Live-load Distribution Factors: A Parametric Study

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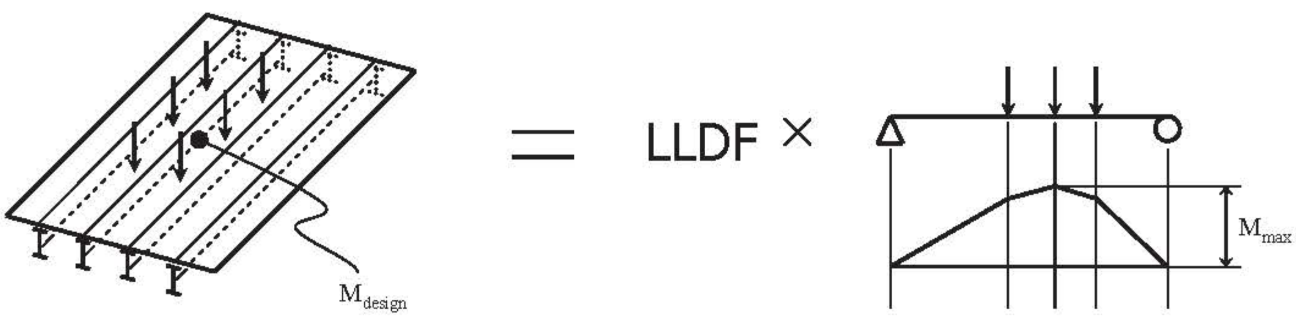
Introduction

- Live-load distribution factors (LLDFs) are used to calculate forces of girders for the design and load rating of bridges.
- AASHTO LRFD live-load distribution factors are



Introduction (cont'd)

- Zokaie included many parameters i.e., girder spacing; span length; bending and torsional inertia; slab thickness; number of girders; overhang width and deck strength.
- The LLDF equations safely predict actual bridge behavior.
- They do not account for components of actual bridges that affect load distribution.
- Secondary parameters are continuity, cross bracing/ diaphragm and barrier/sidewalk.

Problem statements

- Parameters not used:
    - Continuity over support
    - Cross bracing and diaphragm
    - Barrier and sidewalk
    - Axle width
- By neglecting these parameters, LLDFs are possibly conservative.
    - Conservative bridge design
    - Possible unnecessary posting of bridges
- Previous research on LLDFs in presetressed concrete and steel girder bridges Barr et al. (2003), Sotelino et al. (2004), Eamon et al. (2004).

Objectives and scope

- Compare the LLDFs of the AASHTO LRFD code and those of the FEM.
- Study the effects of continuity, diaphragm, barrier, skewness and truck axle width variations on the LLDFs.
- Reinforced concrete girder bridges are studied.

Outline

- Introduction
- Problem statement
- Objectives and scope
- Methodology
- Parameter study
- AASHTO LRFD vs. FEM
- Effects of secondary parameters on LLDFs
- Concluding remarks

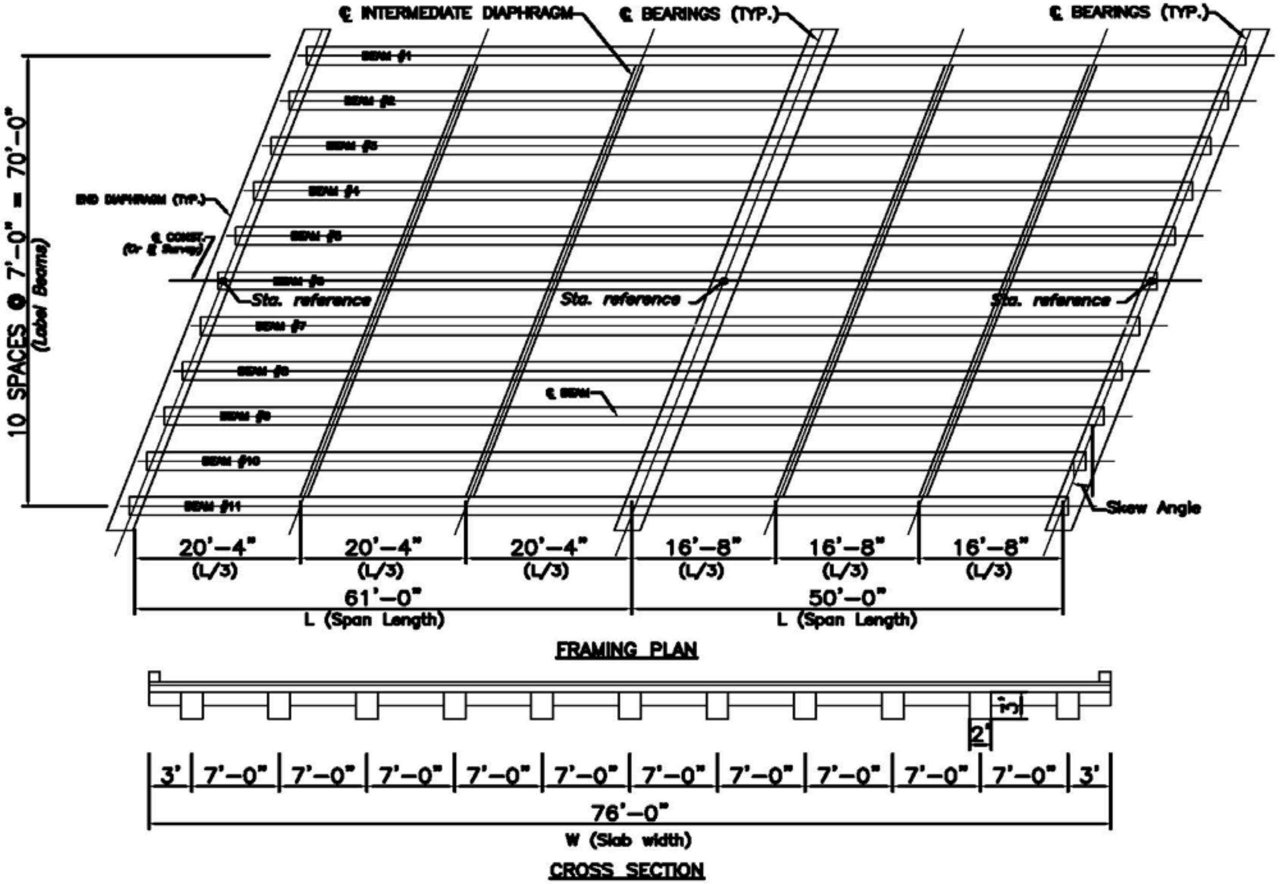
Methodology

- AASHTO LLDFs calculation (hand or software).
- Live-load distribution factors (D) from FEM:
  - D = G / (S/n)
  - n = number of loaded lanes
  - G = girder force
  - S = superstructure force
- Compare LLDFs from AASHTO and those from FEM.
- Investigate the effects of continuity, diaphragm, barrier and truck axle width on LLDFs through various FEM models.

Parametric study

- A series of bridge models was created:
  - Model # 1: simply supported with no diaphragms
  - Model # 2: continuity at supports
  - Model # 3: end diaphragms
  - Model # 4: intermediate diaphragms (at 1/3 of span)
  - Model # 5: barriers/sidewalk
- Skew angle (0, 10, 20, 30, 40, 50 and 60 degrees)

Bridge layout



1: Simply supported

2: Continuity

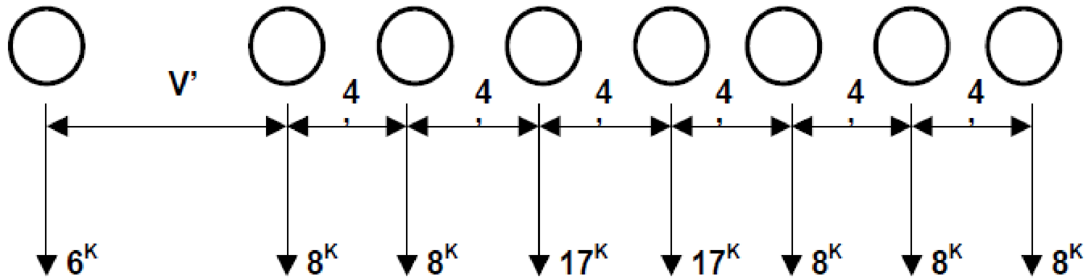
3: End diaphragm

4: Int. diaphragms

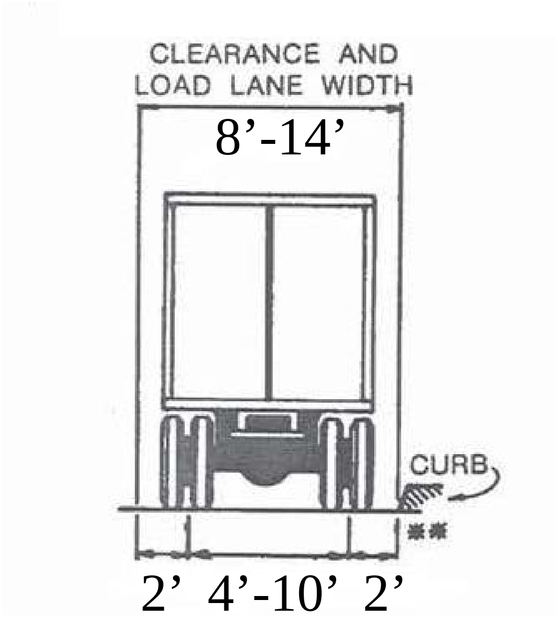
5: Barriers

Trucks

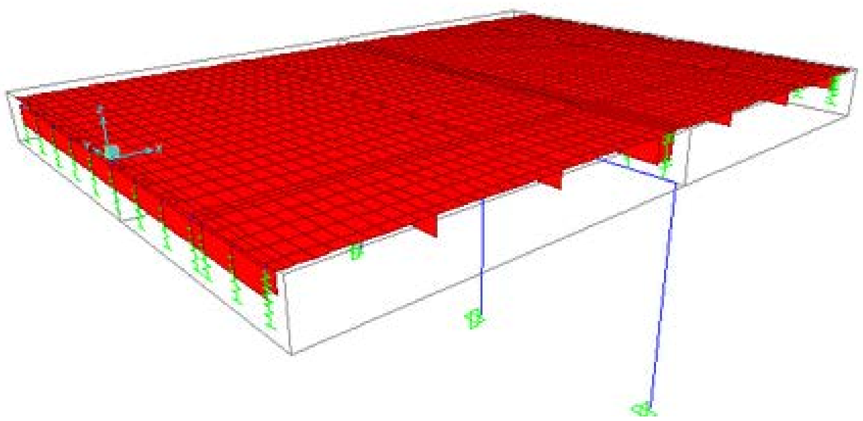
1. Notional Rating Load

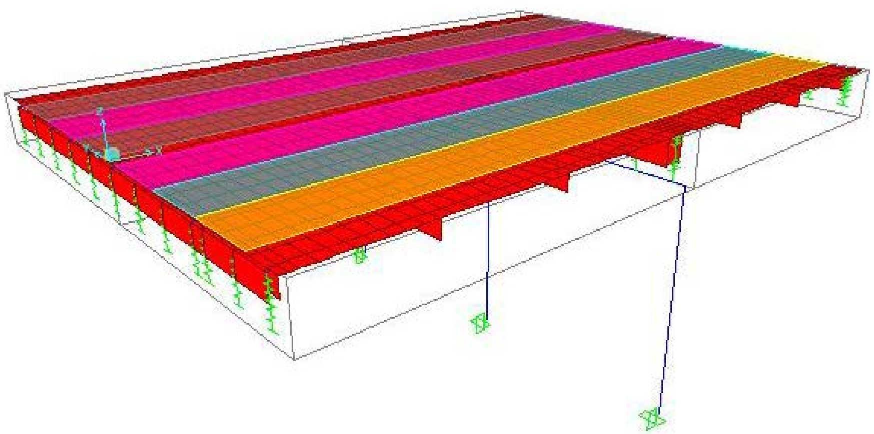


2. Truck axle width



Finite element model

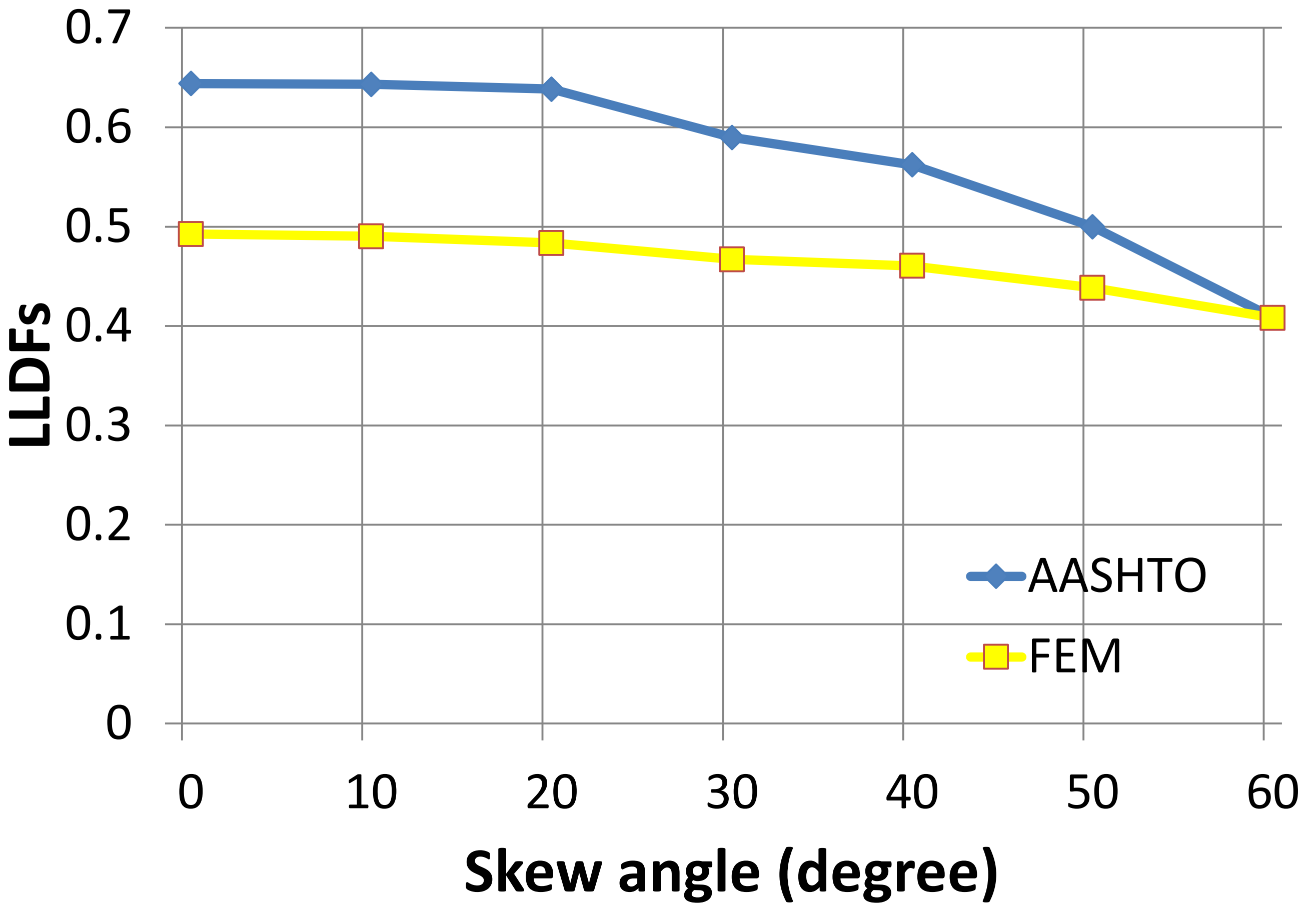




a - FEM:
- Girders
- Diaphragms
- Deck
- Bent

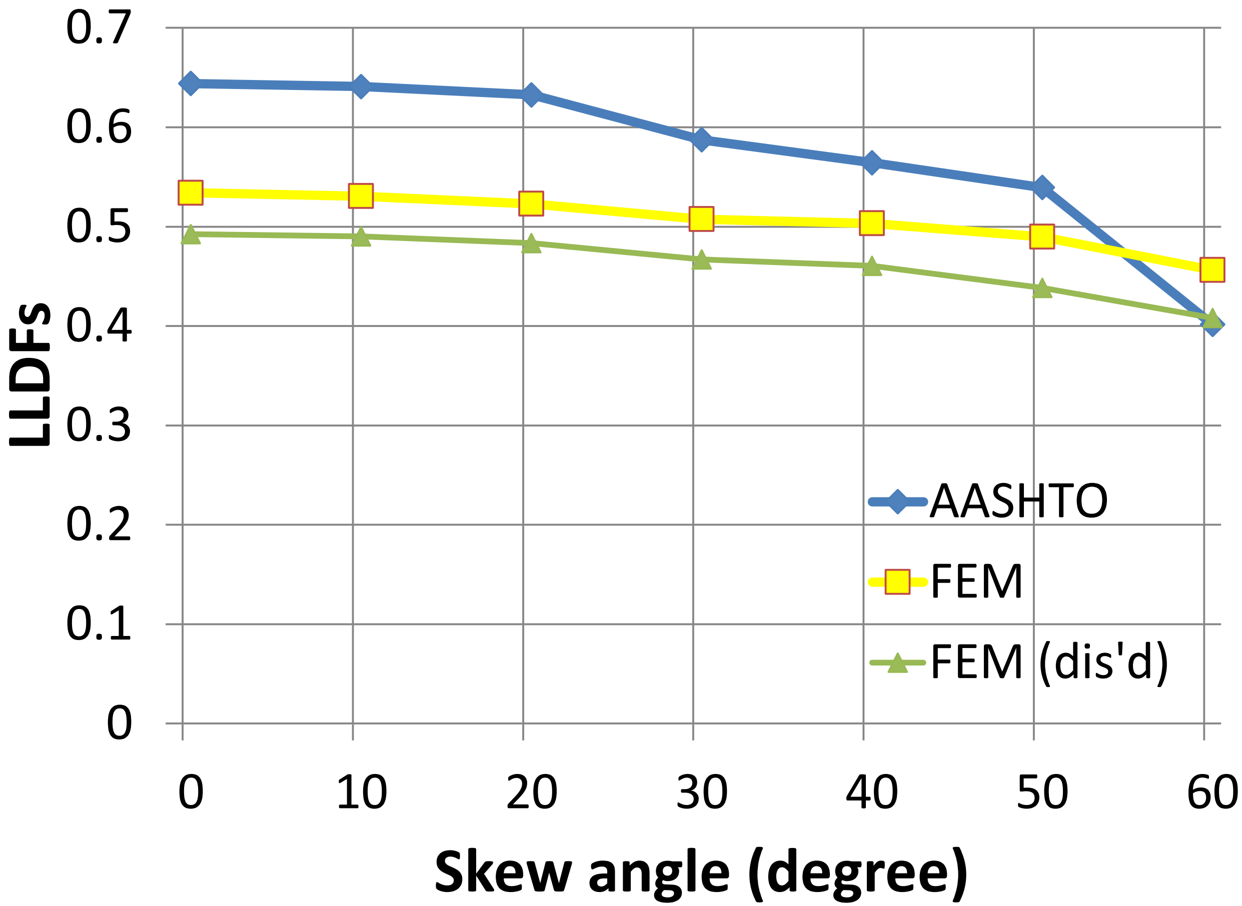
b - Lanes:
- AASHTO: 1 lane
- FEM: 6 lanes

No continuity, no diaphragm



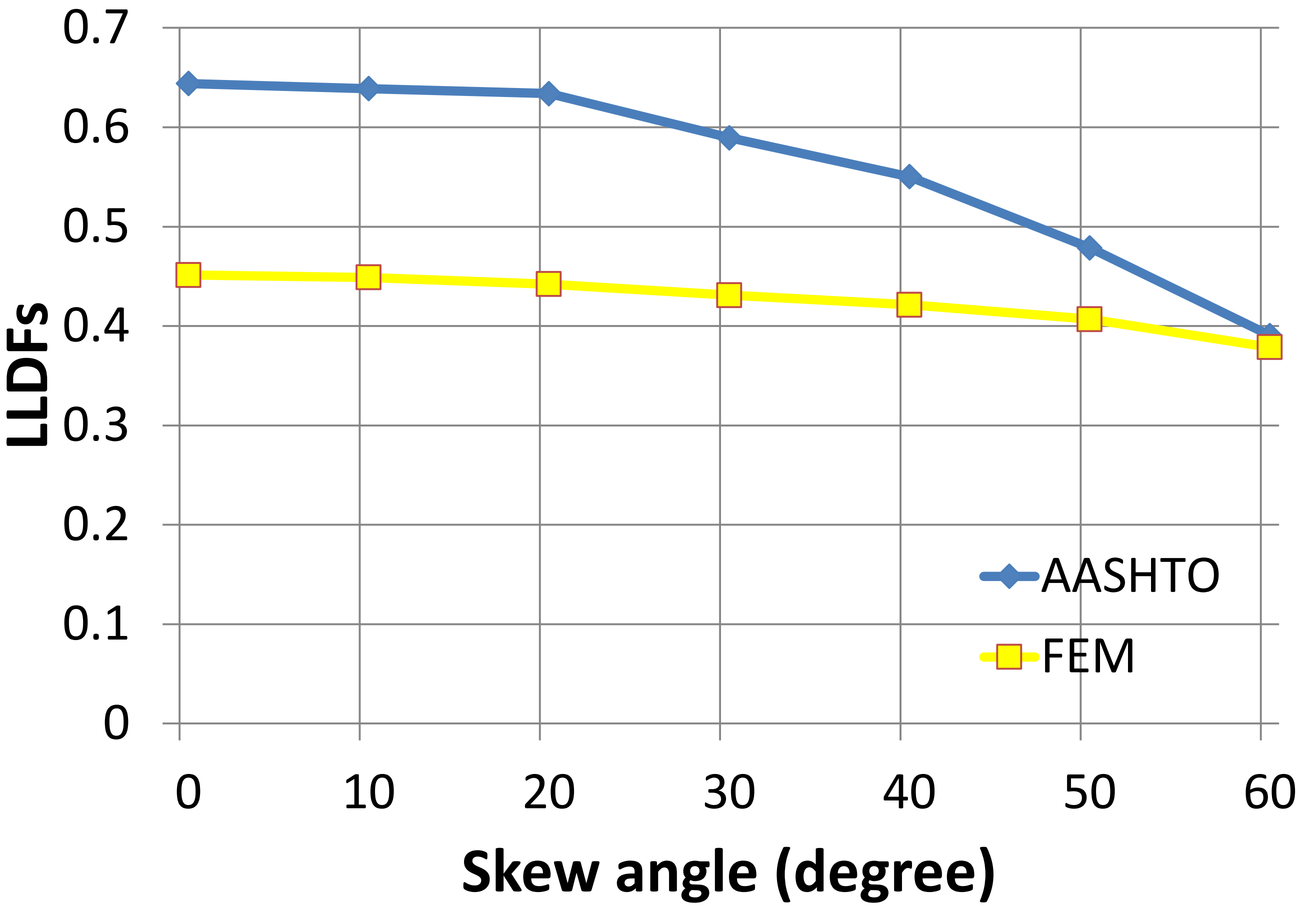
- FEM 25% less
- Similar result at 60°

Continuity, no diaphragm



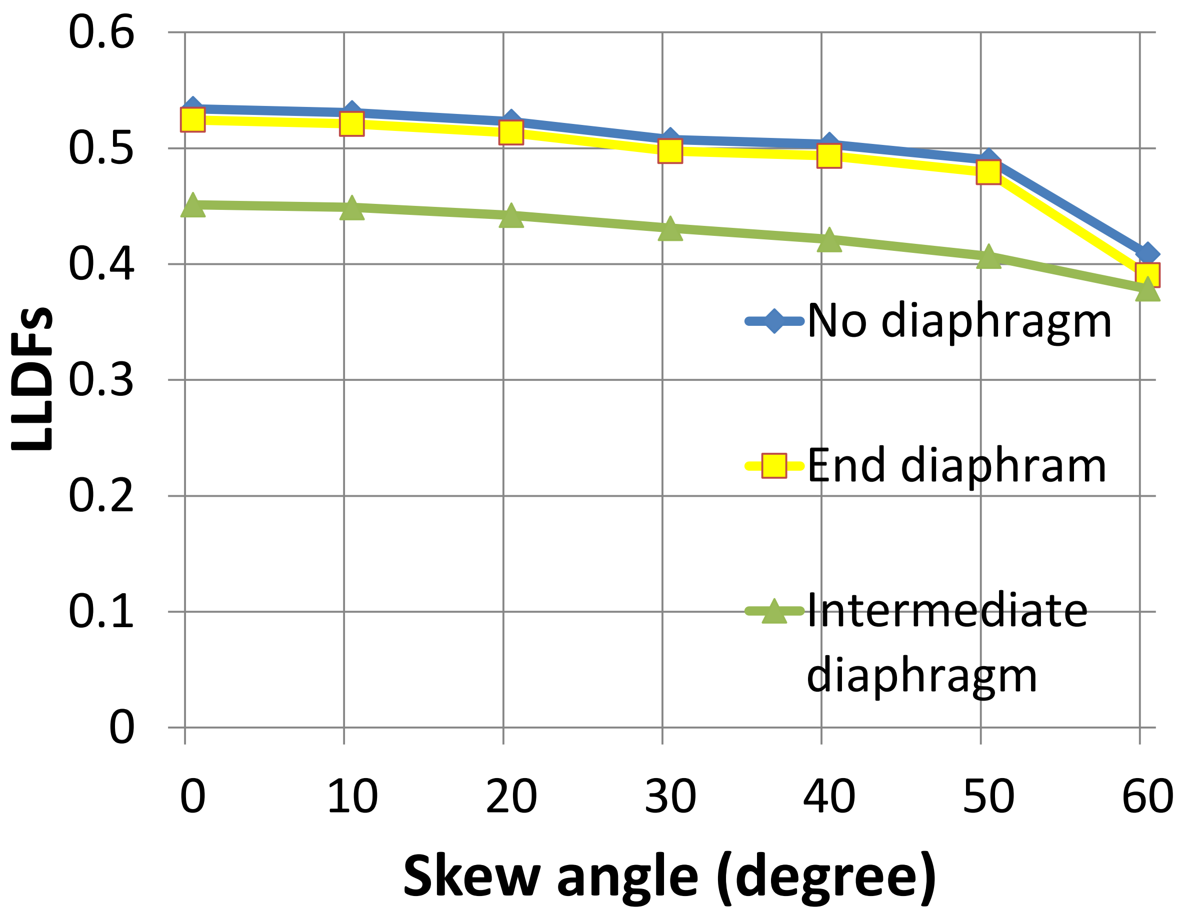
- FEM 17% less
- FEM greater at 60°.
- Continuity increase LLDFs (8%)

Continuity, diaphragm



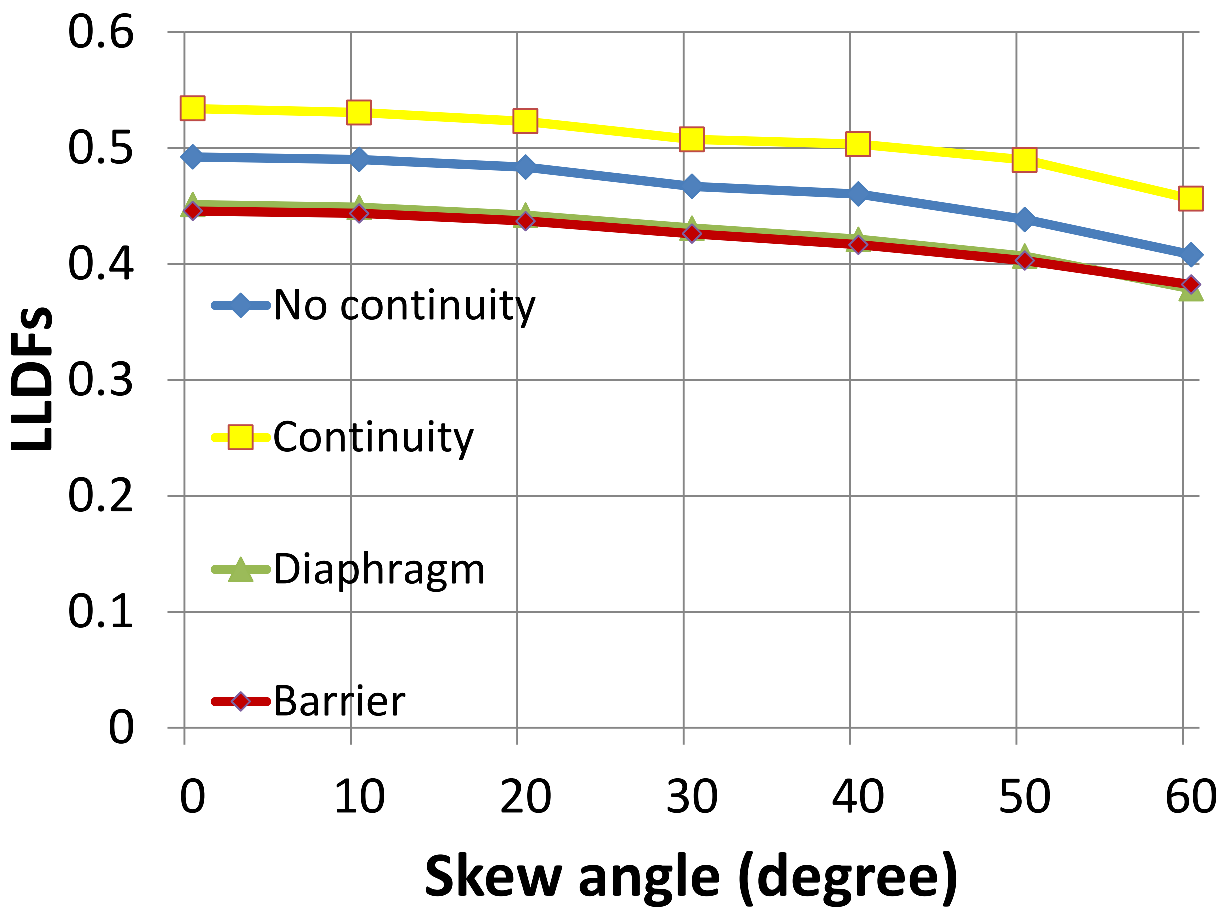
- FEM 35% less
- Similar at 60°
- Diaphragms decrease LLDFs

Effects of diaphragms (FEM)

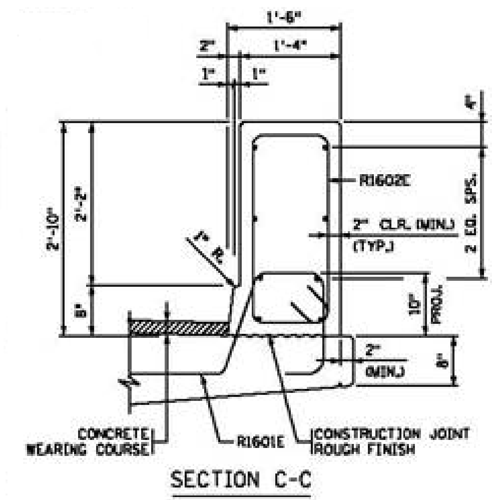


- End dia. decrease LLDFs 2%
- Int. dia. decrease LLDFs 16%

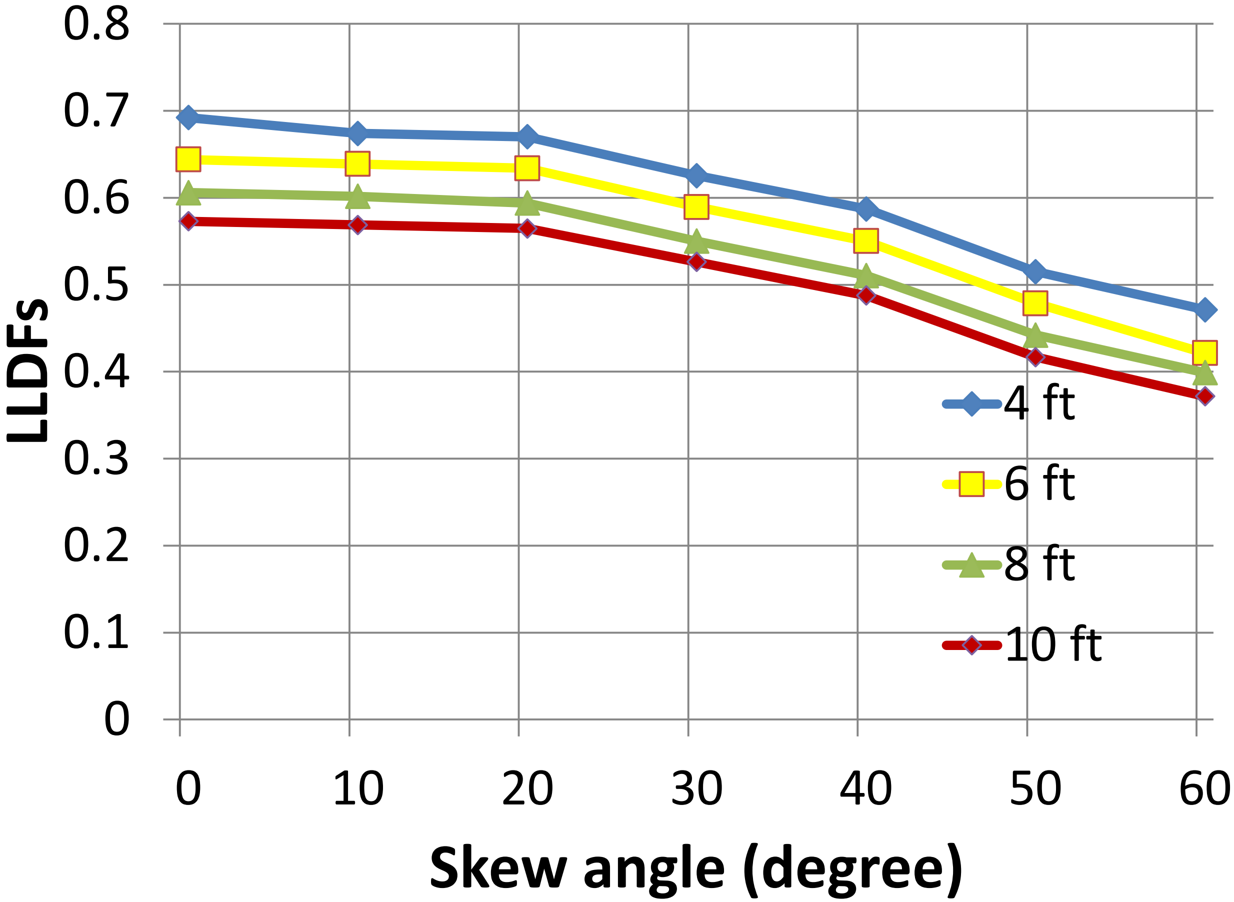
Effects of barrier



- LLDFs decrease 2%



Effects of axle width (FEM)



- 4-ft - LLDFs more 10%
- 10-ft – LLDFs less 10%

Concluding remarks

- LLDFs associated with reinforced concrete girder bridges are studied.
- AASHTO LRFD LLDFs are compared to those of FEM.
- AASHTO LRFD LLDFs are more conservative.
- In case of a simple span bridge model, the difference (between code and FEM) is up to 30%.
- The differences decrease with increasing skew angle. The two methods provide similar results at skew = 60°.
- Continuity increases the LLDFs by 8%.
- Diaphragms decrease the LLDFs by 18%.

Concluding remarks (cont'd)

- Intermediate diaphragms have more effects on LLDFs (16%) compared to end diaphragms (2%).
- Barriers have small effects on LLDFs (2%).
- The shorter axle width the more LLDFs and vice versa.
- 4-ft width increases LLDFs by 10% compared to 6-ft width.
- 10-ft width reduces LLDFs by 10% compared to 6-ft width.
- It is worthwhile to include the secondary components in calculating LLDFs.
- For the case of continuity, no diaphragm and large skewness (≥60°), the code LLDFs are unconservative.

THANK YOU!

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QUESTIONS?