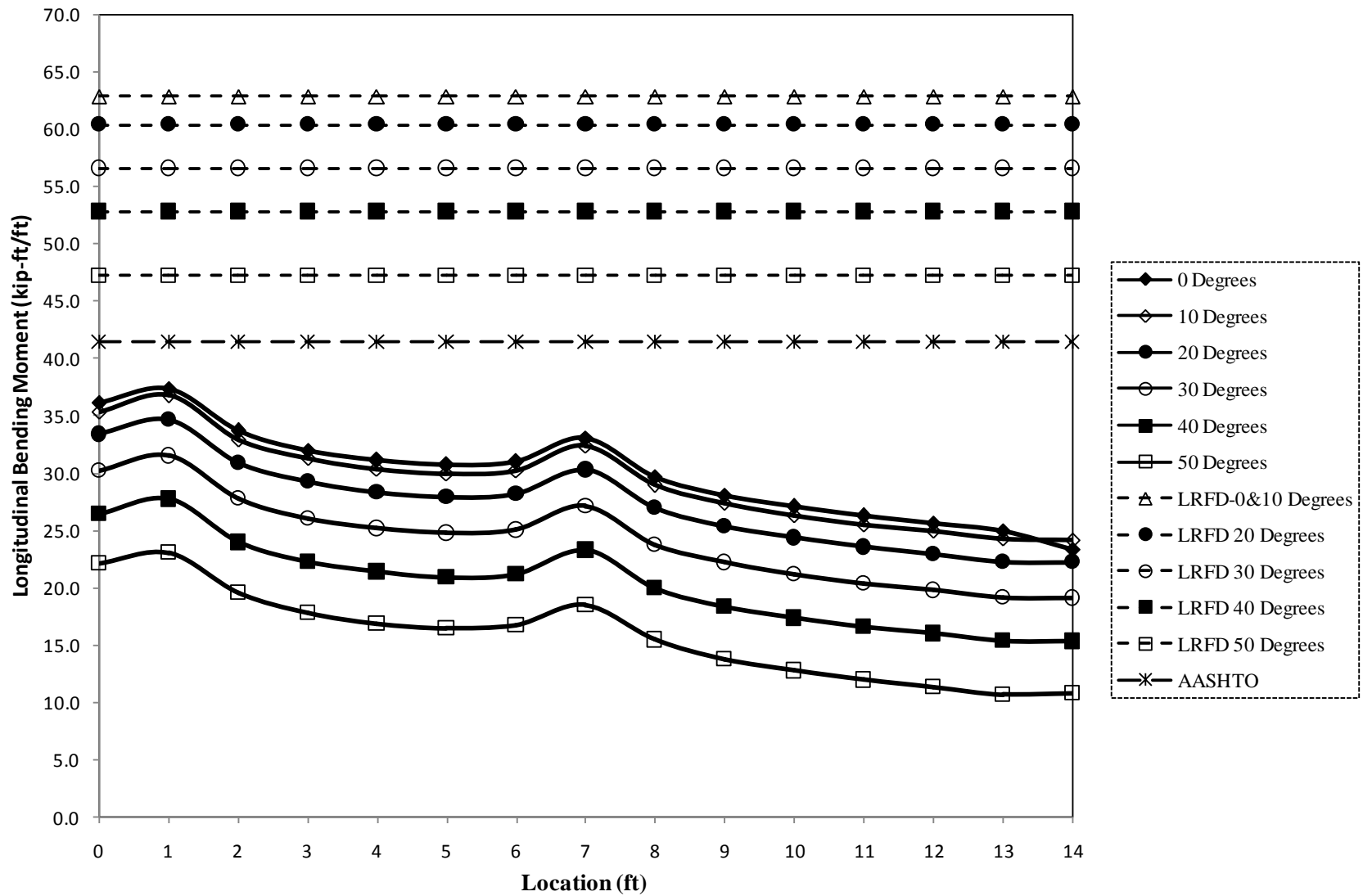


Fig. A35. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 1
One Railing with Edge Loading E2.

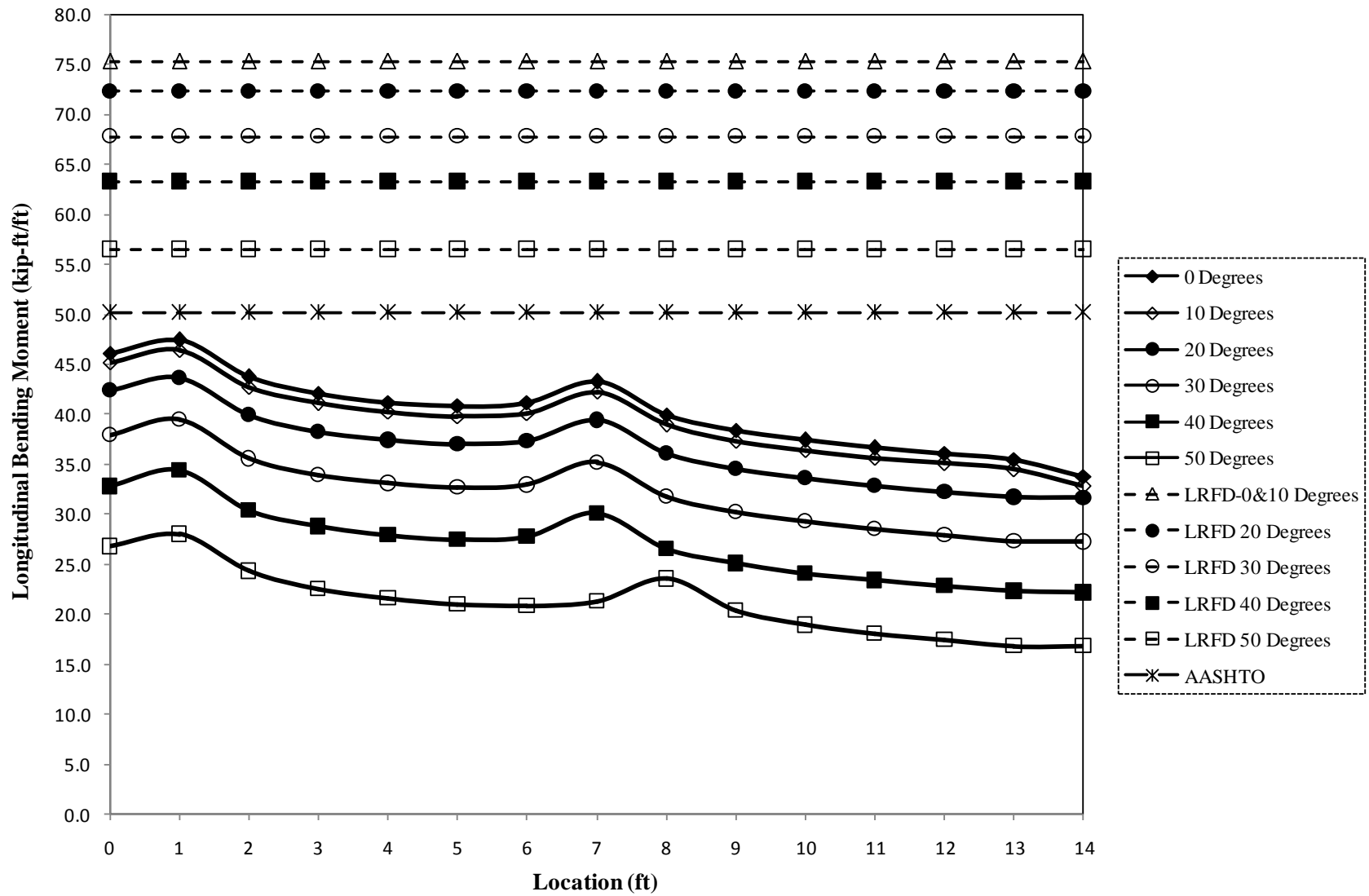


Fig. A36. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 1
One Railing with Edge Loading E2.

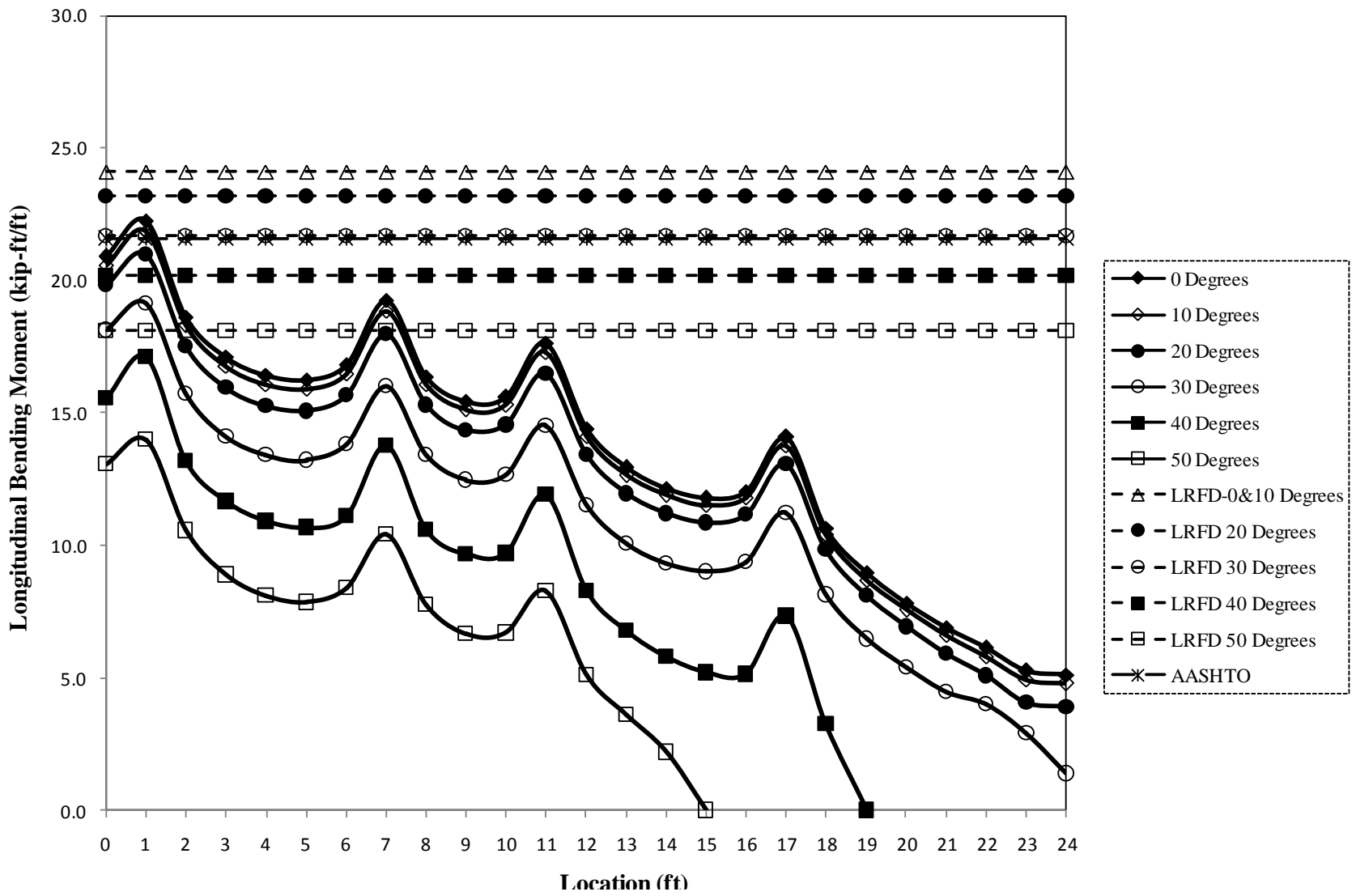


Fig. A37. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 2
One Railing with Edge Loading E2.

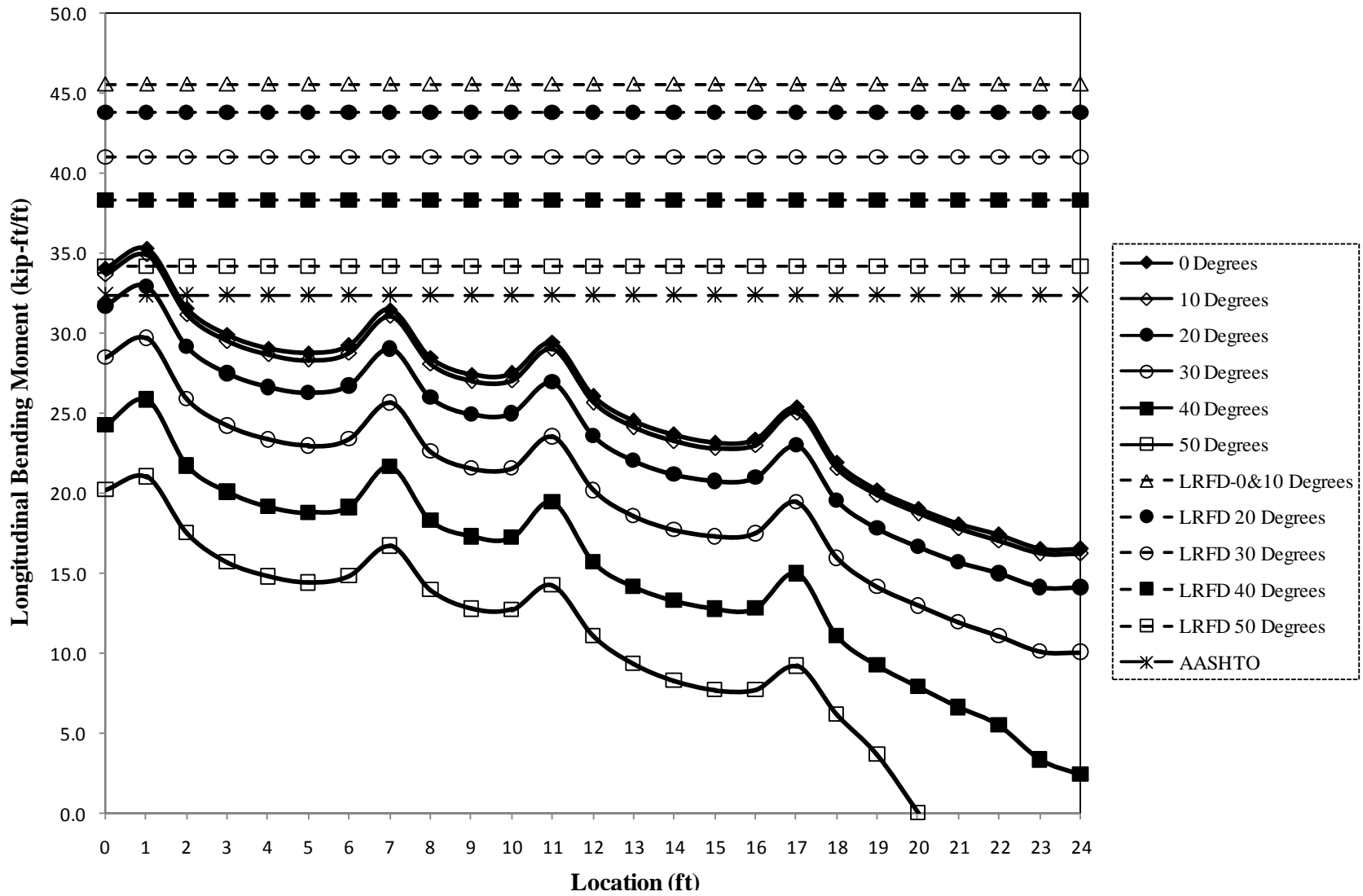


Fig. A38. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 2
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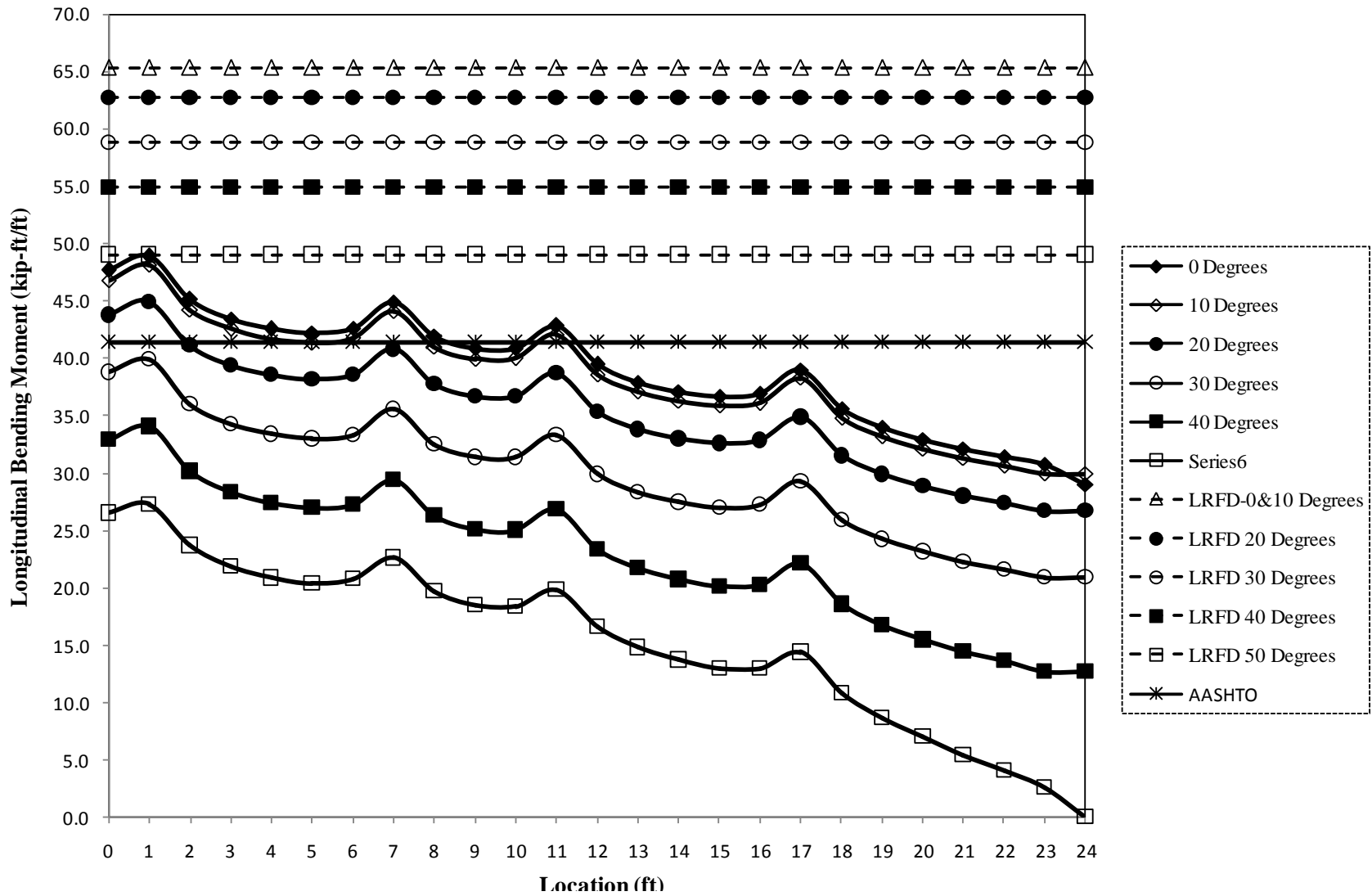


Fig. A39. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 2
One Railing with Edge Loading E2.

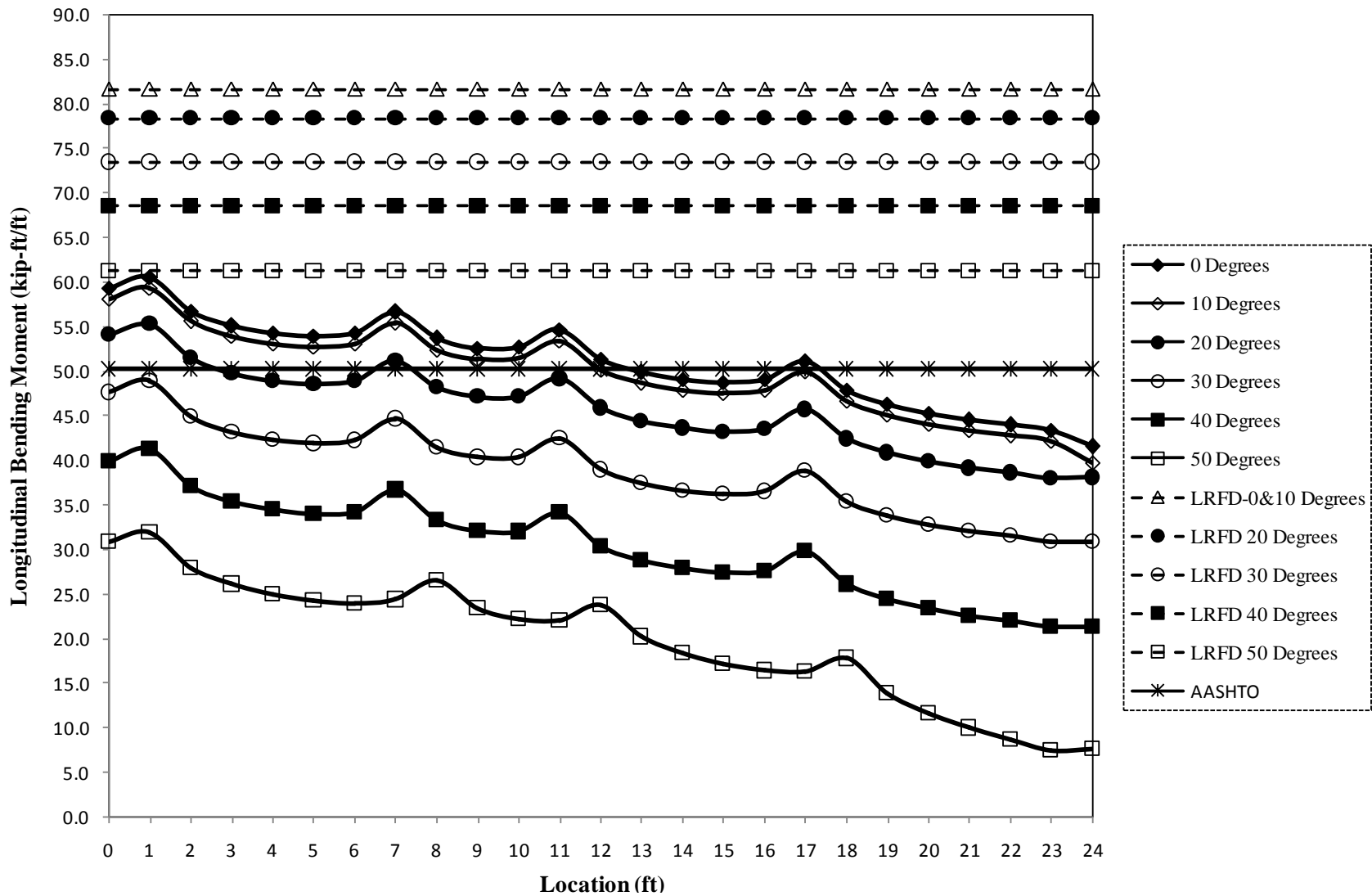


Fig. A40. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 2
One Railing with Edge Loading E2.

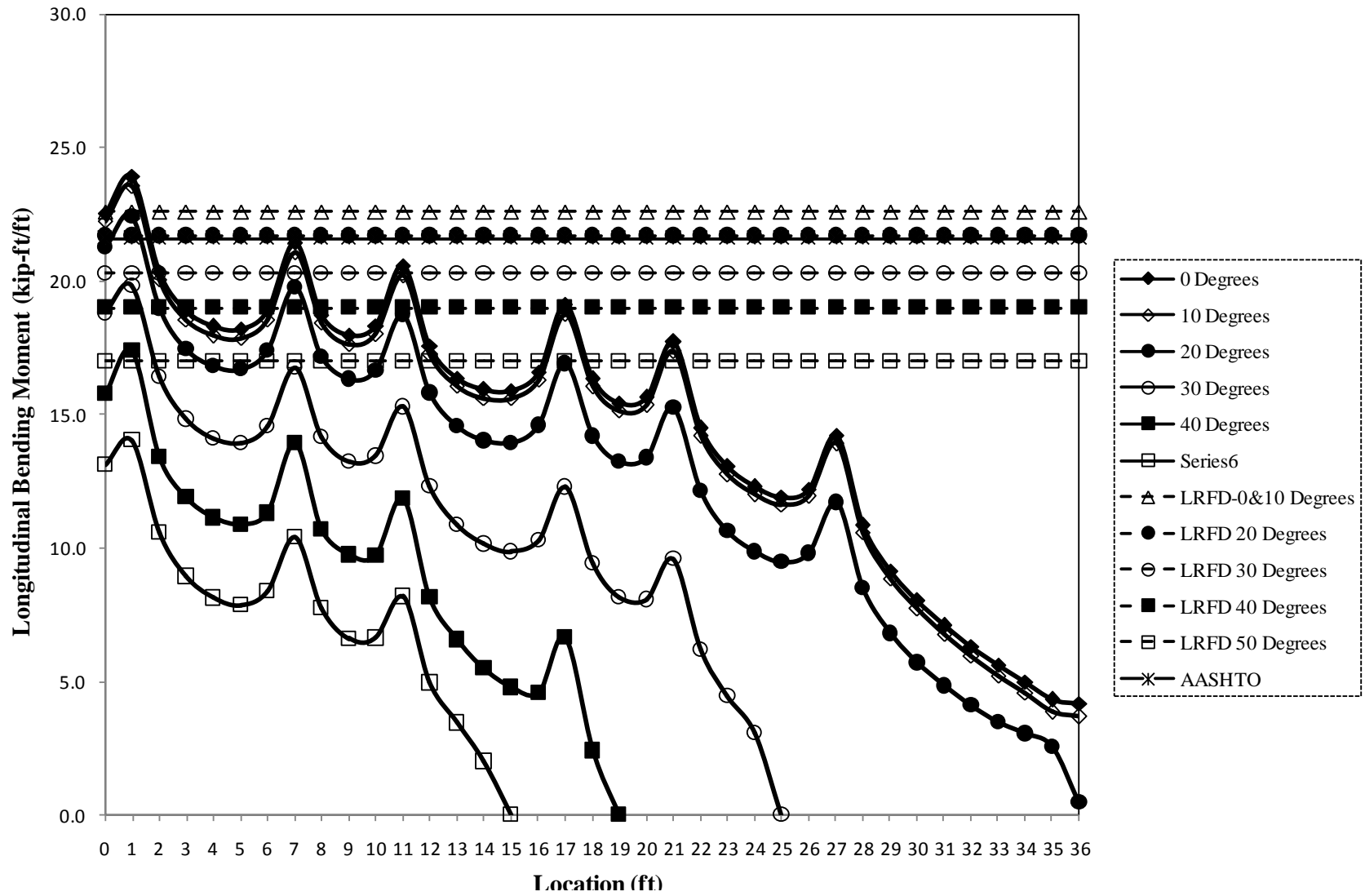


Fig. A41. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 3
One Railing with Edge Loading E2.

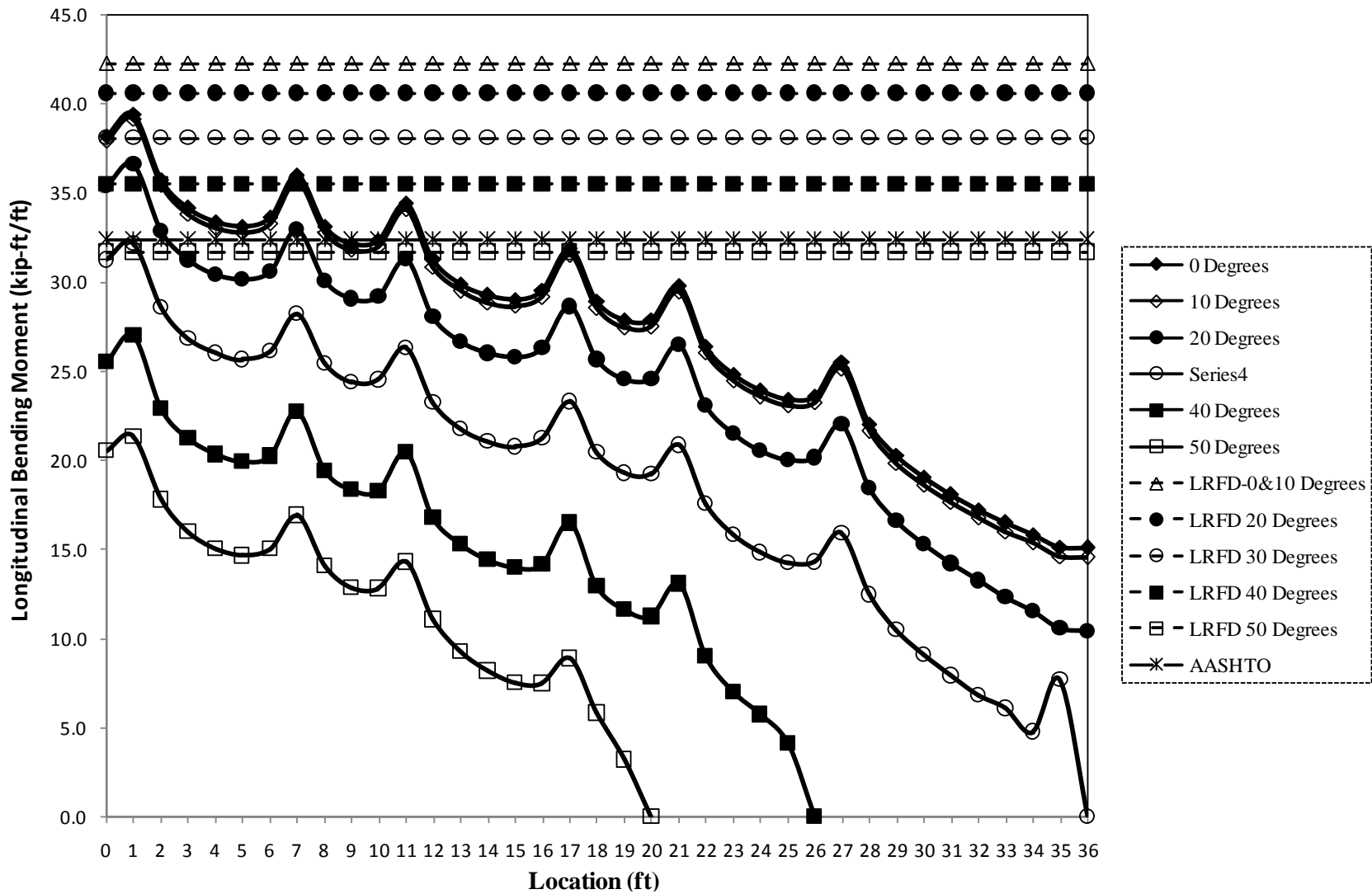


Fig. A42. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 3
One Railing with Edge Loading E2.

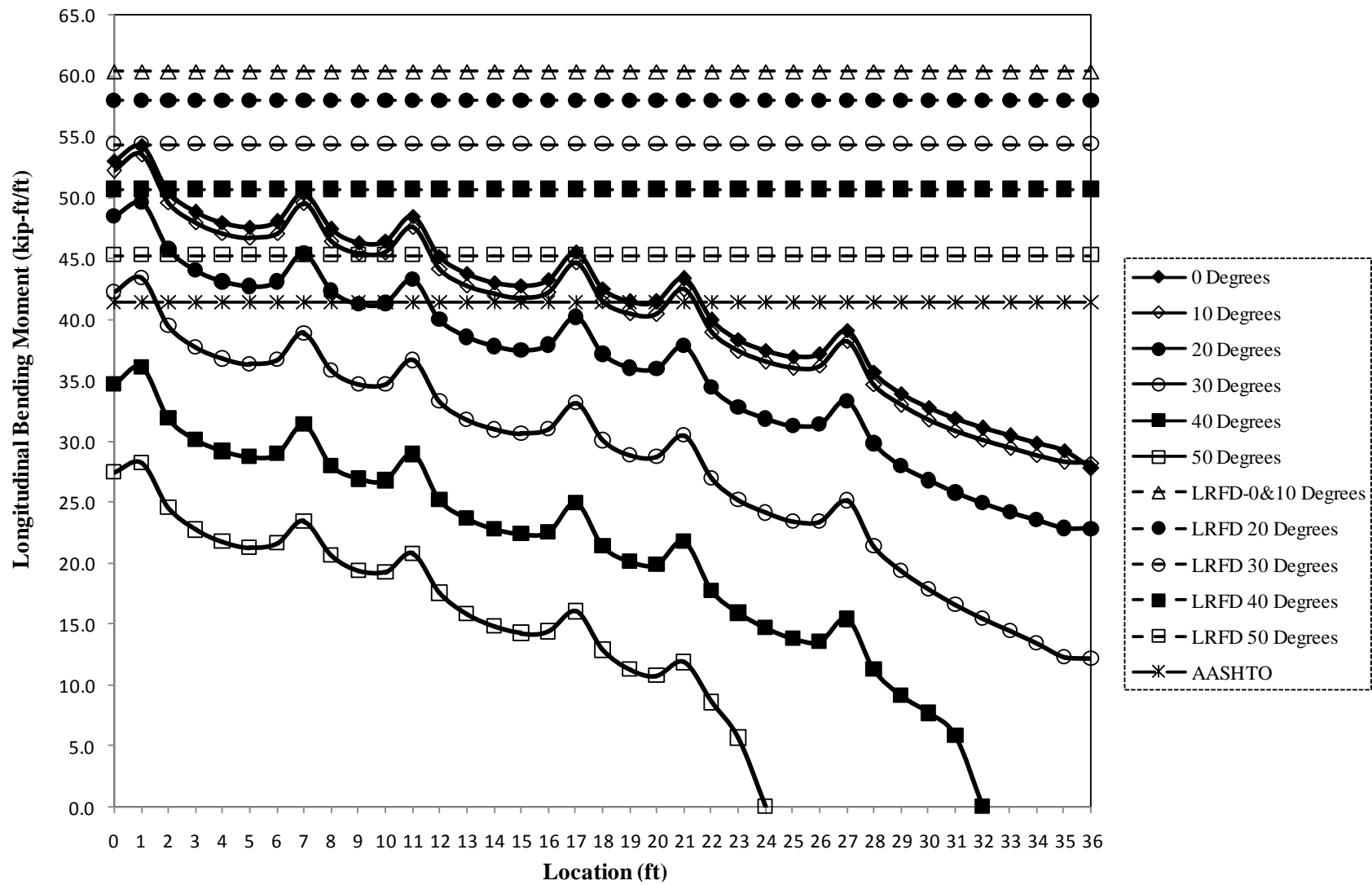


Fig. A43. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 3
One Railing with Edge Loading E2.

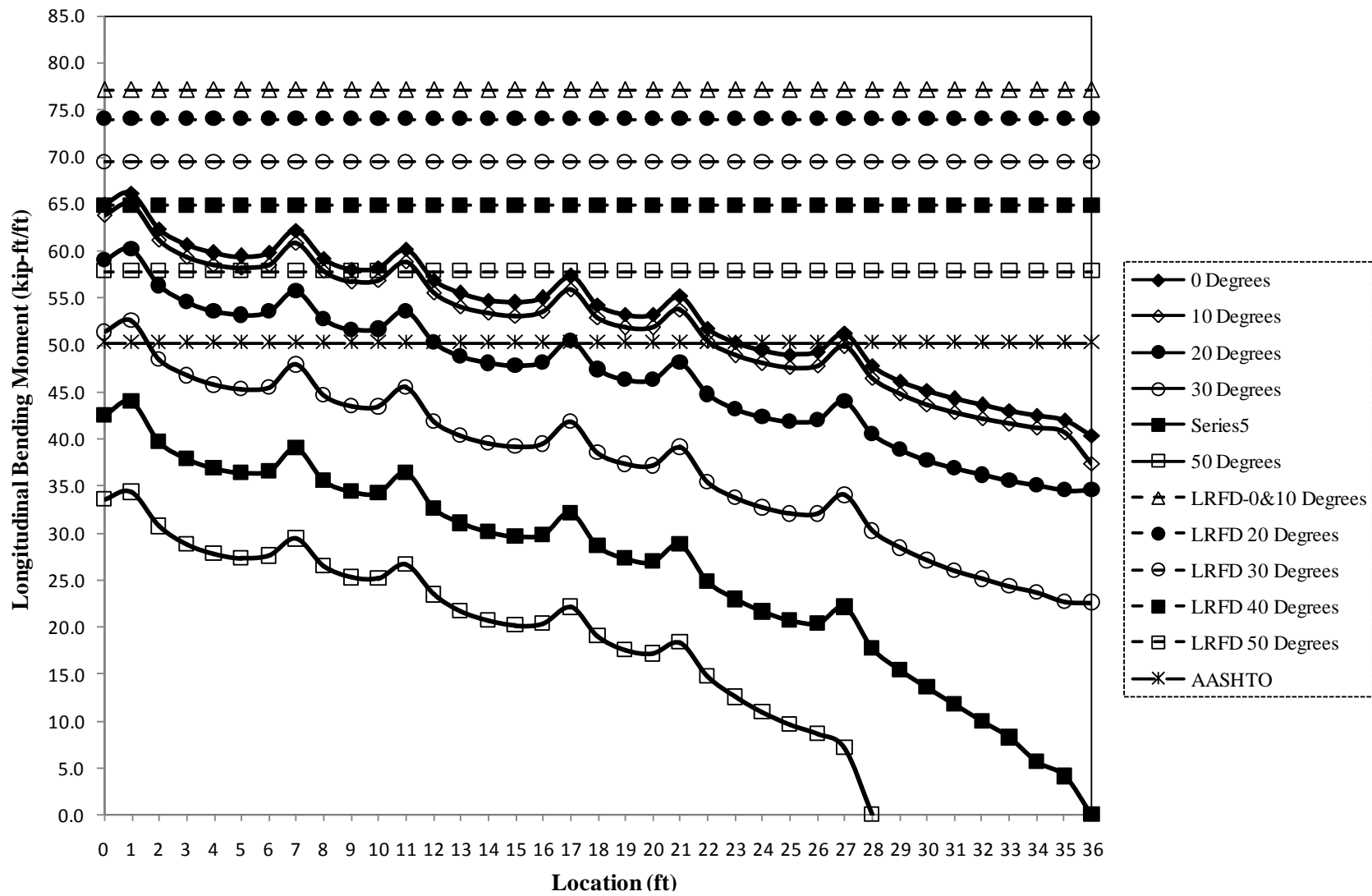


Fig. A44. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 3
One Railing with Edge Loading E2.

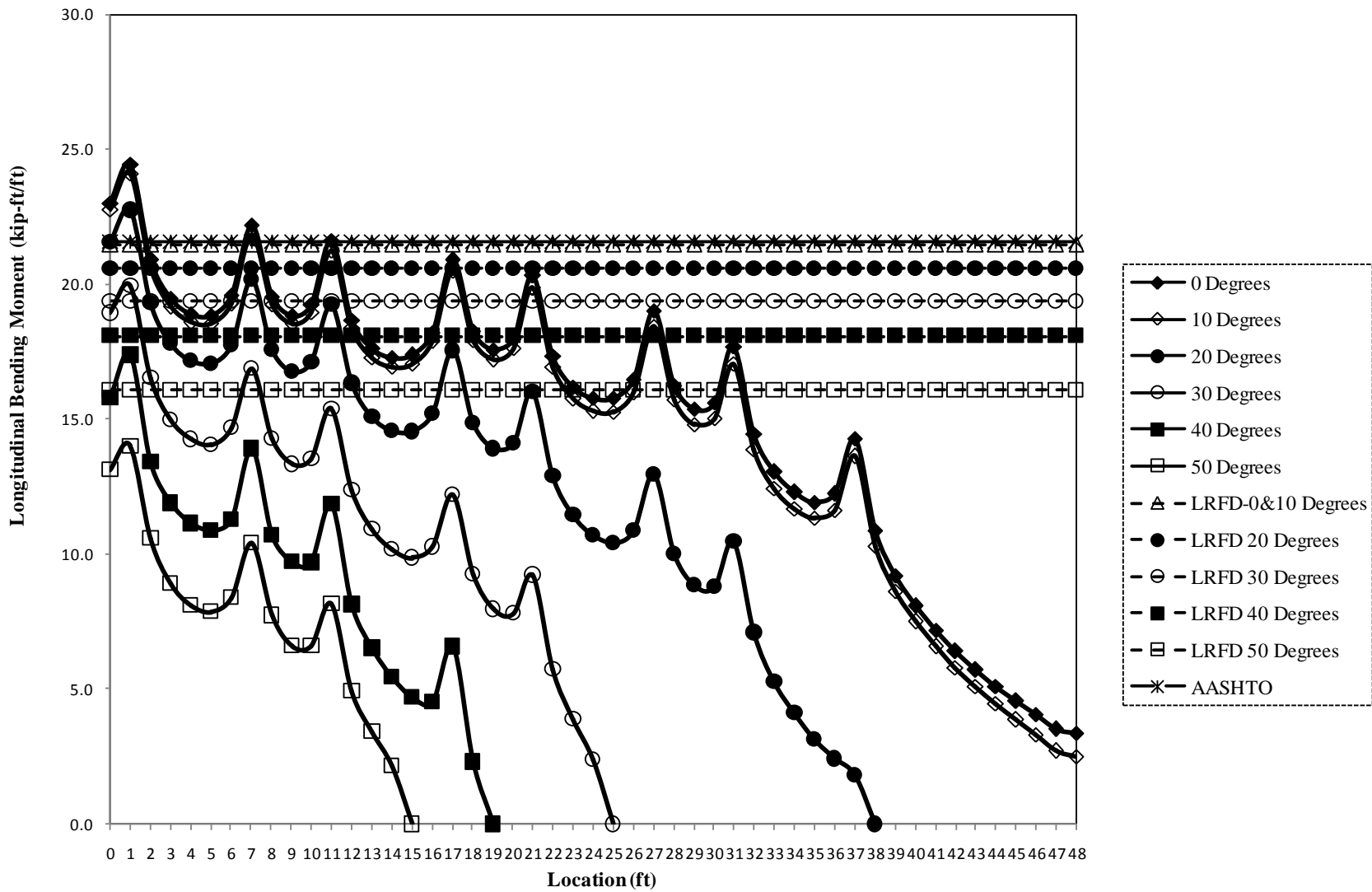


Fig. A45. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 4 One Railing with Edge Loading E2.

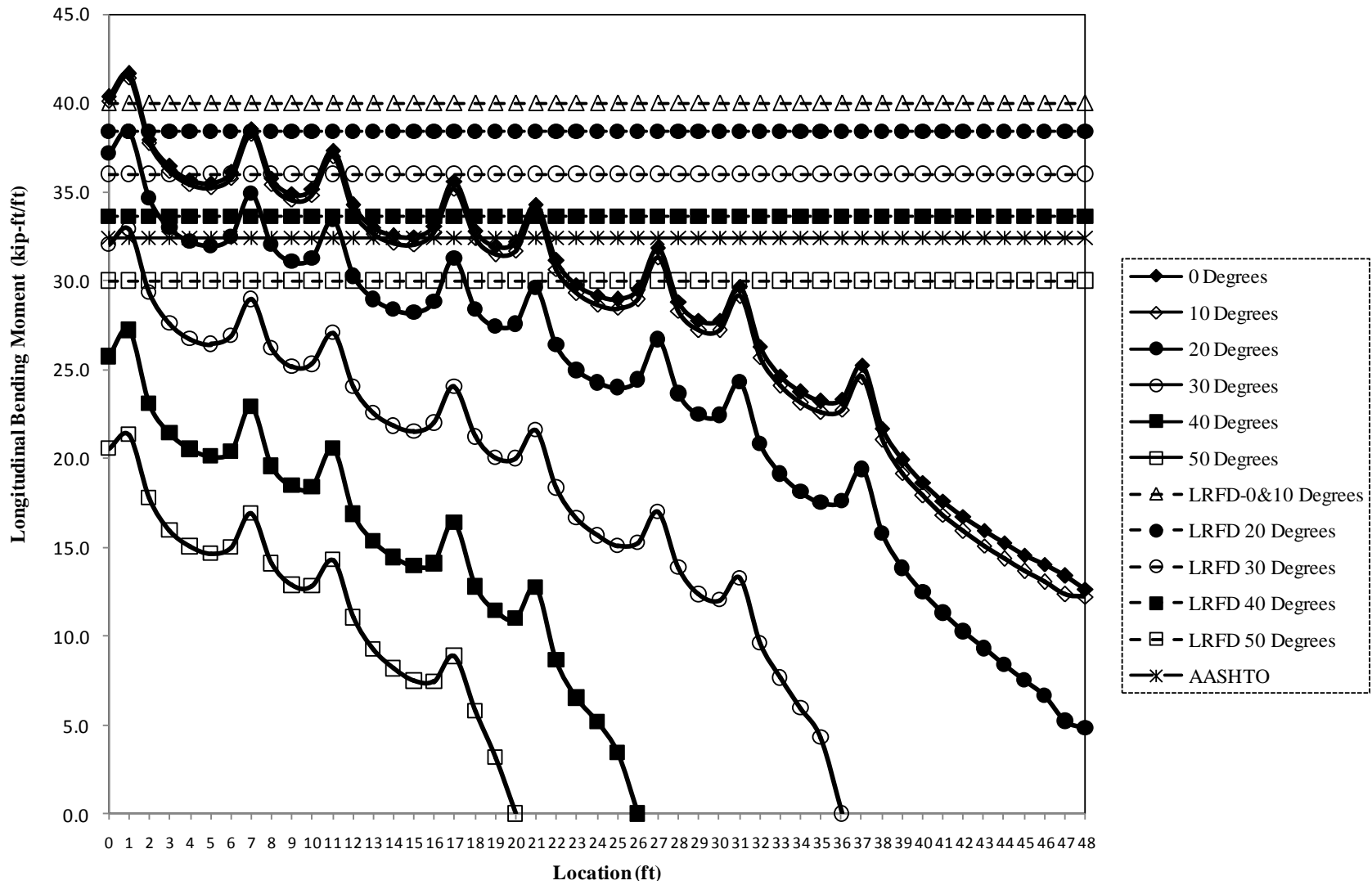


Fig. A46. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 4
One Railing with Edge Loading E2.

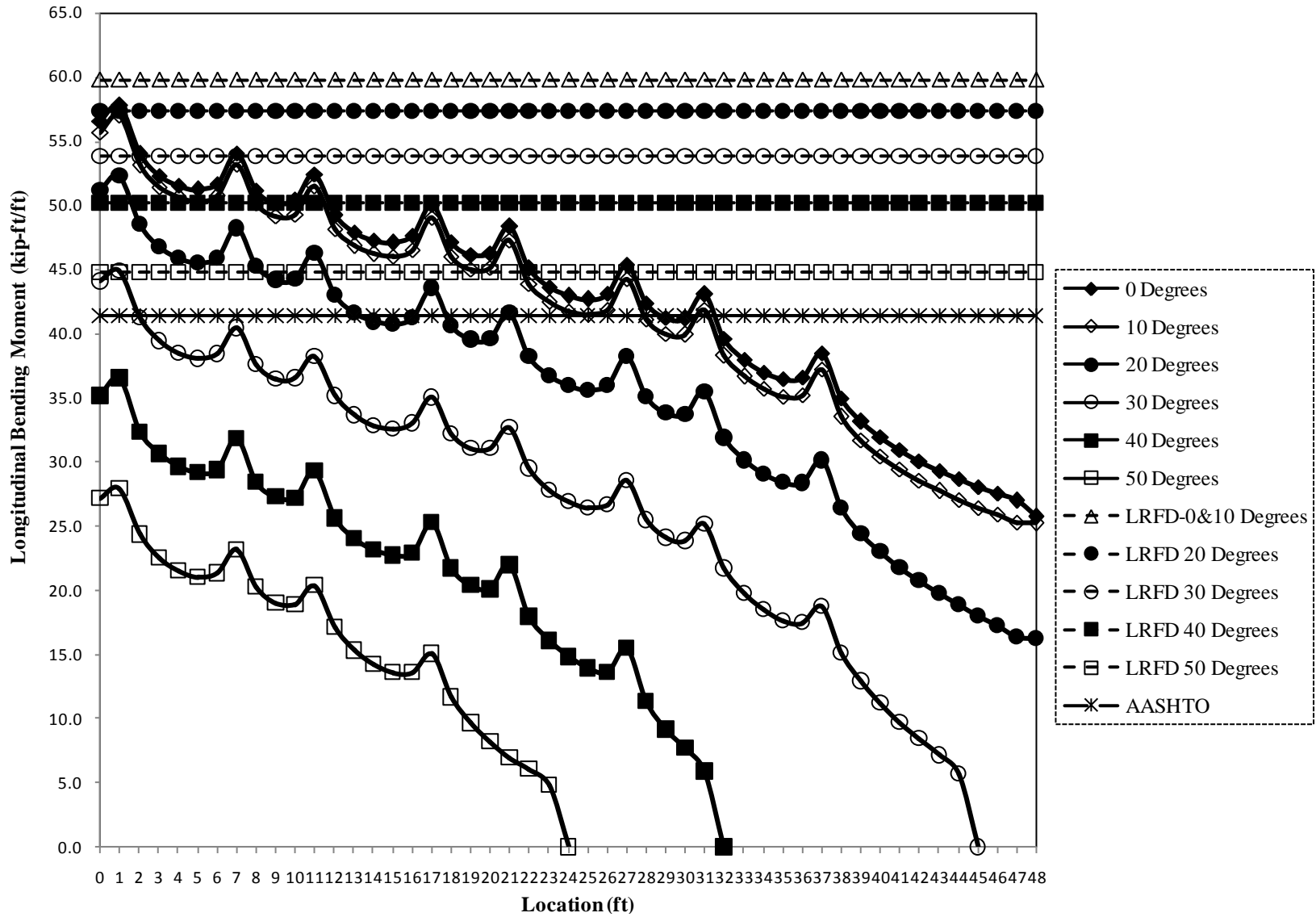


Fig. A47. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 4 One Railing with Edge Loading E2.

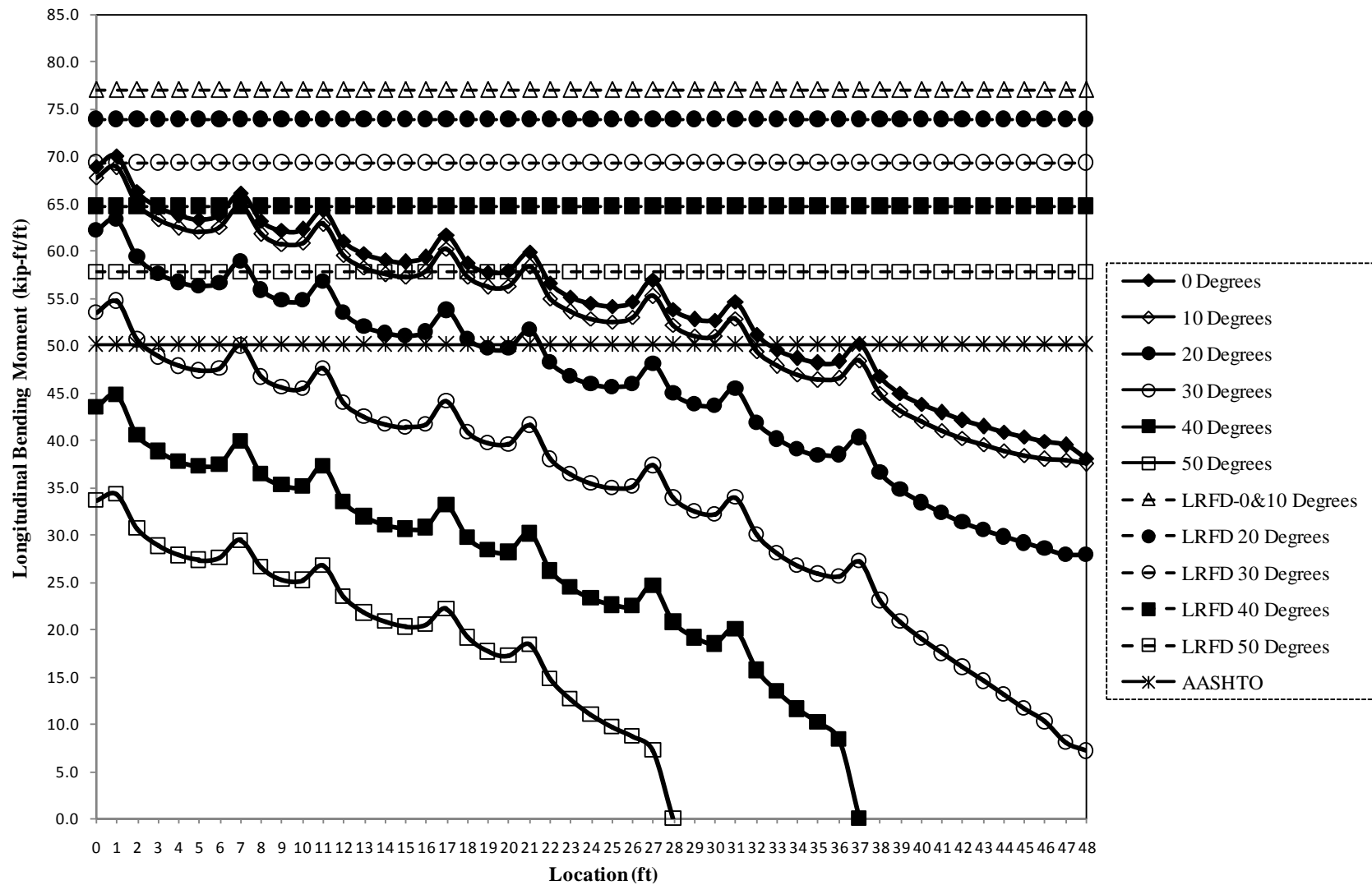


Fig. A48. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 4
One Railing with Edge Loading E2.

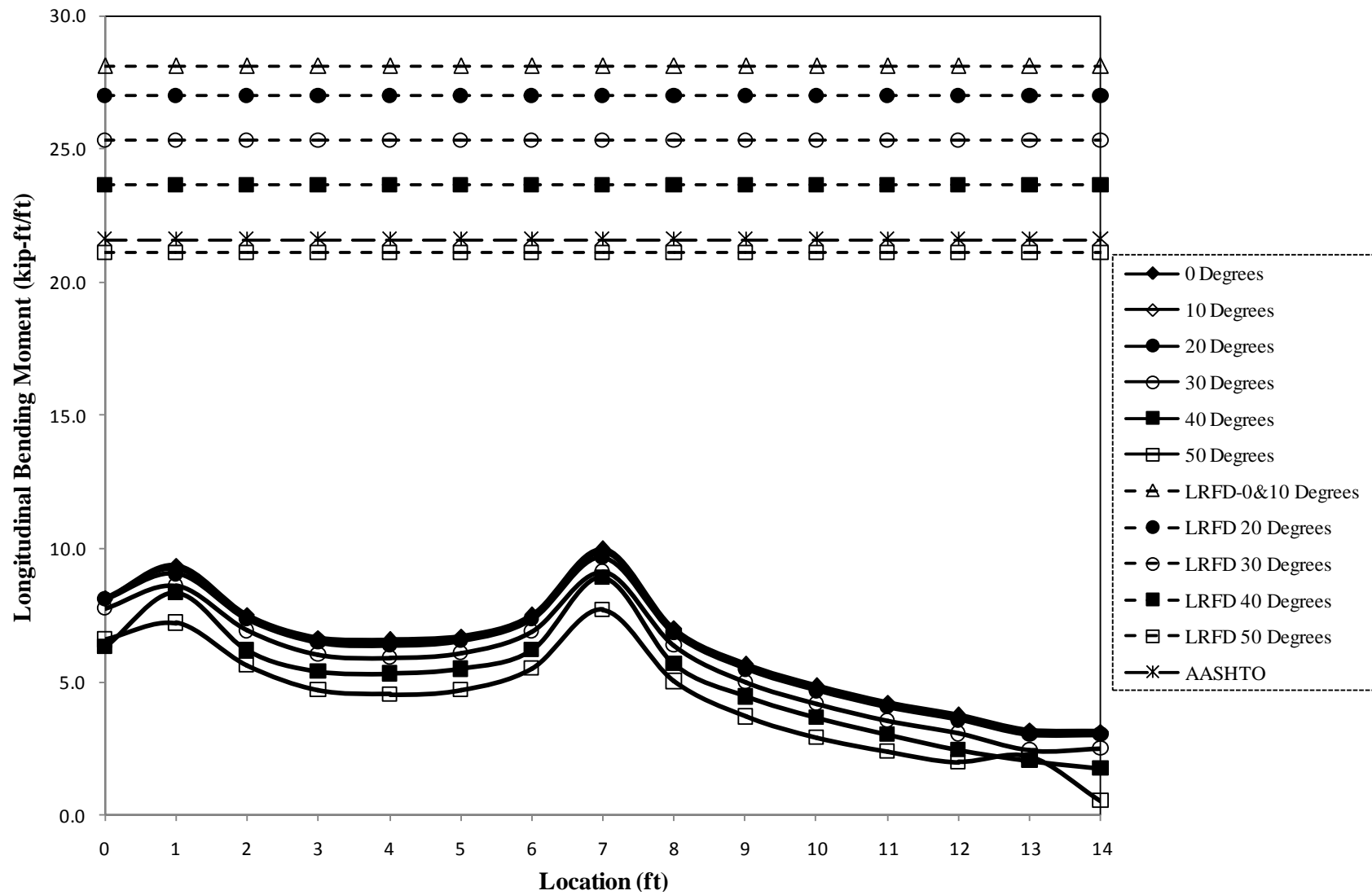


Fig. A49. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 1
Two Railings with Edge Loading E1.

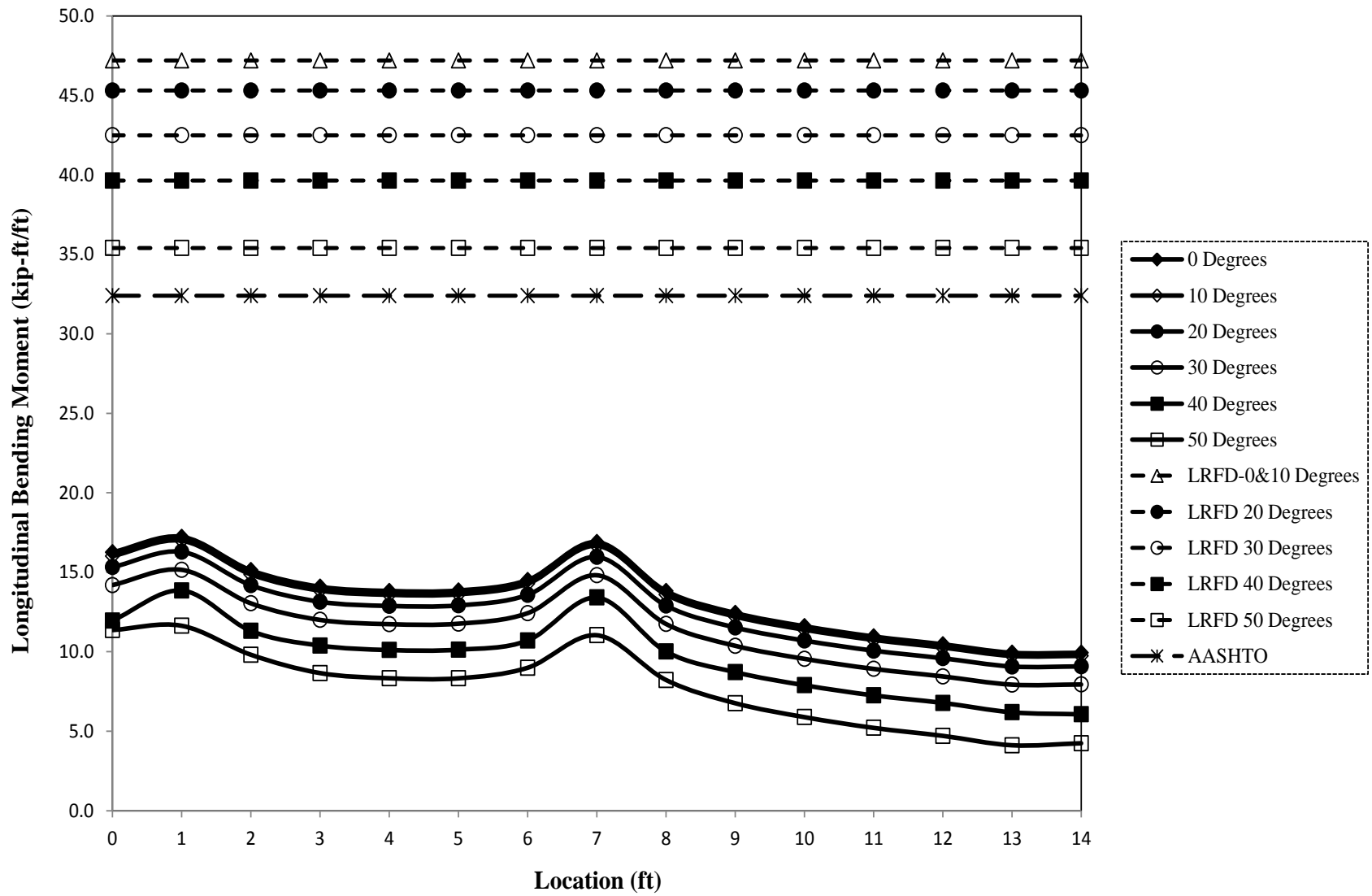


Fig. A50. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 1
Two Railings with Edge Loading E1.

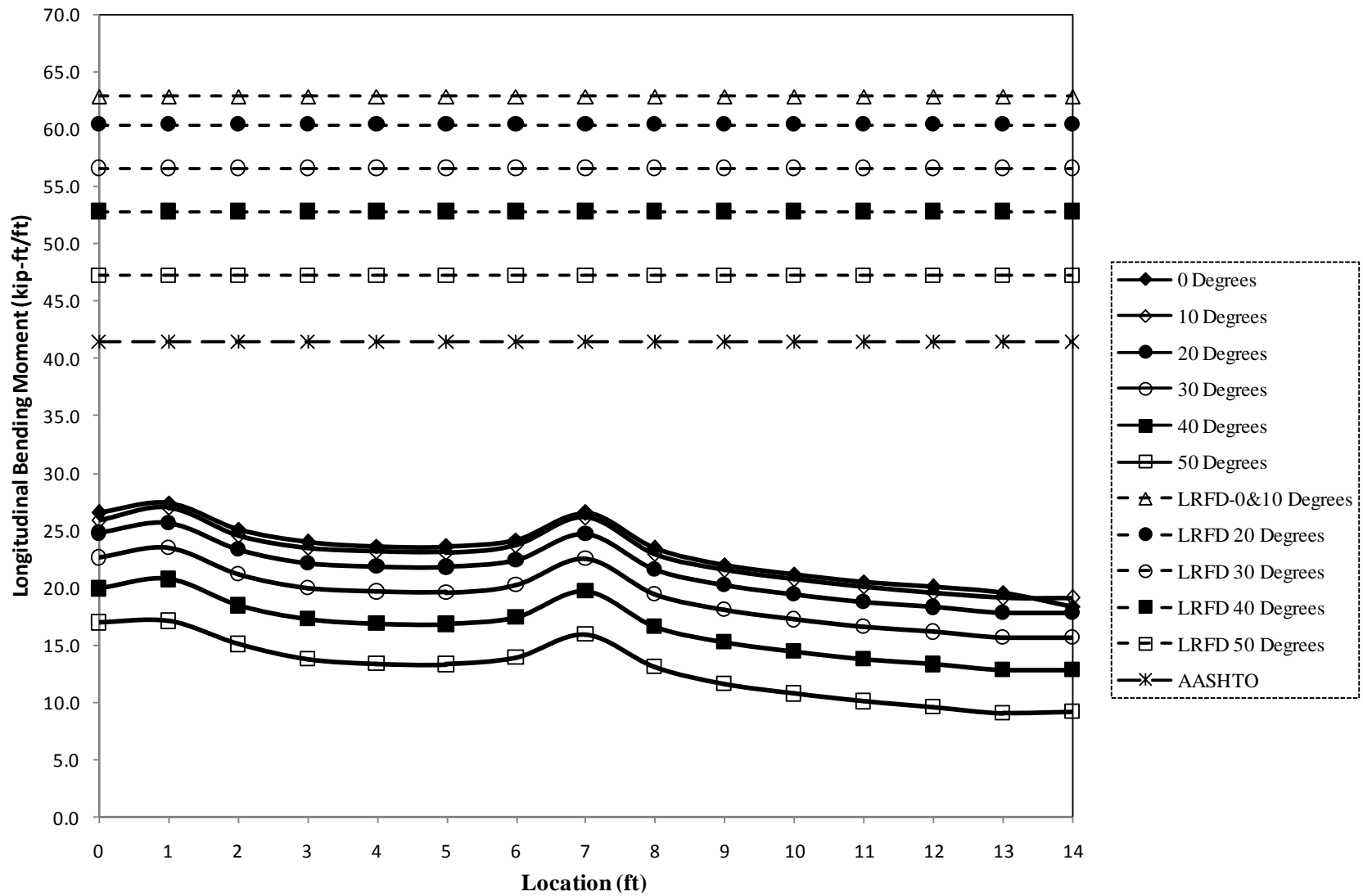


Fig. A51. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 1
Two Railings with Edge Loading E1.

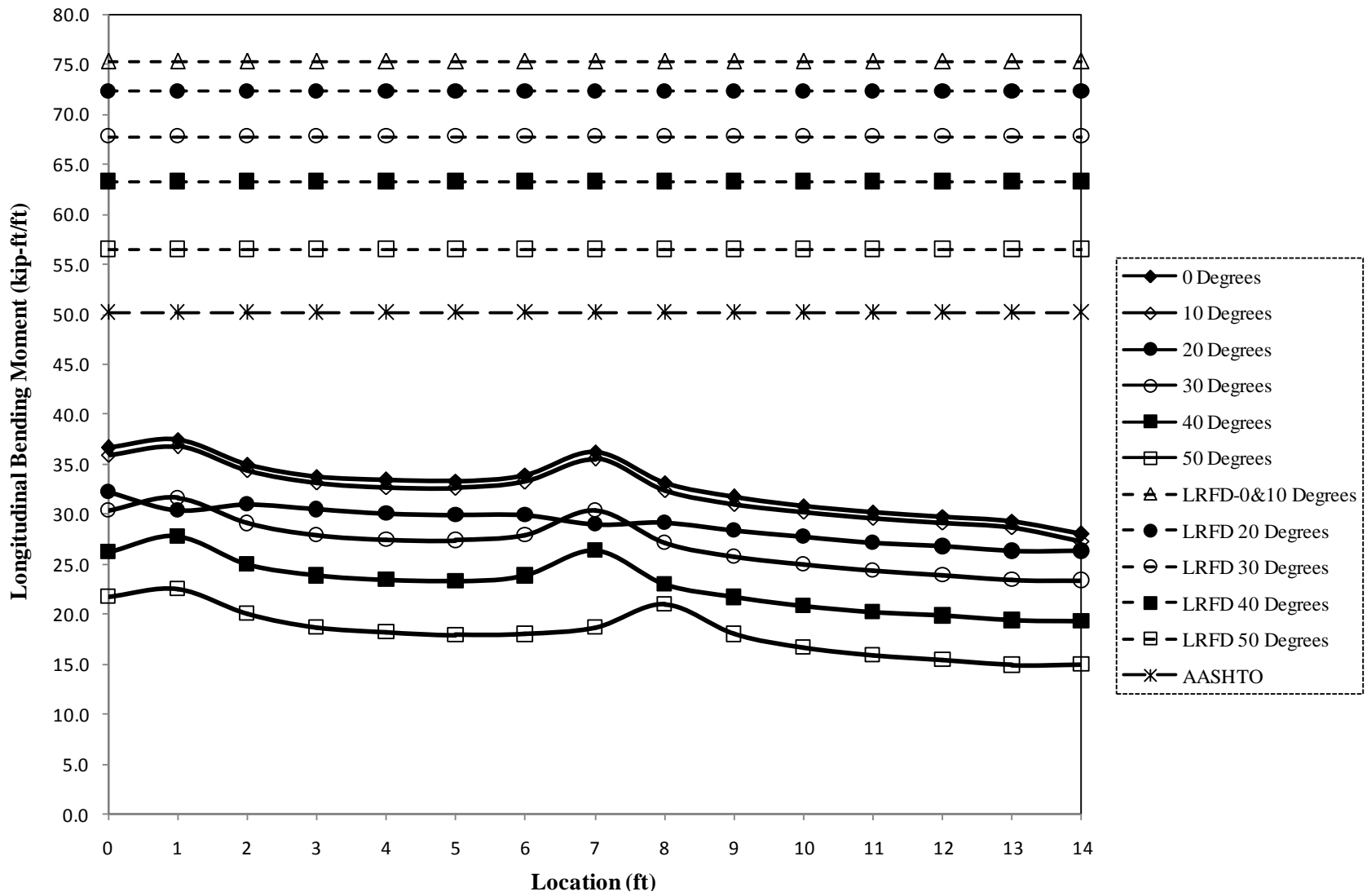


Fig. A52. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 1
Two Railings with Edge Loading E1.

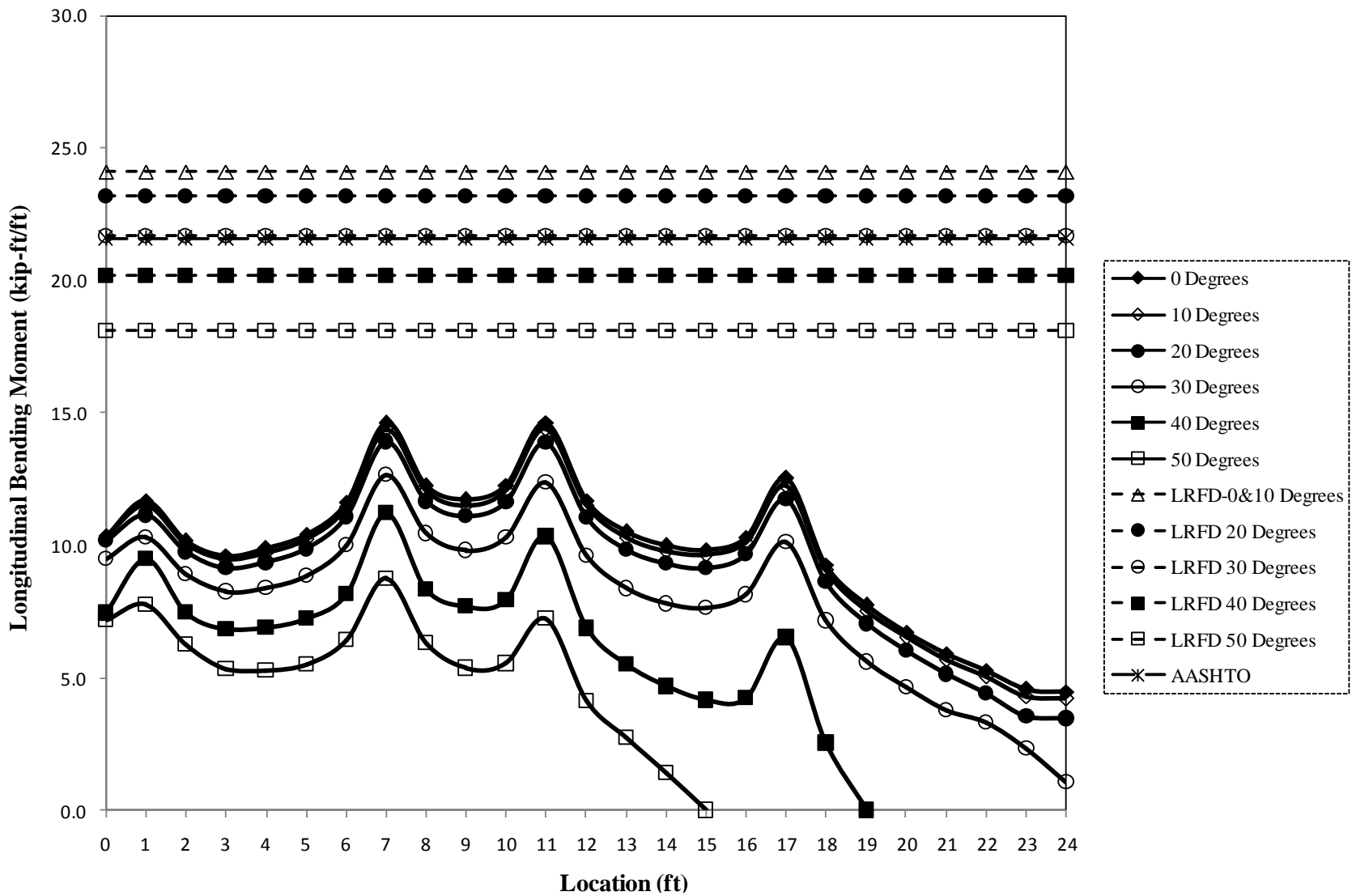


Fig. A53. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 2
Two Railings with Edge Loading E1.

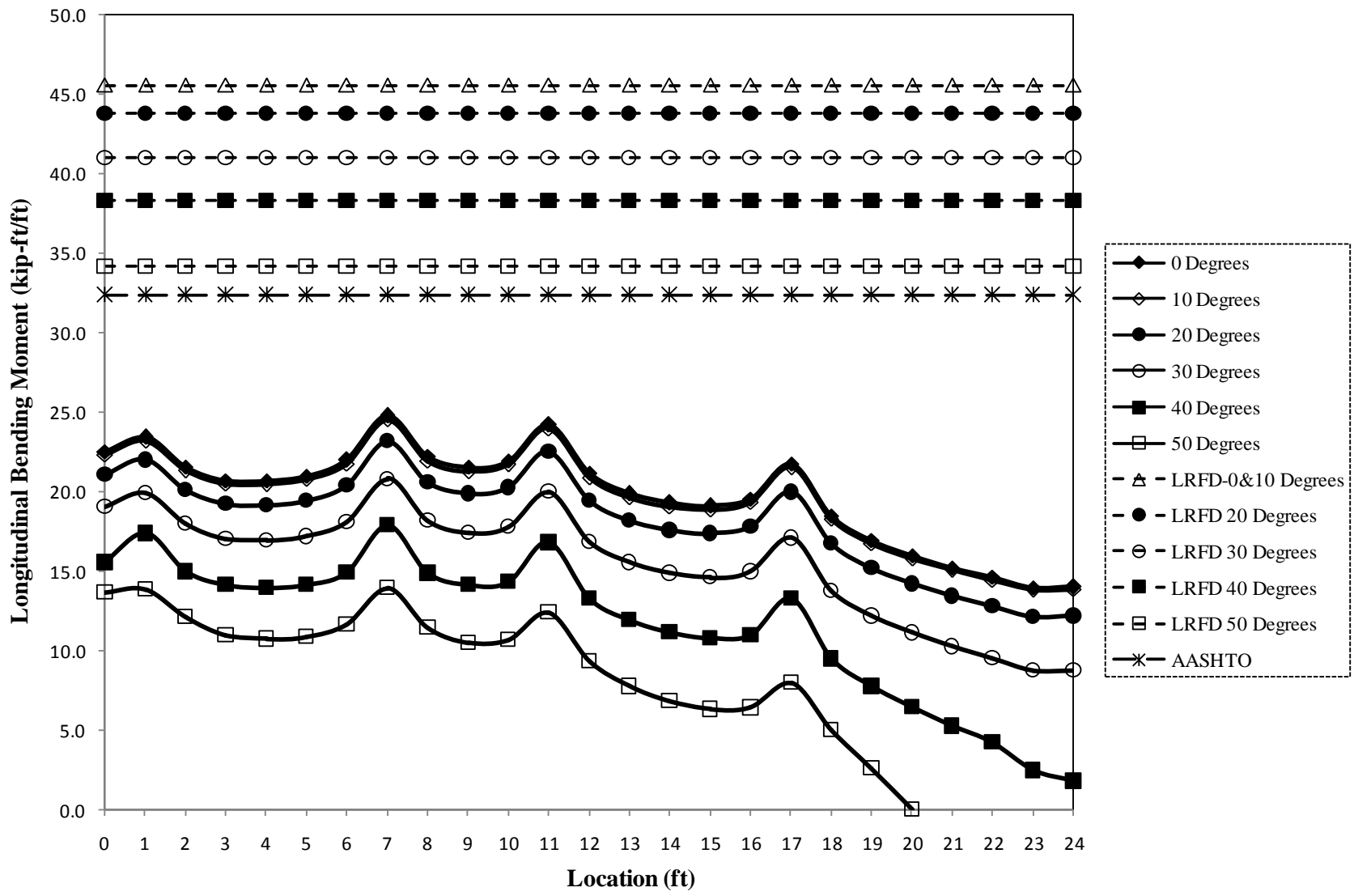


Fig. A54. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 2
Two Railings with Edge Loading E1.

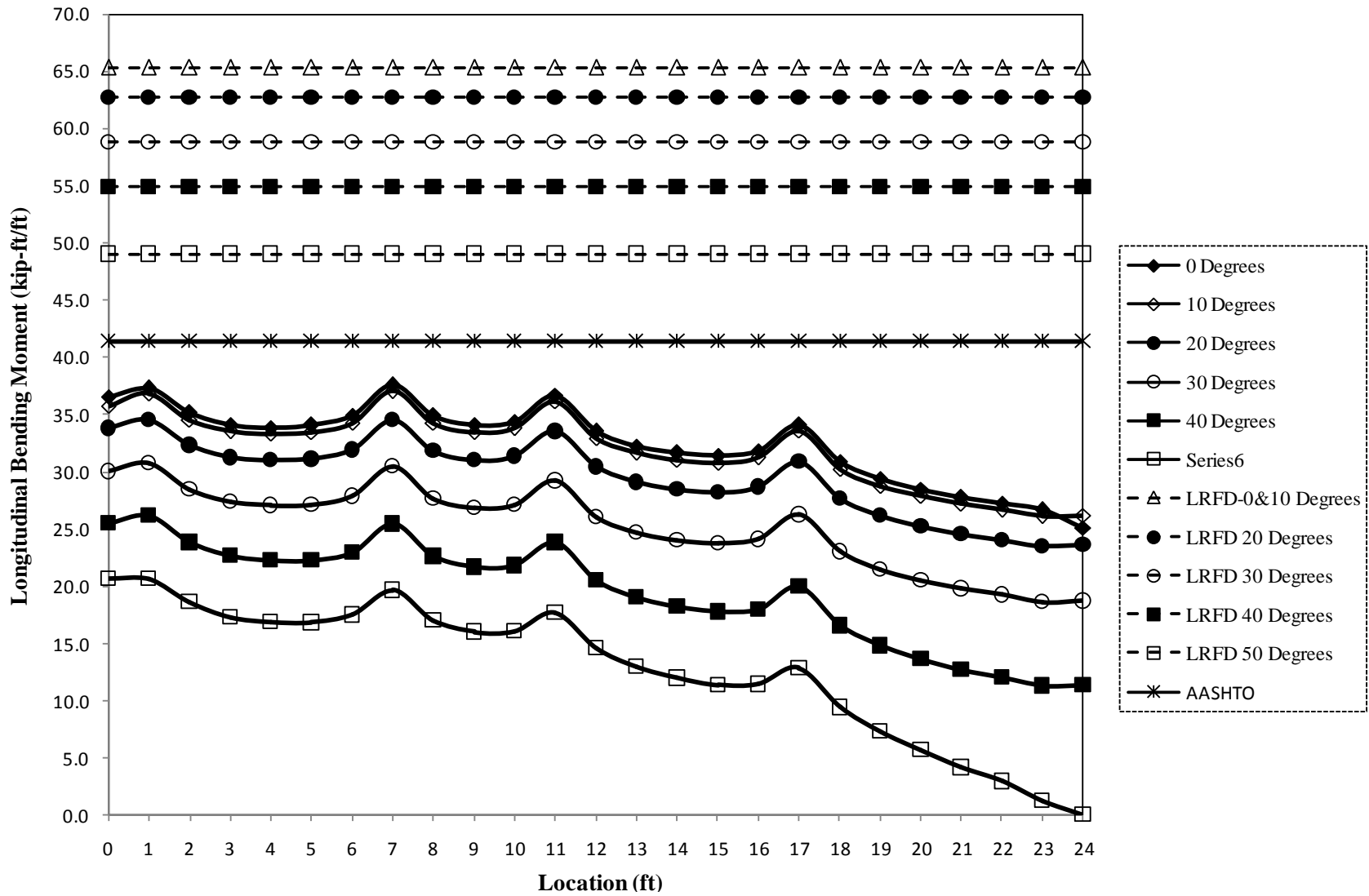


Fig. A55. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 2
Two Railings with Edge Loading E1.

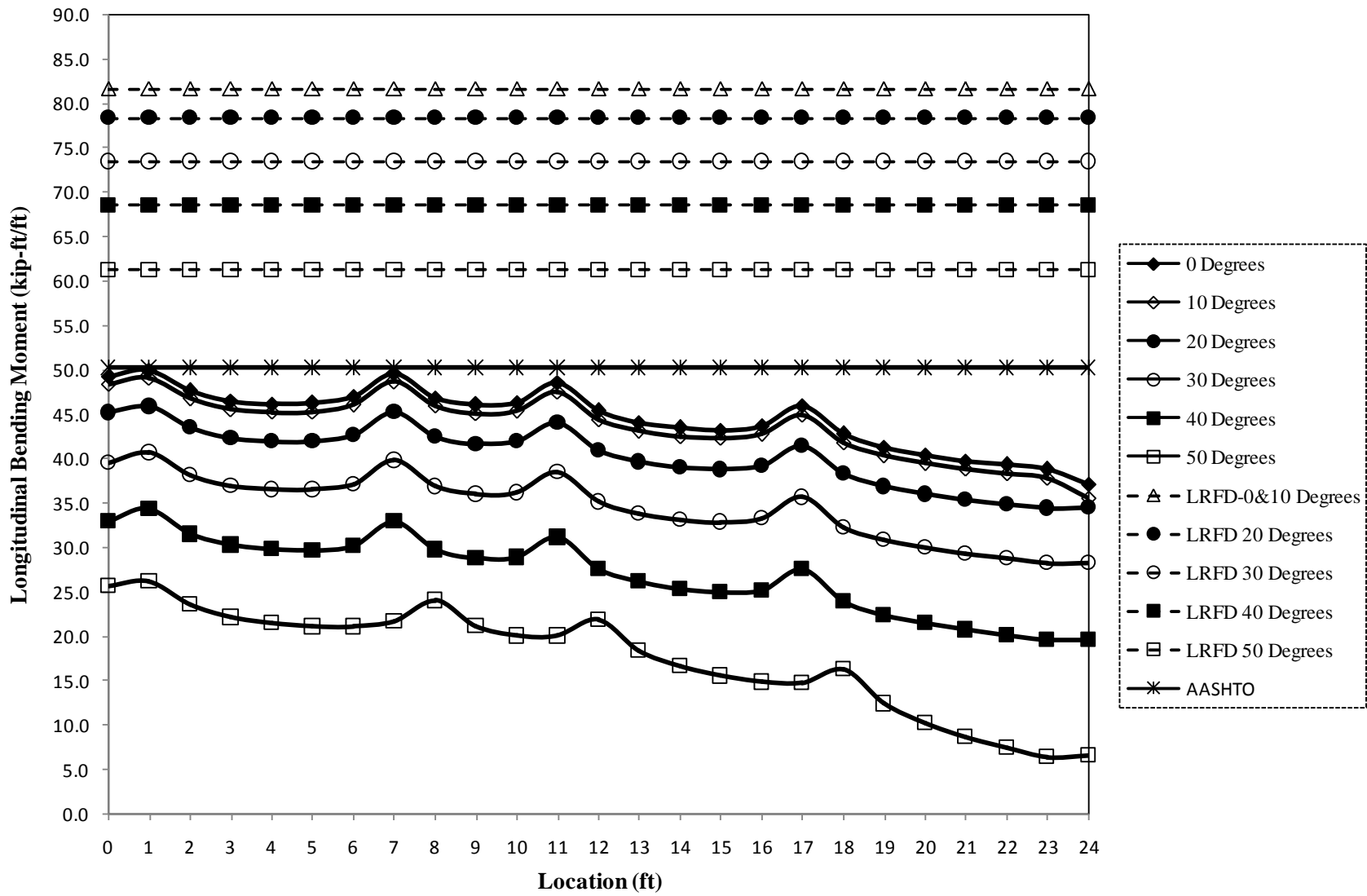


Fig. A56. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 2
Two Railings with Edge Loading E1.

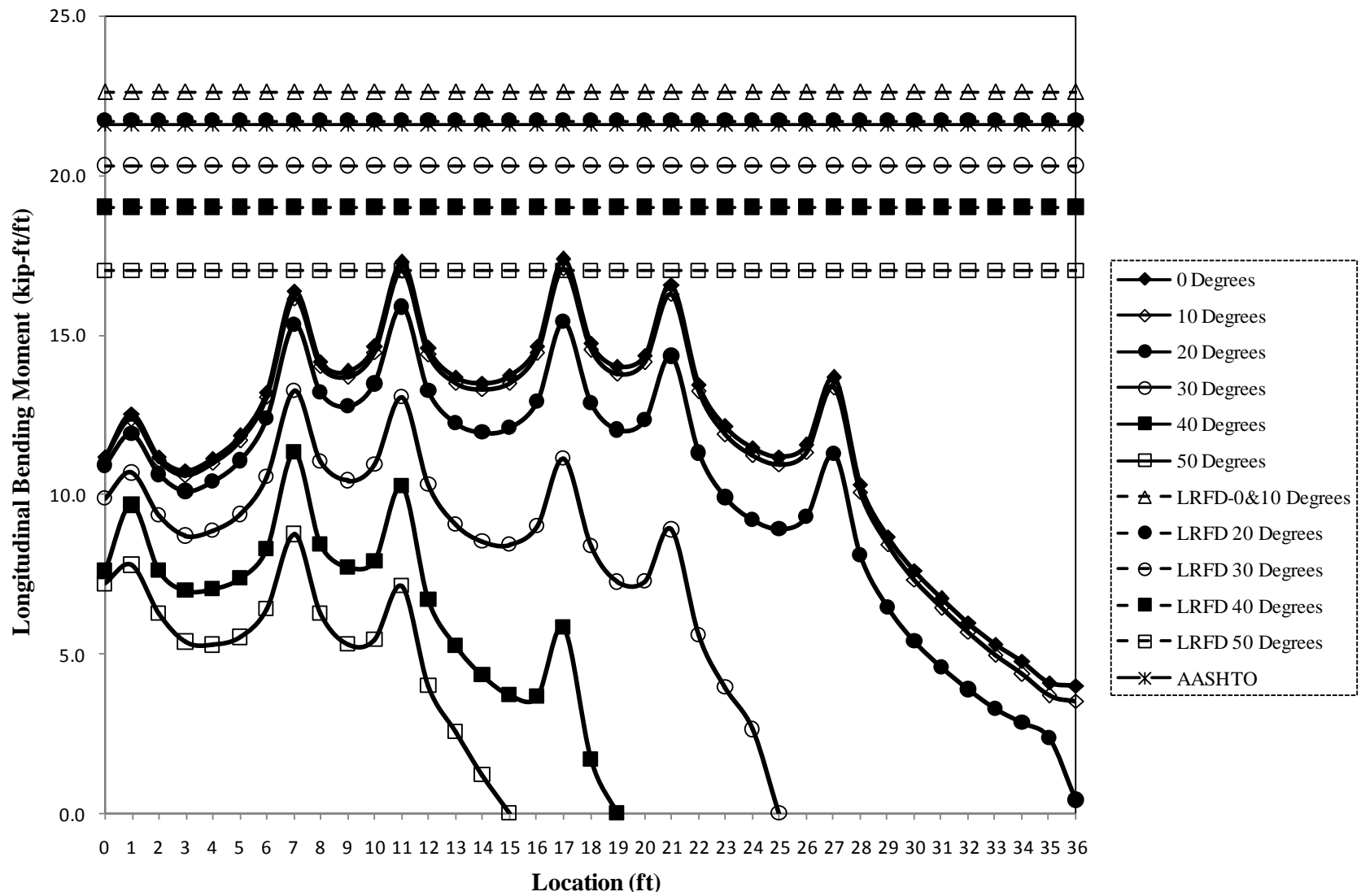


Fig. A57. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 3
Two Railings with Edge Loading E1.

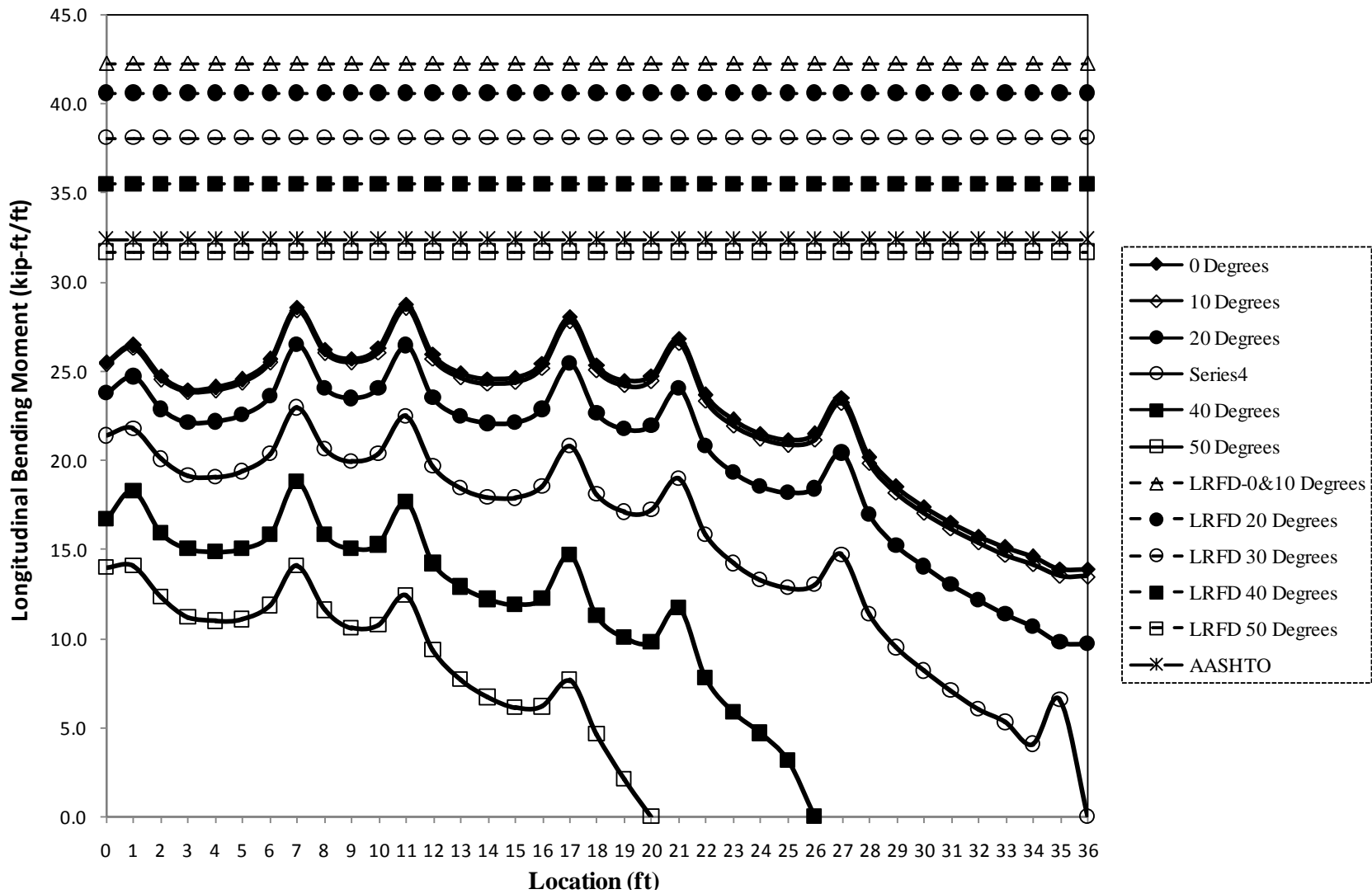


Fig. A58. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 3
Two Railings with Edge Loading E1.

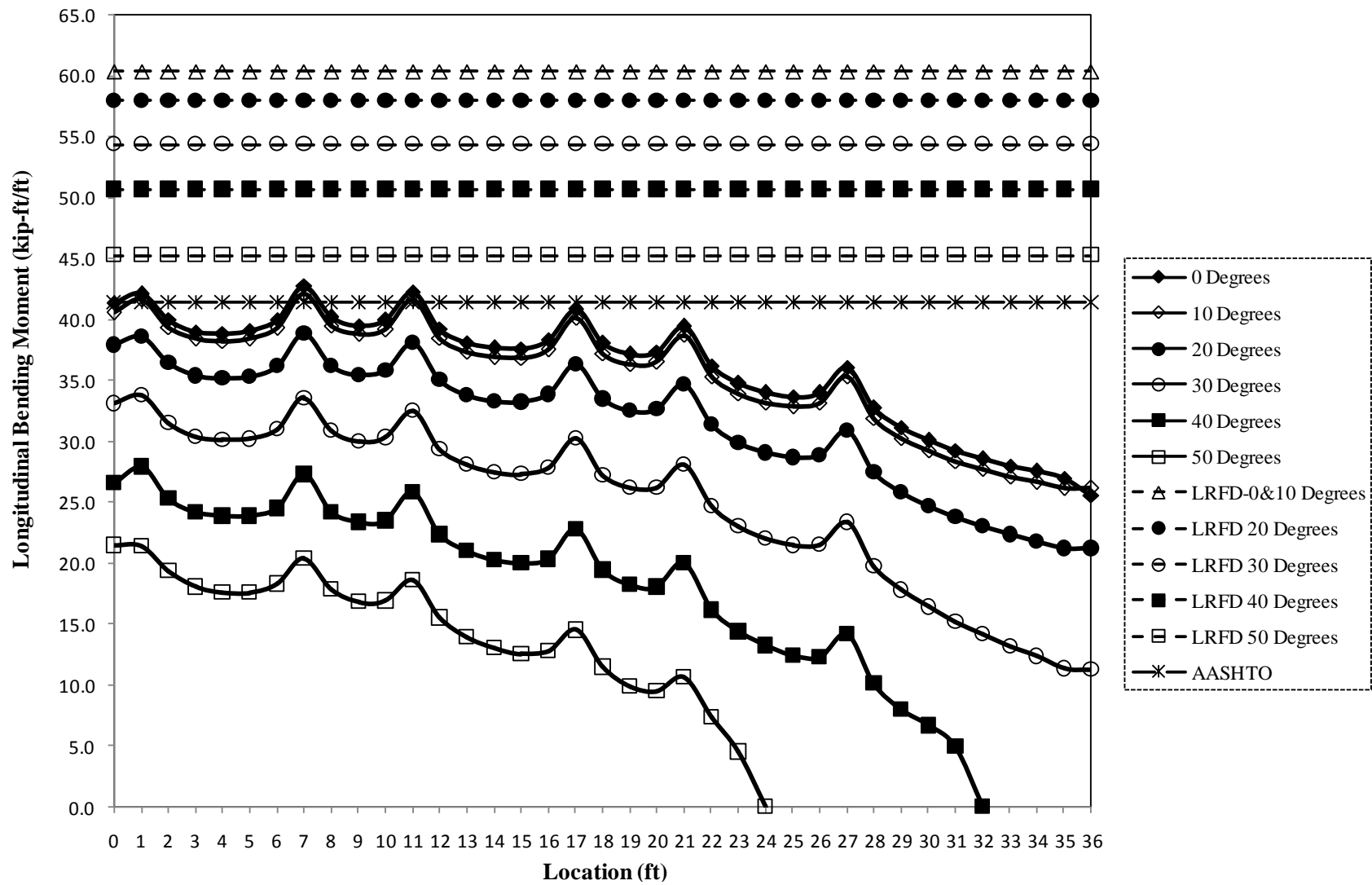


Fig. A59. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 3
Two Railings with Edge Loading E1.

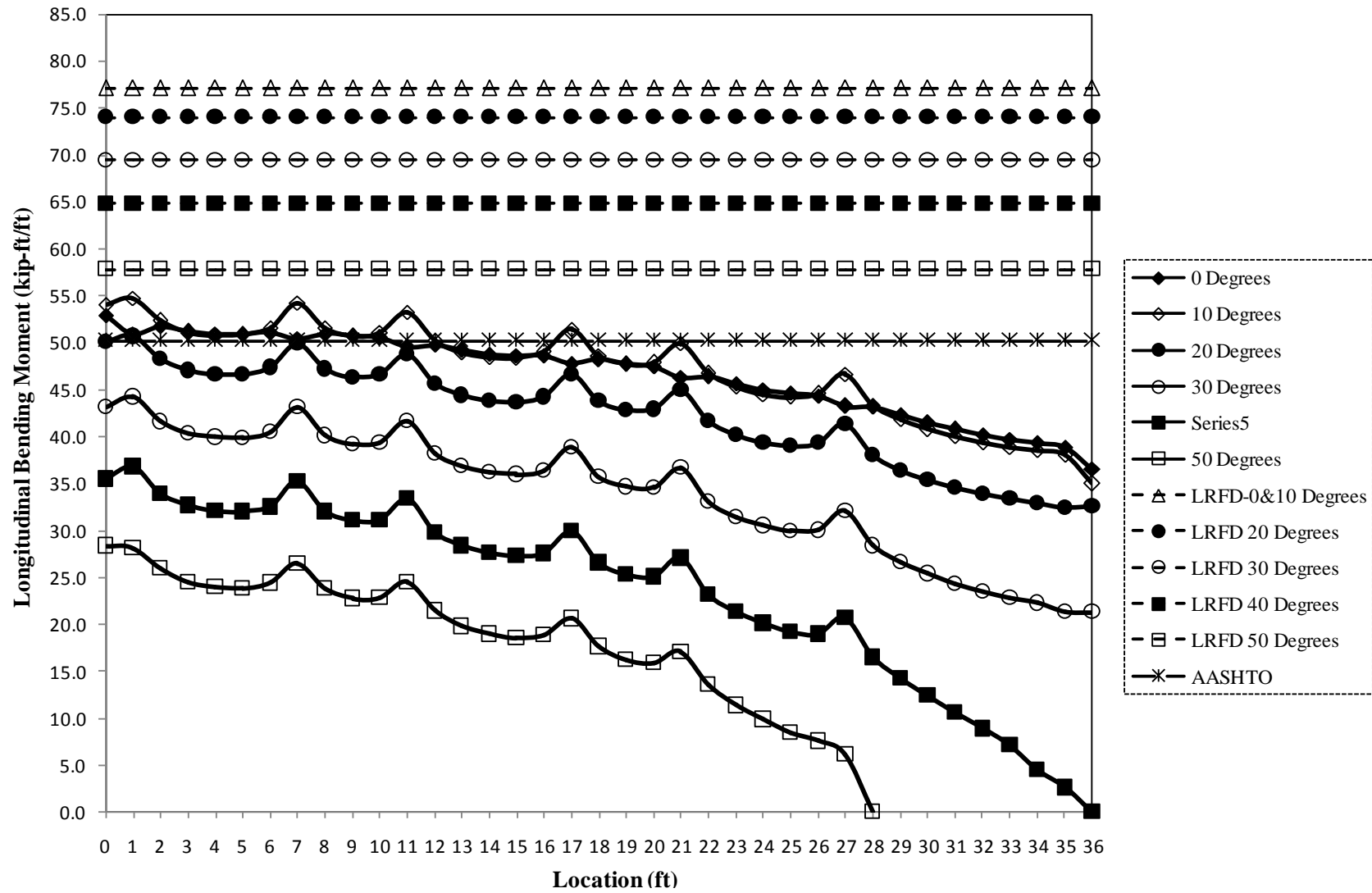


Fig. A60. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 3
Two Railings with Edge Loading E1.

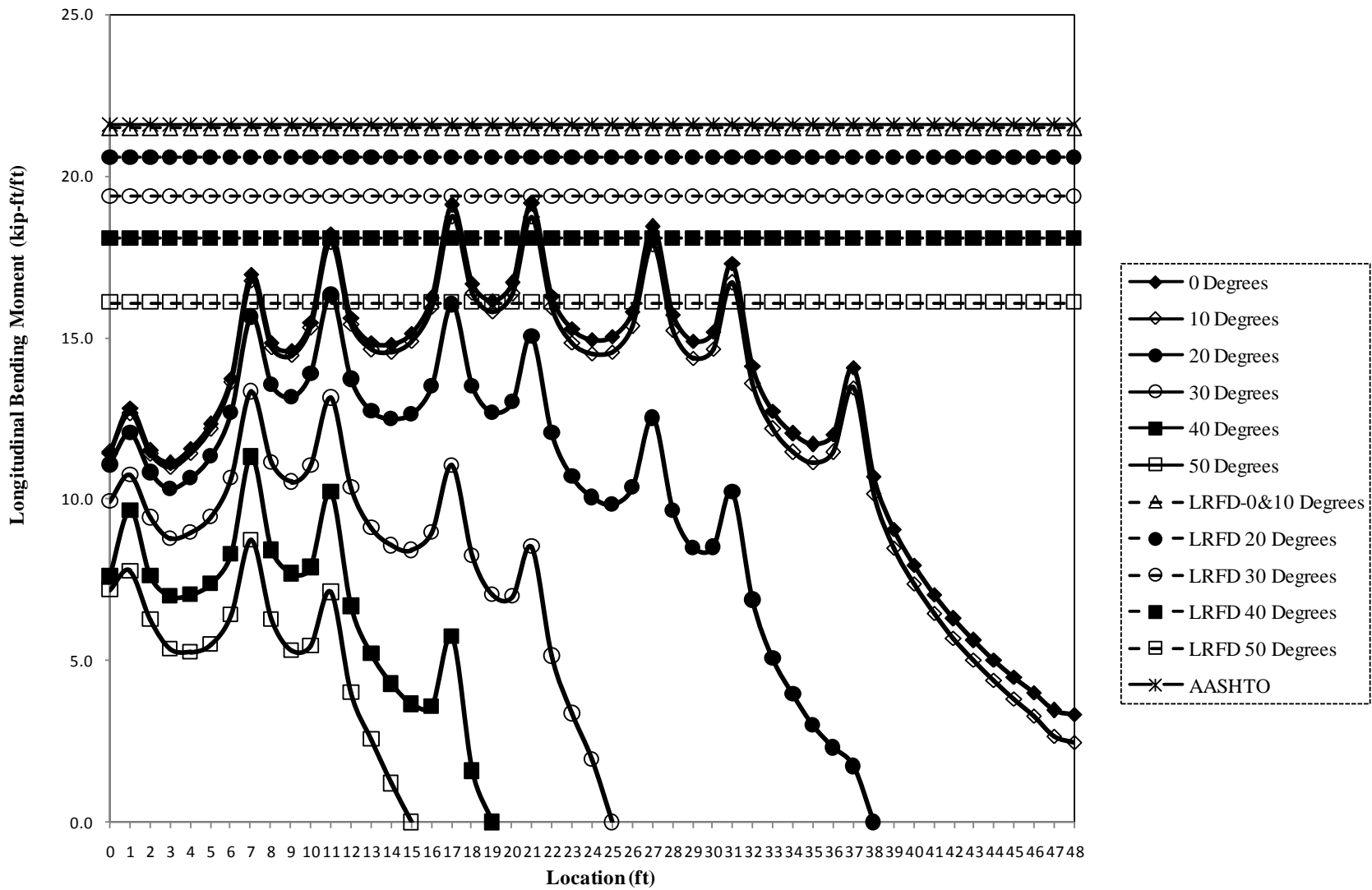


Fig. A61. Longitudinal Moment at Critical Section – Span Length = 24 ft, Number of Lanes = 4 Two Railings with Edge Loading E1.

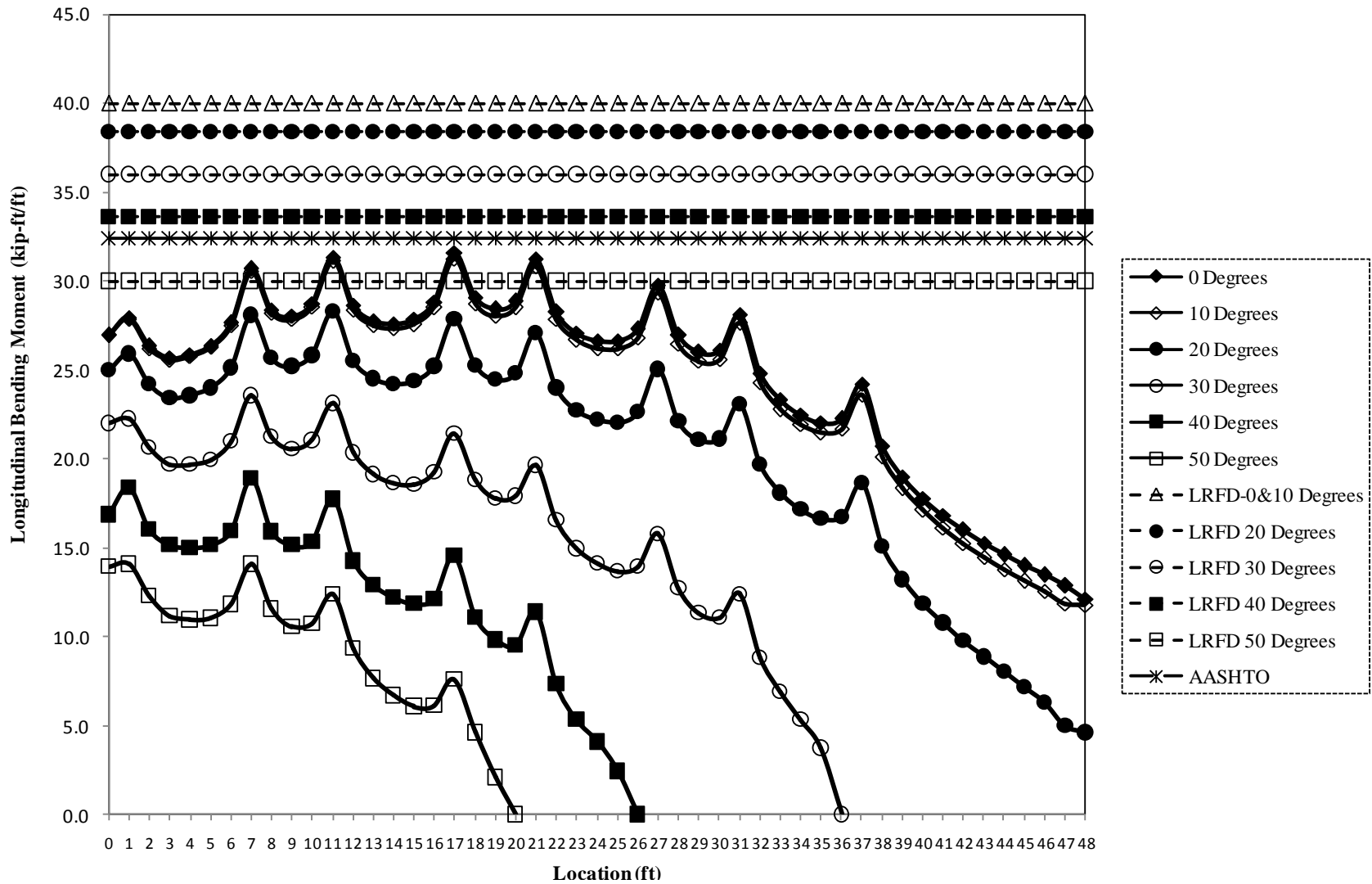


Fig. A62. Longitudinal Moment at Critical Section – Span Length = 36 ft, Number of Lanes = 4
Two Railings with Edge Loading E1.

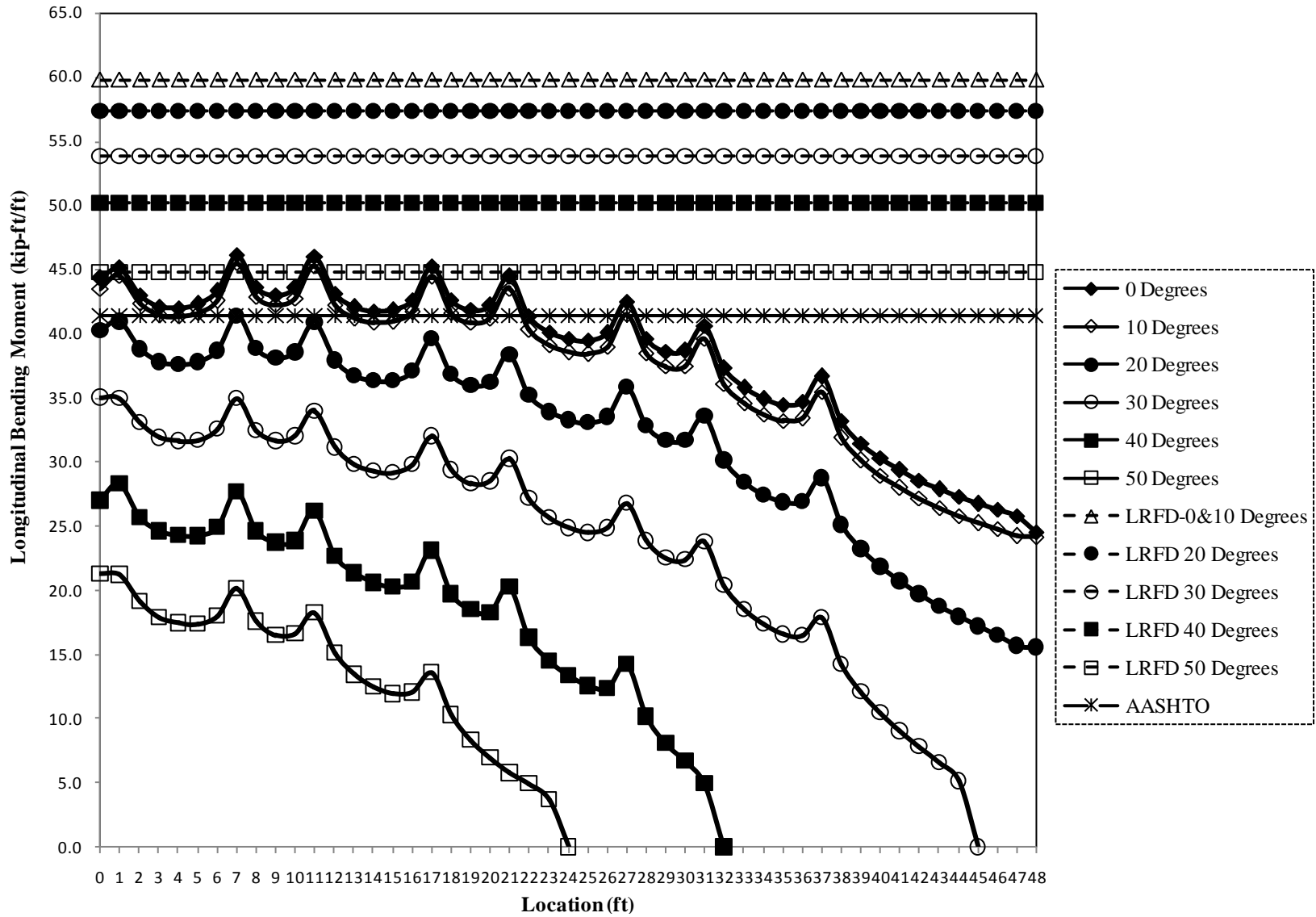


Fig. A63. Longitudinal Moment at Critical Section – Span Length = 46 ft, Number of Lanes = 4
Two Railings with Edge Loading E1.

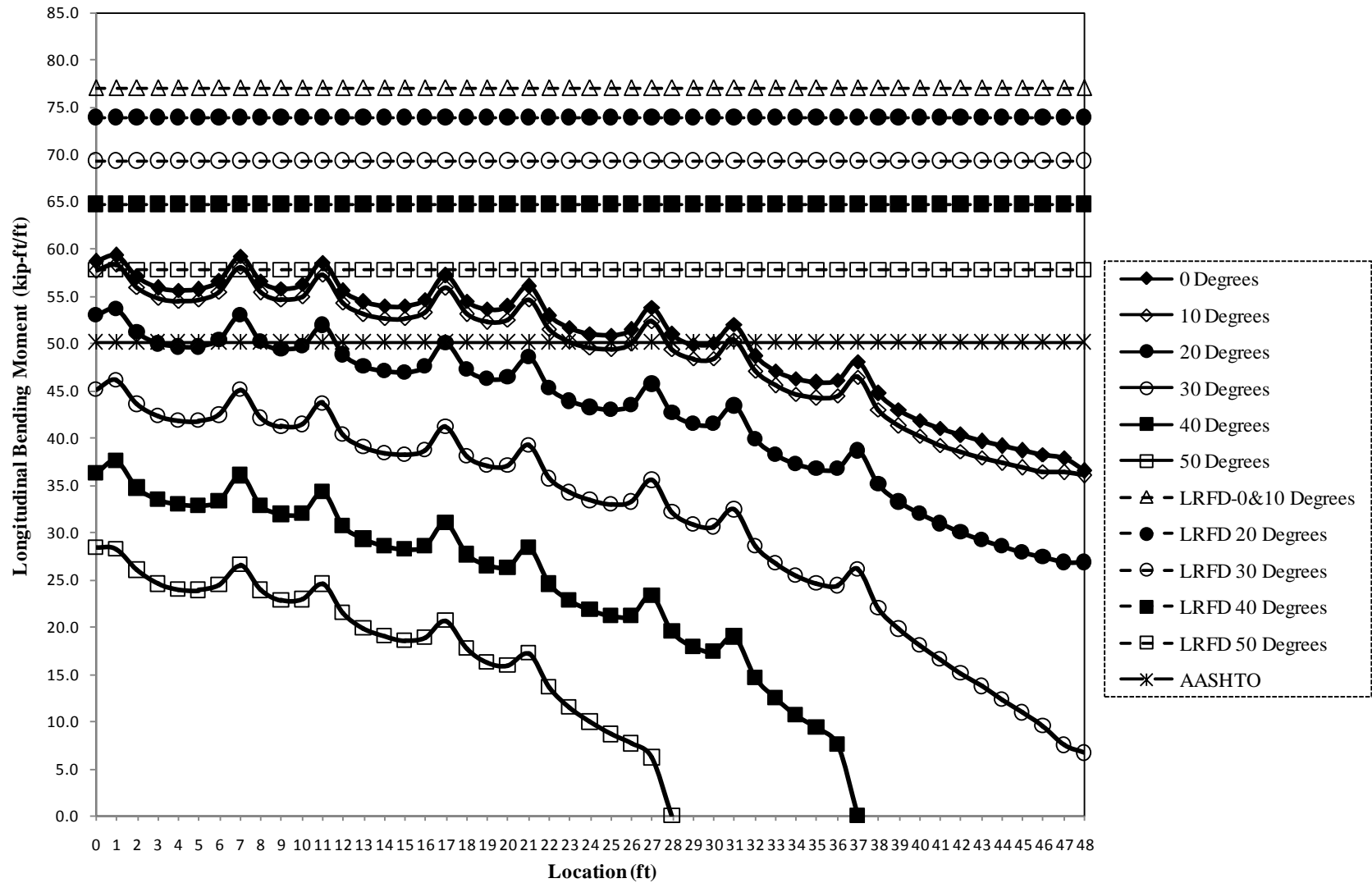


Fig. A64. Longitudinal Moment at Critical Section – Span Length = 54 ft, Number of Lanes = 4
Two Railings with Edge Loading E1.