Live Load on Concrete Bridge Decks

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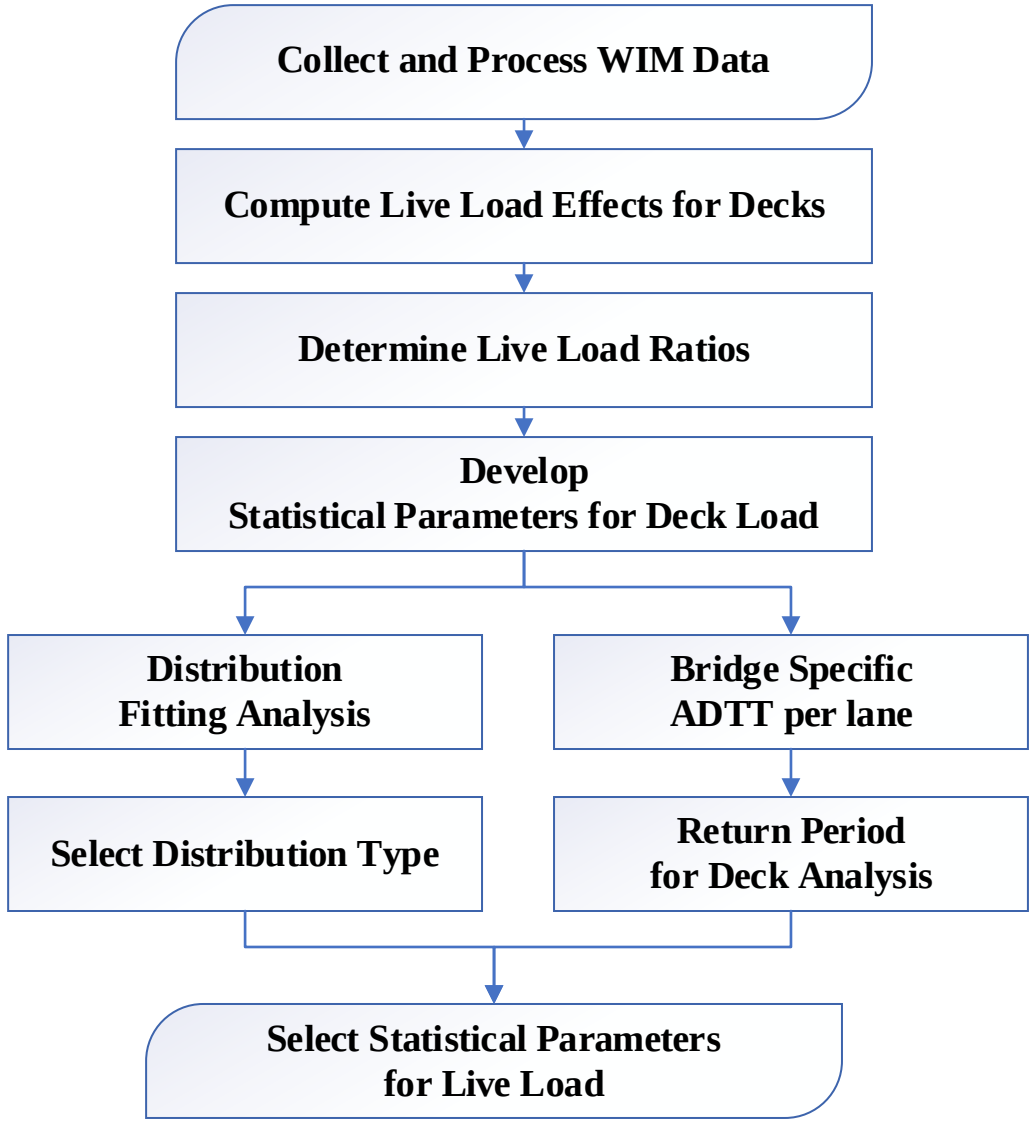
PROBLEM STATEMENT

- Rapid bridge deck deterioration.
- Increased heavy traffic.
- Design loads were not calibrated for decks.
- Need for live load model verification.
- Wheel load available in Weigh-in-Motion database.
- Live load factors needed for bridge decks.

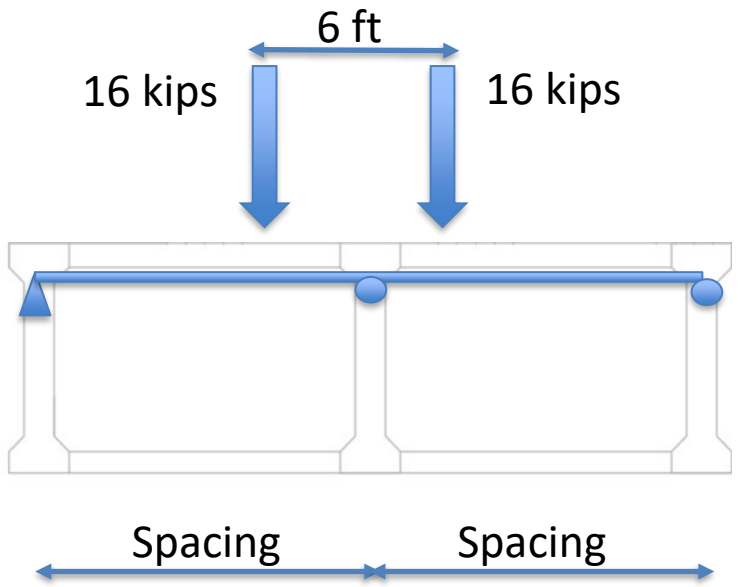
DECK LIVE LOAD MODEL

- Calculations of transverse live load effects.
- Traffic extrapolation.
- Statistical distribution fitting.
- Service life of a deck.
- Development of live load statistical parameters.
- Calibration of live load factor.

DEVELOPMENT OF DECK LIVE MODEL

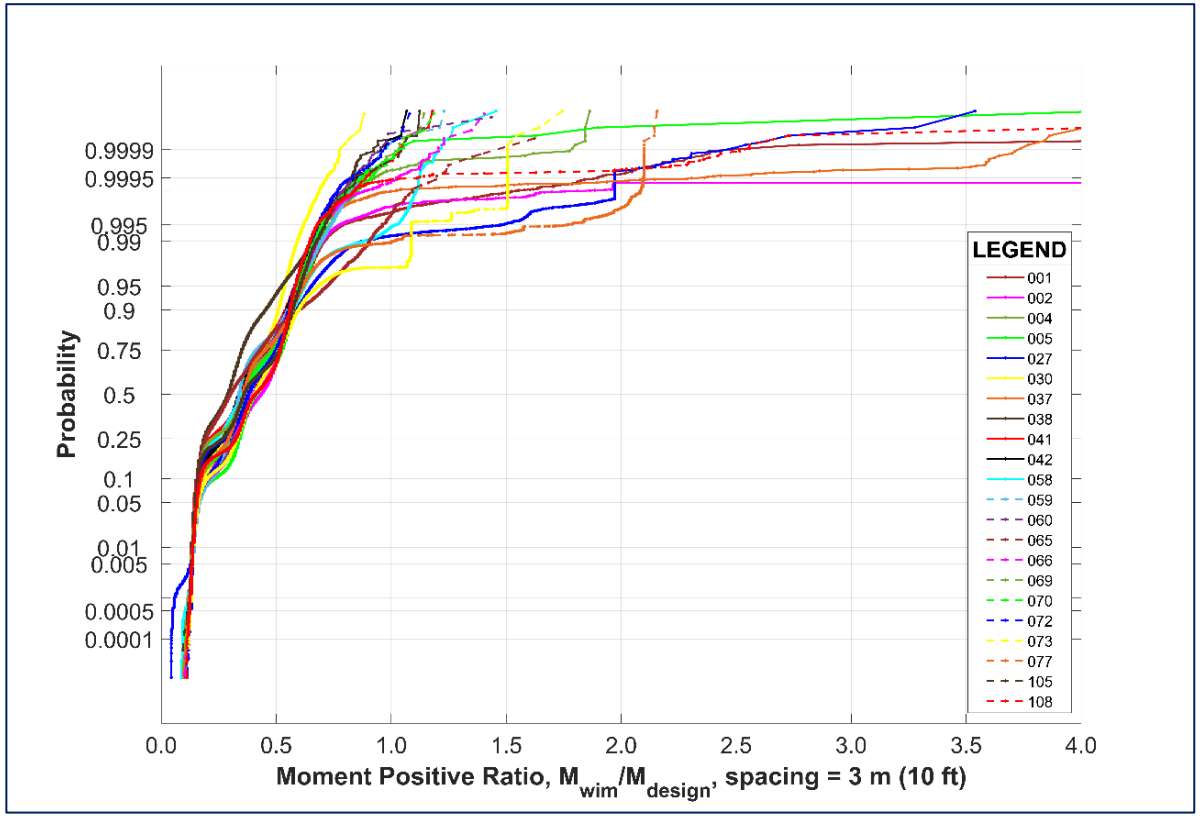


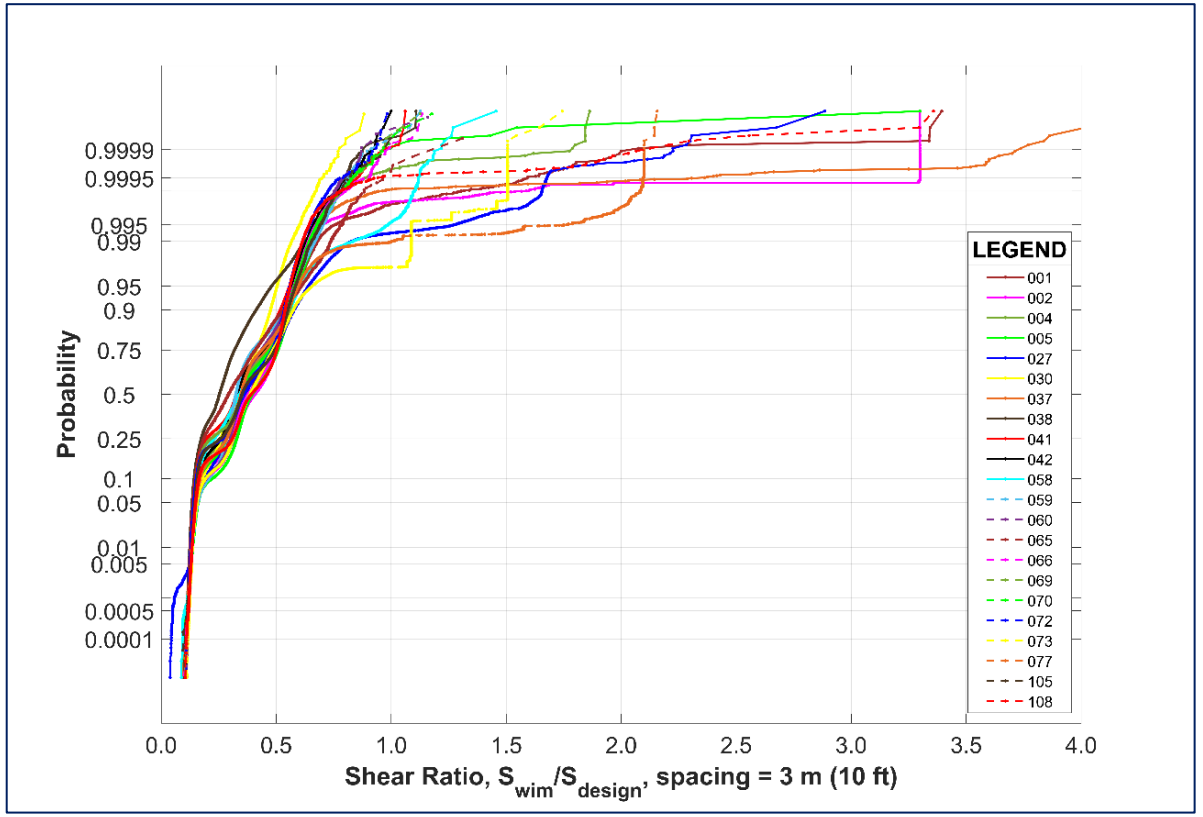
TRANSVERSE LIVE LOAD EFFECTS



- California WIM have wheel load data.
- Maximum axle load was taken for every WIM truck.
- Analysis was performed for two continuous span model.
- Maximum moment and shear were found using influence lines.

TRANSVERSE LIVE LOAD RATIOS





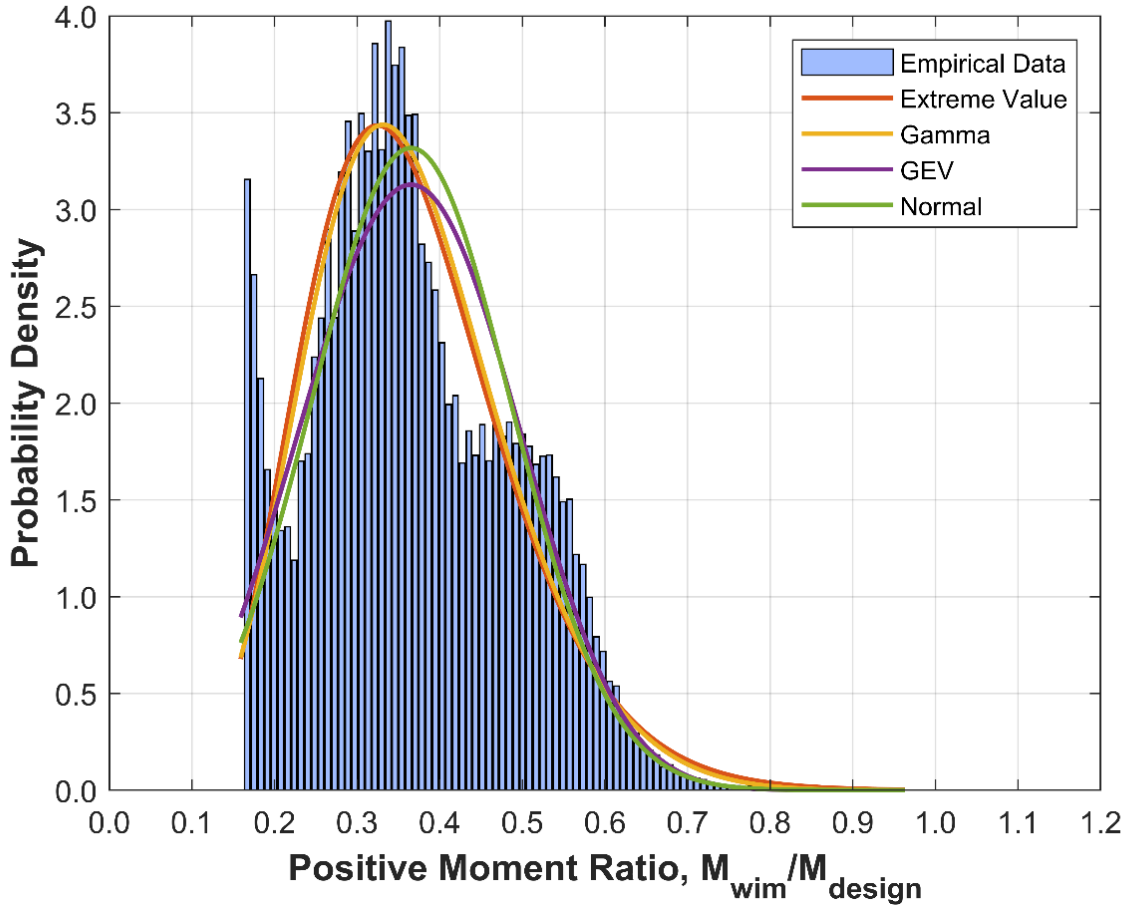
LIVE LOAD EXTRAPOLATION

- Prediction of the expected maximum live load for a specific time (return) period and traffic volume.
- N = expected number of trucks in time (T days) and traffic volume (ADTT):

$$N = \text{Return Period (days)} \cdot \text{Traffic Volume (ADTT)}$$

- 1/N = probability of exceeding the maximum WIM-based live load.

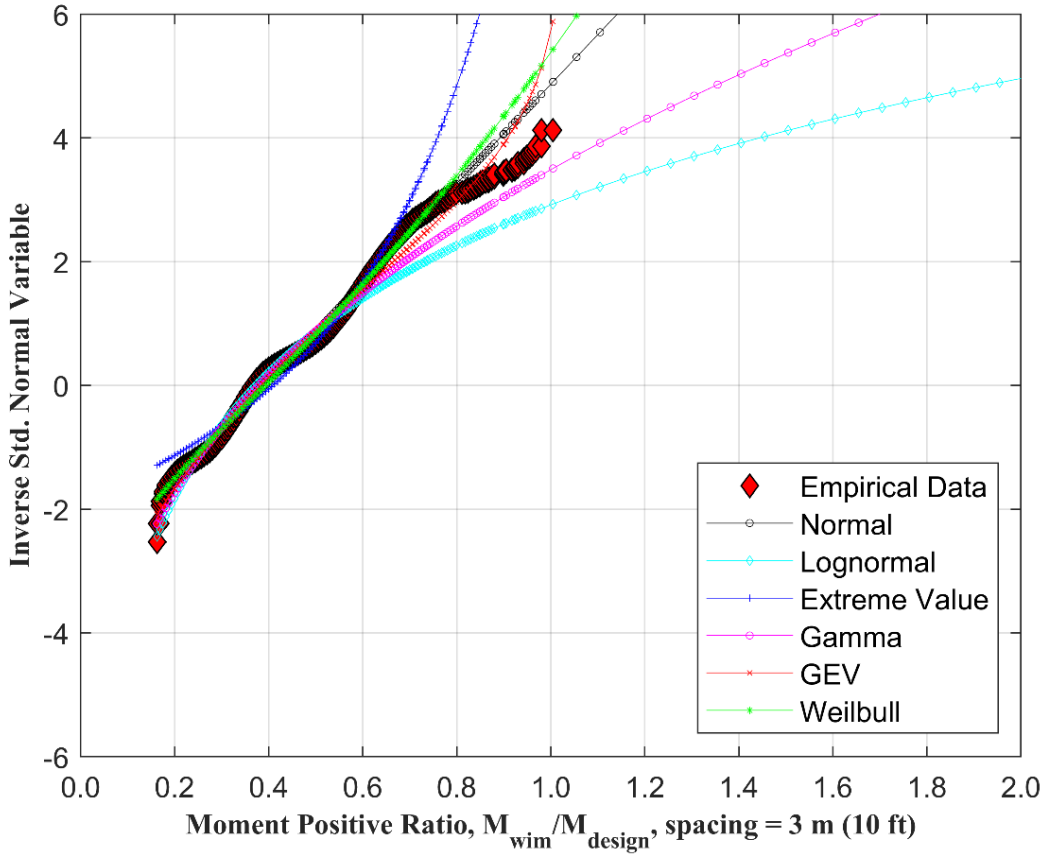
FITTING DISTRIBUTION

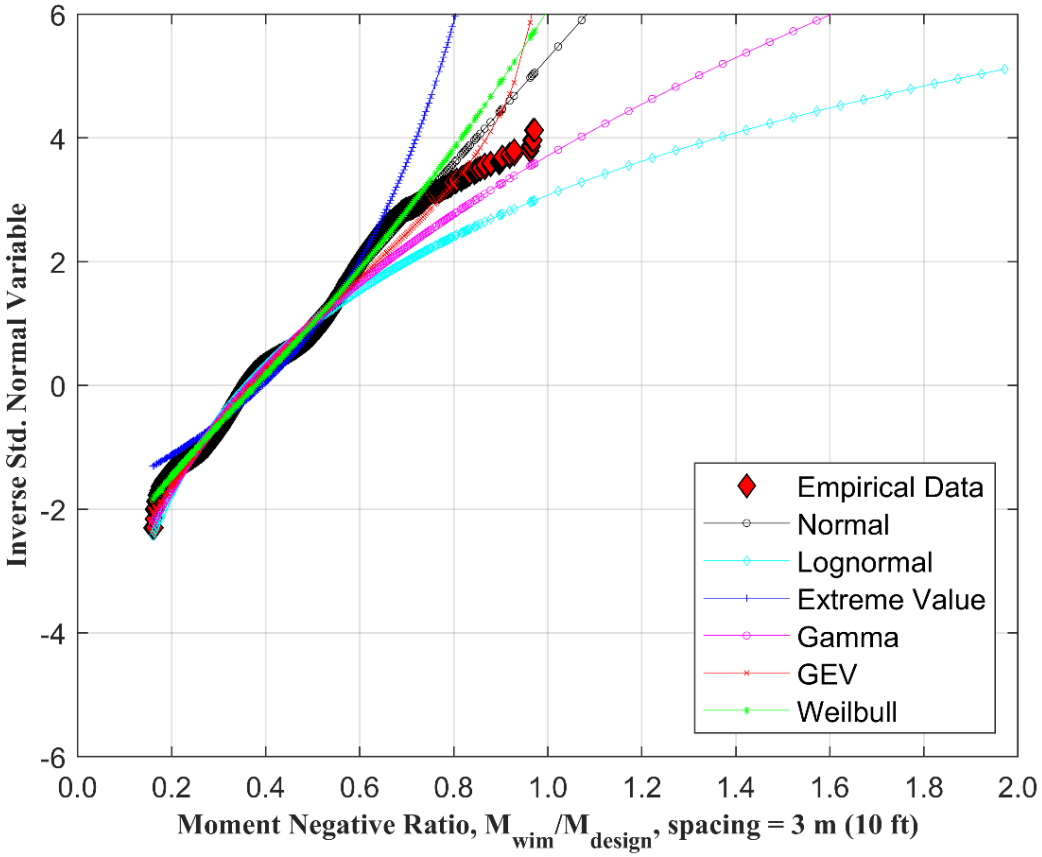


- Best fit was conducted for the following distributions: Beta, Exponential, Extreme Value, Gamma, Generalized Extreme Value (GEV), Generalized Pareto, Inverse Gaussian, Logistic, Loglogistic, Lognormal, Nakagami, Normal, Rayleigh, Rician, Weibull.

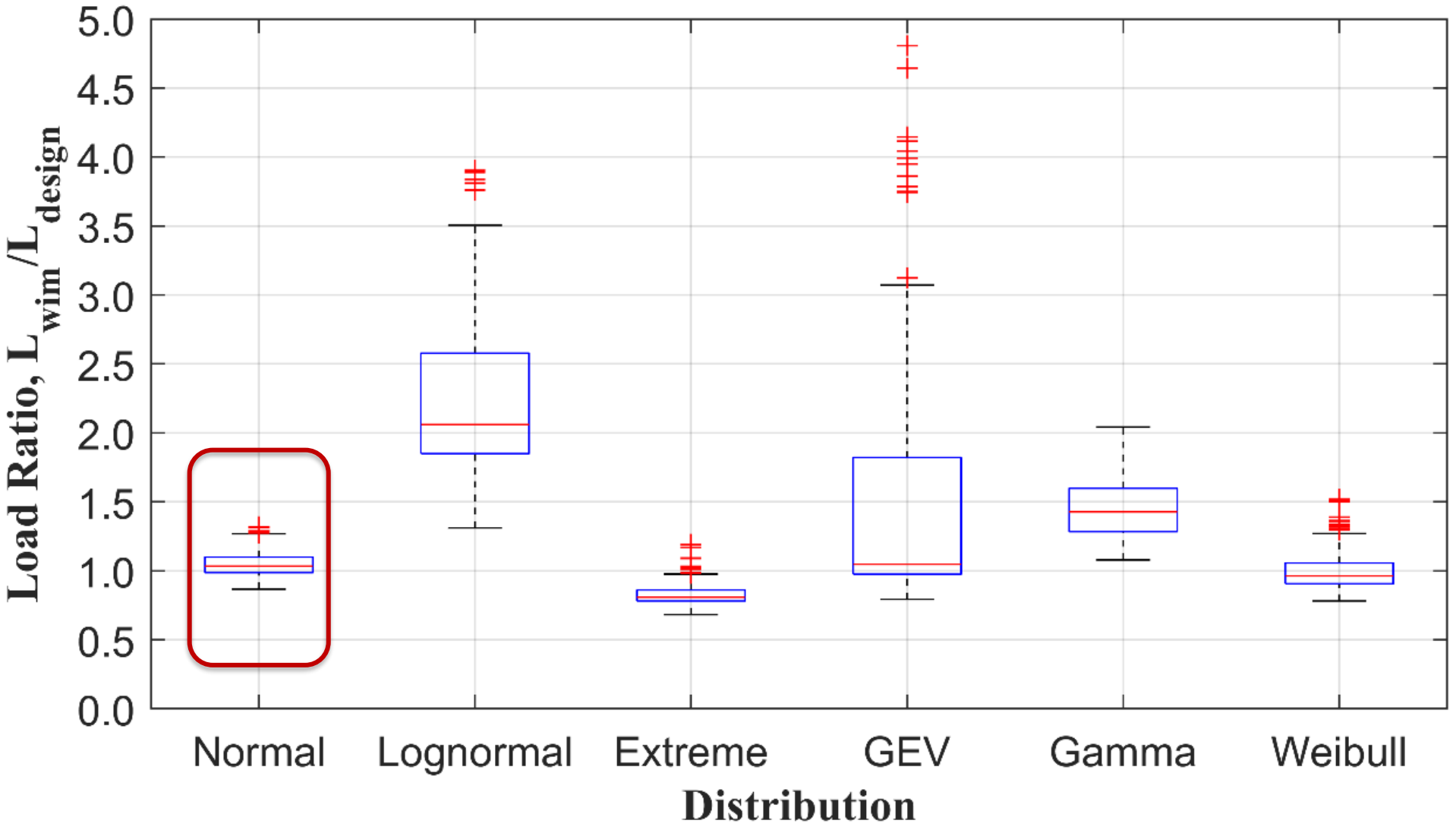
- The fitting procedure was applied to every WIM site and a wide range of spacings.

FITTING FOR CALIFORNIA TRAFFIC

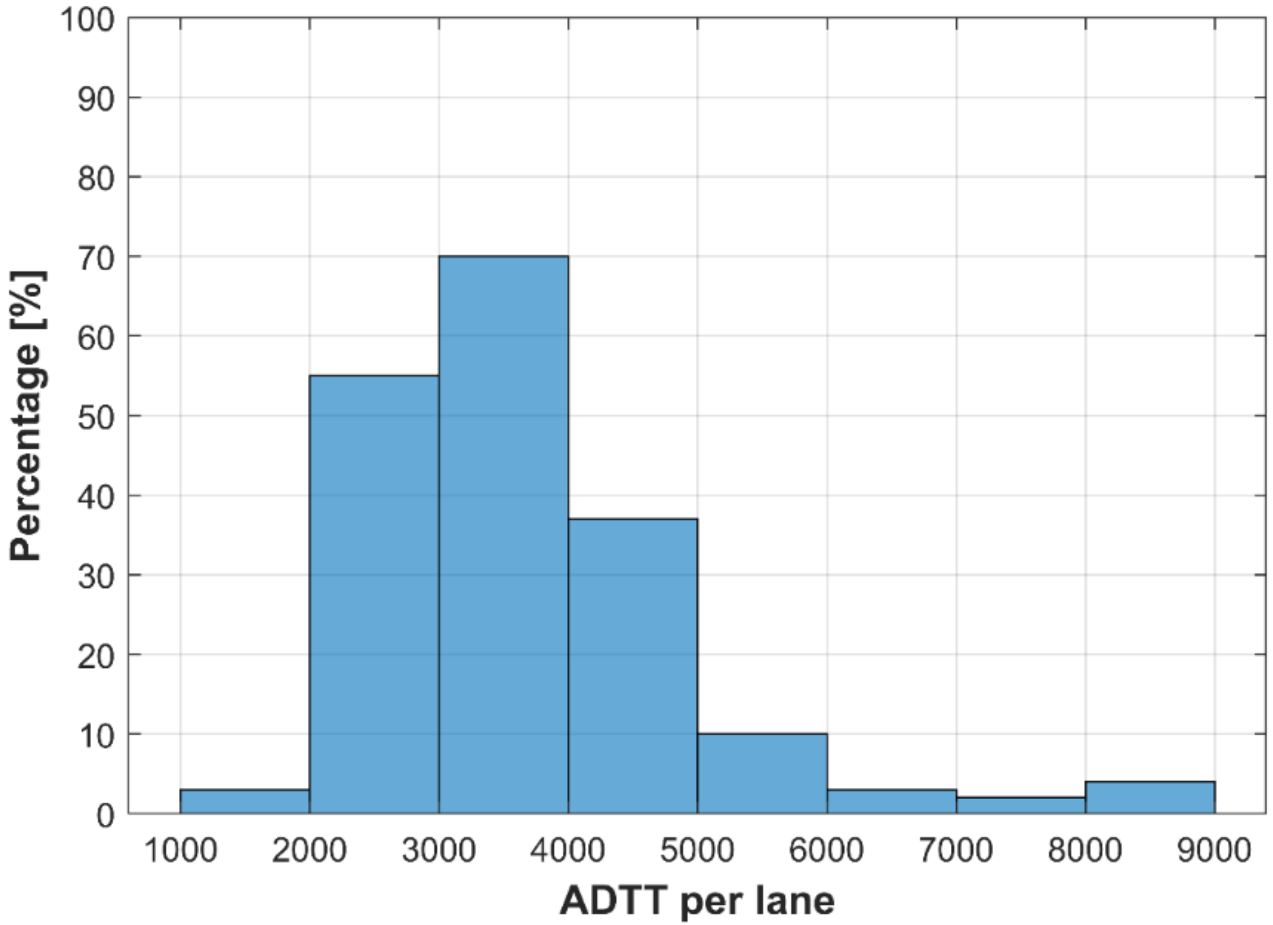




FITTED DISTRIBUTIONS



AVERAGE DAILY TRUCK TRAFFIC PER LANE IN CALIFORNIA

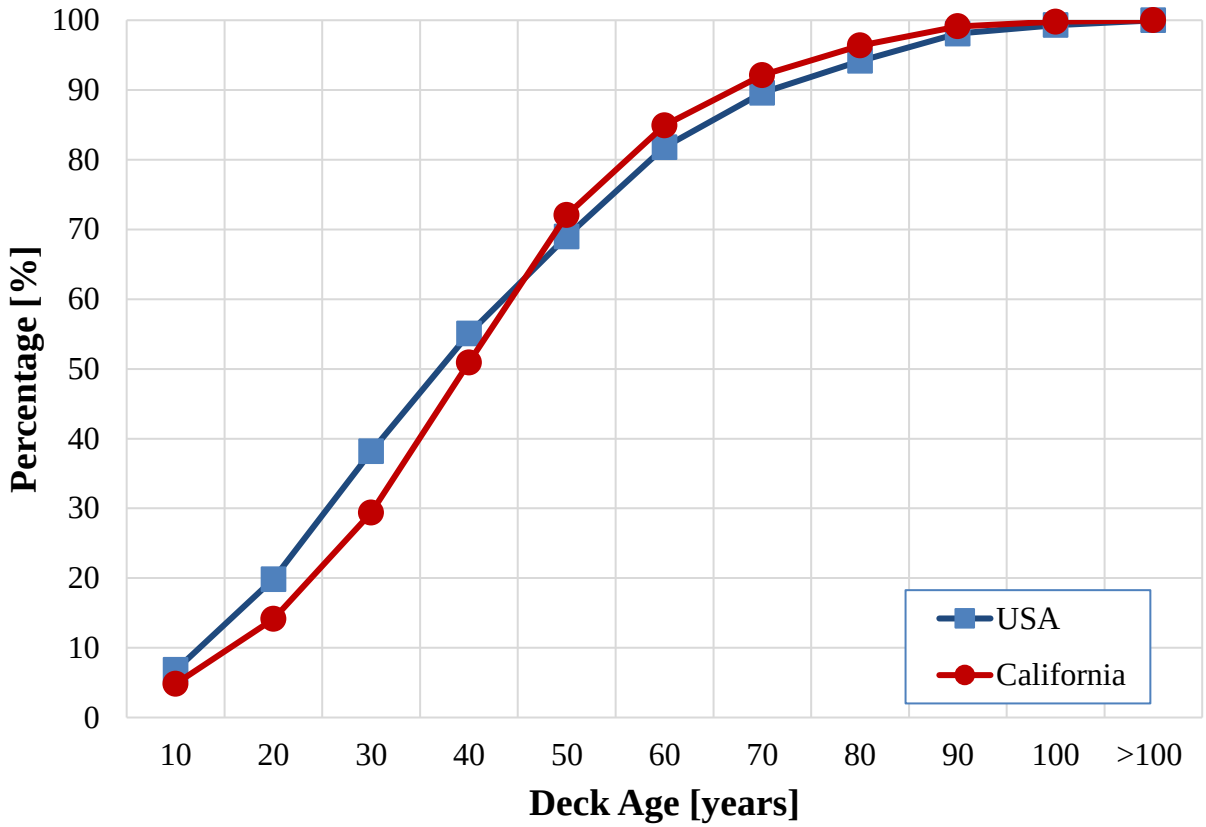


- Selected ADTT (trucks/day/lane):
  - 1,000
  - 2,000
  - 3,000
  - 4,000
  - 5,000
  - 6,000

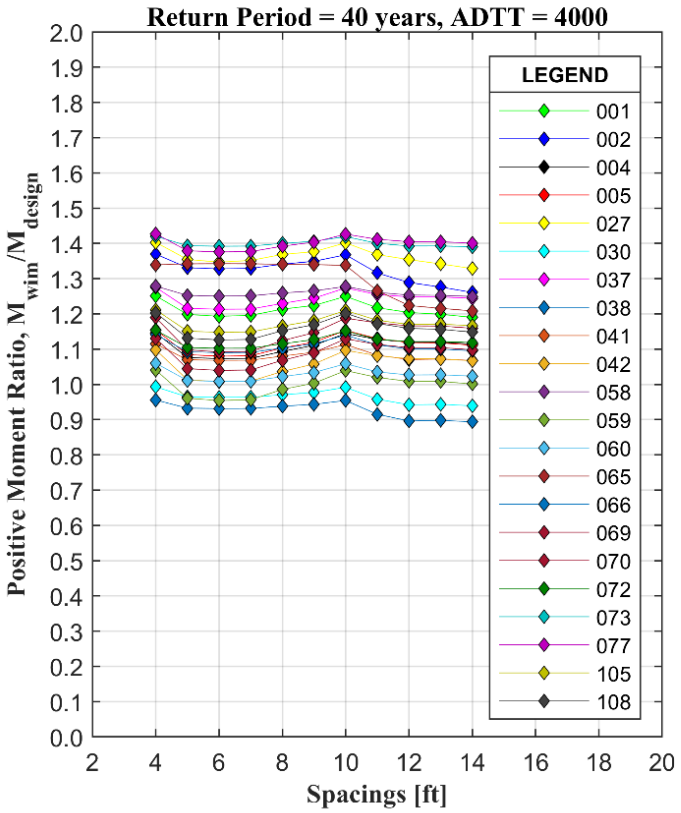
SERVICE LIFE OF DECK AND RETURN PERIOD

- Service life of a bridge is specified as 75 years in AASHTO.
- Service life of a deck has not been specified.
- In practice, it varies considerably.

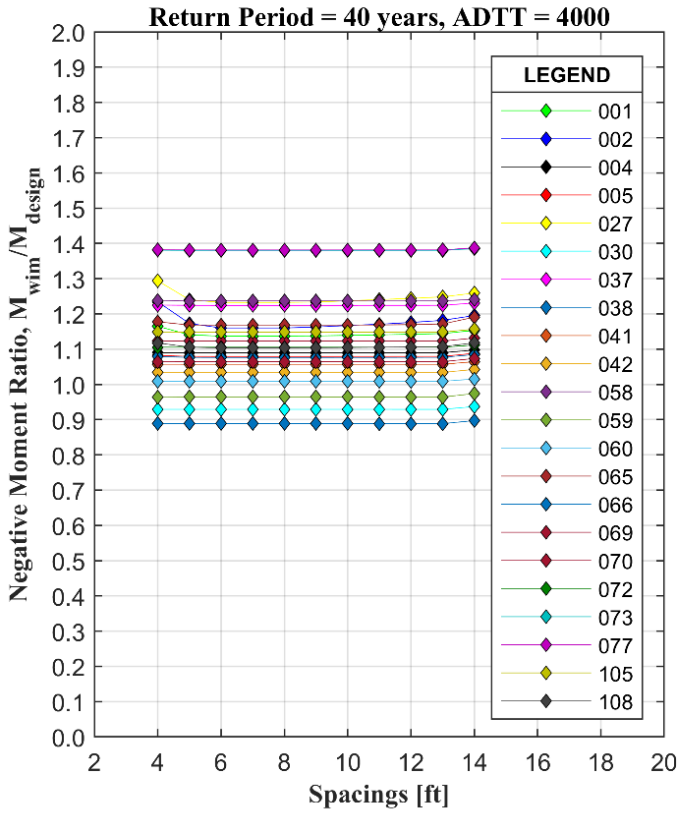
- Deck age at the first major maintenance activity is as shown (InfoBridge, 1983-2020).
- The following return periods were considered:
  - 10 years
  - 20 years
  - 30 years
  - 40 years
  - 50 years



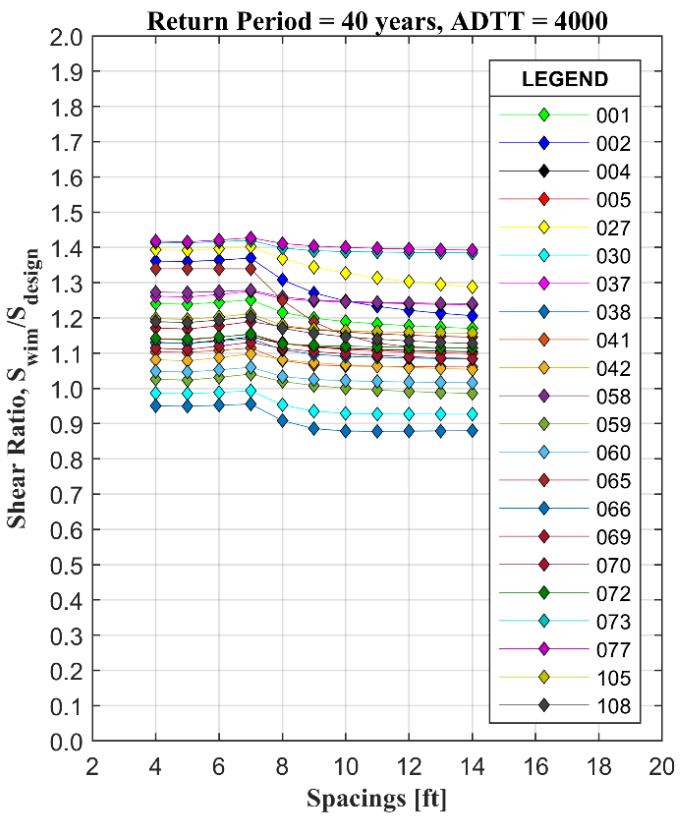
BIAS FACTOR FOR LIVE LOAD



Positive Moment



Negative Moment



Shear

STATISTICAL PARAMETERS FOR VARIOUS RETURN PERIODS

Spacing	10 years		20 years		30 years		40 years		50 years	
[ft]	λ	CoV	λ	CoV	λ	CoV	λ	CoV	λ	CoV
4	1.29	0.11	1.32	0.11	1.33	0.11	1.34	0.11	1.35	0.11
5	1.29	0.12	1.31	0.12	1.32	0.12	1.33	0.13	1.34	0.13
6	1.29	0.12	1.31	0.13	1.32	0.13	1.33	0.13	1.33	0.13
7	1.29	0.12	1.31	0.13	1.32	0.13	1.33	0.13	1.34	0.13
8	1.30	0.12	1.32	0.12	1.33	0.12	1.34	0.12	1.35	0.12
9	1.29	0.12	1.32	0.12	1.33	0.12	1.34	0.12	1.35	0.12
10	1.29	0.11	1.32	0.11	1.33	0.11	1.34	0.11	1.34	0.11
11	1.22	0.11	1.24	0.11	1.26	0.11	1.27	0.11	1.27	0.11
12	1.21	0.11	1.23	0.12	1.25	0.12	1.25	0.12	1.26	0.12
13	1.21	0.11	1.23	0.11	1.24	0.11	1.25	0.11	1.26	0.11
14	1.21	0.11	1.23	0.11	1.24	0.11	1.25	0.11	1.26	0.11
Average	***1.26***	***0.12***	***1.28***	***0.12***	***1.30***	***0.12***	***1.31***	***0.12***	***1.31***	***0.12***

Bias factor: 1.21-1.35

Coefficient of variation 11-13%

STATISTICAL PARAMETERS FOR VARIOUS ADTT

Spacing [ft]	ADTT											
	1,000		2,000		3,000		4,000		5,000		6,000	
	λ	CoV	λ	CoV	λ	CoV	λ	CoV	λ	CoV	λ	CoV
4	1.28	0.11	1.31	0.11	1.32	0.11	1.33	0.11	1.34	0.11	1.34	0.11
5	1.28	0.12	1.30	0.12	1.31	0.12	1.32	0.12	1.33	0.13	1.33	0.13
6	1.28	0.12	1.30	0.12	1.31	0.13	1.32	0.13	1.33	0.13	1.33	0.13
7	1.28	0.12	1.30	0.12	1.31	0.13	1.32	0.13	1.33	0.13	1.33	0.13
8	1.29	0.12	1.31	0.12	1.32	0.12	1.33	0.12	1.34	0.12	1.34	0.12
9	1.29	0.12	1.31	0.12	1.32	0.12	1.33	0.12	1.34	0.12	1.34	0.12
10	1.28	0.11	1.31	0.11	1.32	0.11	1.33	0.11	1.34	0.11	1.34	0.11
11	1.21	0.11	1.24	0.11	1.25	0.11	1.26	0.11	1.26	0.11	1.27	0.11
12	1.20	0.11	1.23	0.11	1.24	0.12	1.25	0.12	1.25	0.12	1.26	0.12
13	1.20	0.11	1.22	0.11	1.24	0.11	1.24	0.11	1.25	0.11	1.26	0.11
14	1.20	0.11	1.22	0.11	1.23	0.11	1.24	0.11	1.25	0.11	1.25	0.11
Average	***1.25***	***0.12***	***1.28***	***0.12***	***1.29***	***0.12***	***1.30***	***0.12***	***1.30***	***0.12***	***1.31***	***0.12***

Bias factor: 1.20-1.34

Coefficient of variation 11-13%

For 40 years return period

CONCLUSIONS

- Big traffic live load including wheel load is available to develop deck live load model.
- Transverse live load analysis for California traffic was considered.
- Bias factor is 1.18-1.35.
- Coefficient of variation is 11-13%.
- Recommended statistical parameters for California loads are:
  - **Bias factor 1.25.**
  - **Coefficient of variation of 12%.**
- Developed statistical models can serve as a basis for reliability-based calibration of live load factor for concrete decks.