Evaluation of Bridge Approach Slab and Dynamic Load Allowance (IM) Using Sub-mm 3D Laser Imaging Technology

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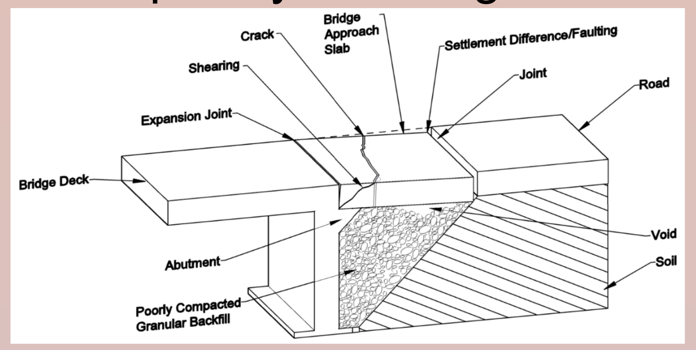
Guolong Wang, Kelvin C. P. Wang, Guangwei Yang, and Joshua Qiang Li
School of Civil & Environmental Engineering, Oklahoma State University, kelvin.wang@okstate.edu

OKLAHOMA STATE UNIVERSITY

Introduction

❖ Background: bridge approaches are frequently suffering from differential settlement/faulting
- ➢ Increase ride discomfort
- ➢ Distract driver
- ➢ Cause high live loads on bridges
- ➢ Develop and accelerate distress
- ➢ High maintenance cost with late action



❖ Problem statement
- ➢ Current documentations to evaluate bridge approach vary in states or research communities.
- ➢ No standard to specifically evaluate bridge approach slab
- ➢ No definite criteria on different approach roughness levels to determine the Dynamic Load Allowance (IM).

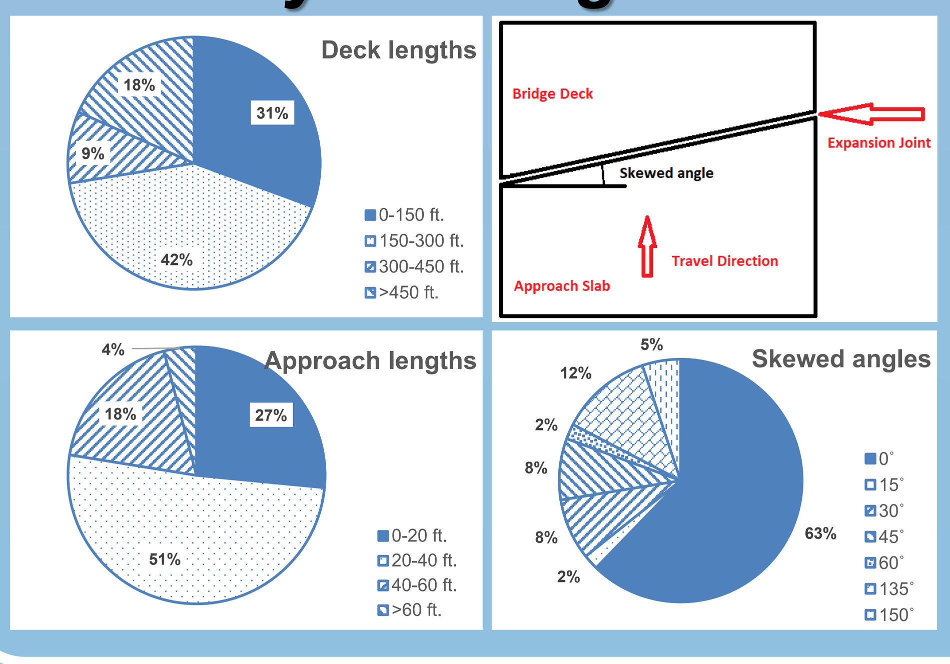
❖ Research objectives: propose a general criterion specifically for bridge approach bump classification and develop a formula for Dynamic Load Allowance (IM) estimation for bridges in Oklahoma based on recently developed sub-mm 3D laser imaging technology.

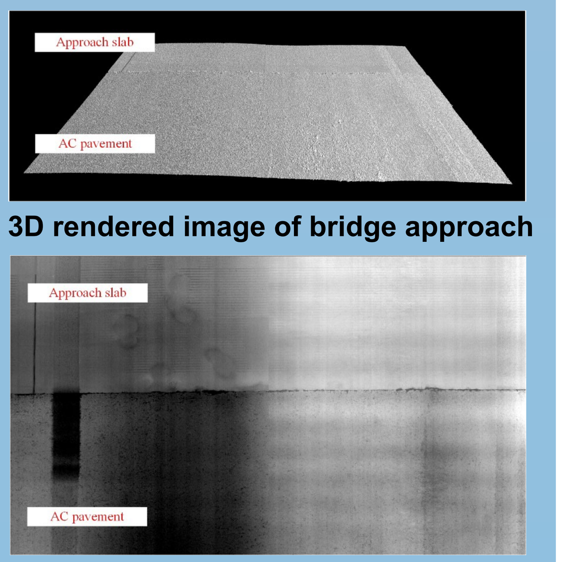
Data Collection Sites & Devices

❖ Data collection: a total of 98 bridge decks located in Oklahoma, including bridge approaches, decks, and two 20-feet abutting pavement sections, were collected in Feb-21.

❖ Pave3D 8K System
- ➢ Sub-mm 2D/3D images for distress inspection
- ➢ ROW images for full-view road
- ➢ Inertial profiles for roughness evaluation

Summary of Bridges





3D rendered image of bridge approach

Top view 3D image of 3D rendered image of bridge approach

Approach Slab Evaluation

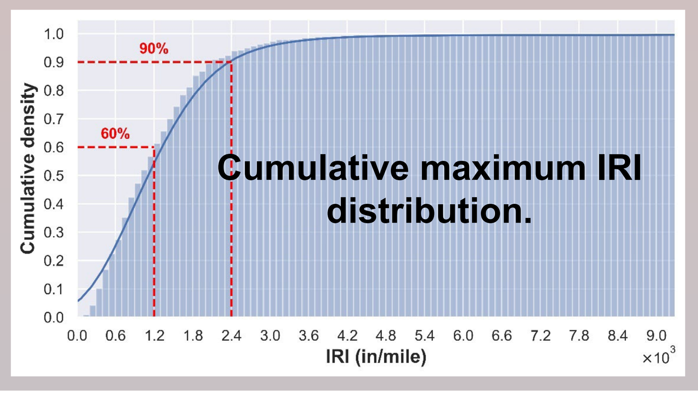
❖ IRI interval: the 1 ft interval was selected as optimality for approach bump evaluation

Row image

IRI summary

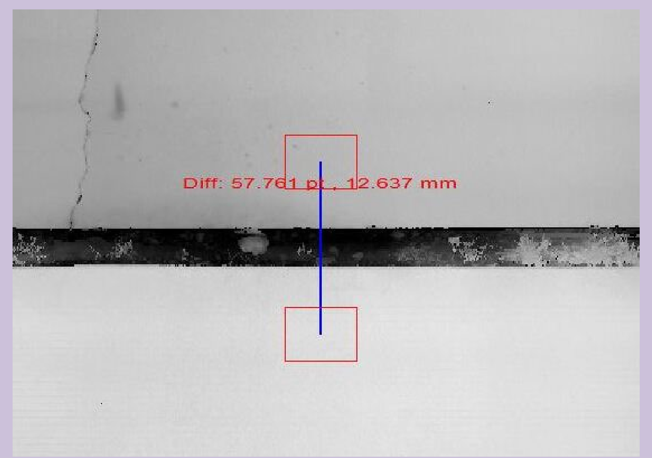
Minor Distress and derived IRI (< 1,200 in/mi) | Fair Distress and derived IRI (1,200 in/mi to 2,400 in/mi) | Severe Distress and derived IRI (>2,400 in/mi)

❖ IRI threshold: proposed based on cumulative maximum IRI distribution via considering both the field crew's sensation during data collection and the surface distress that causes or is associated with different levels of IRI magnitudes.
- ➢ Good: < 1200 in/mi
- ➢ Fair: 1200 to 2400 in/mi
- ➢ Poor: > 2400 in/mi

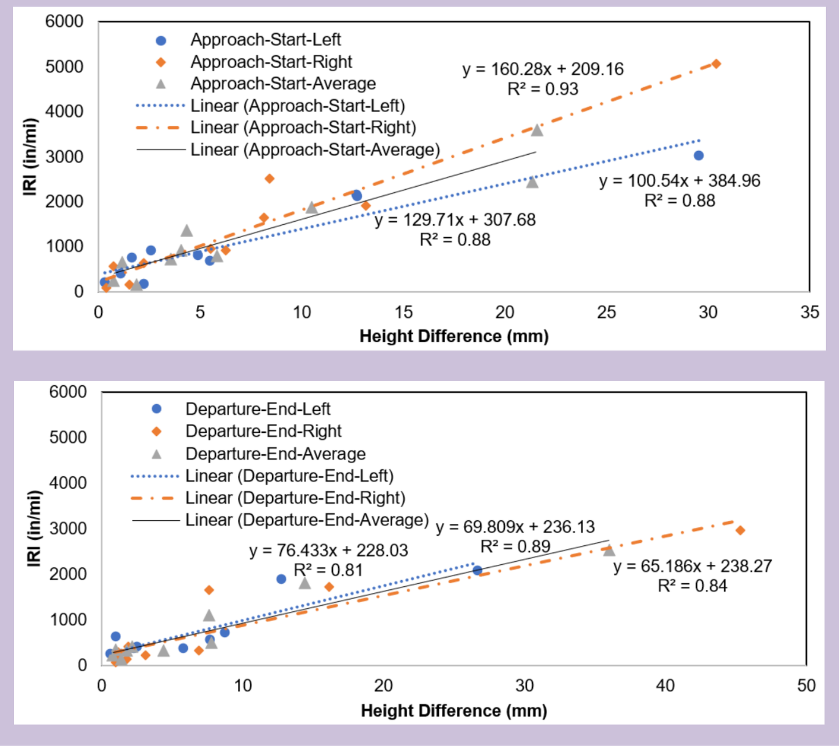


Relationship between IRI and Faulting

❖ Manual measurement tool: to calculate the average height information of the two squares and reports the difference between the two average heights
- ➢ Faulting at "Approach Start"
- ➢ Faulting at "Departure End"



Manual tool to measure faulting



Dynamic Load Allowance (IM) Estimation

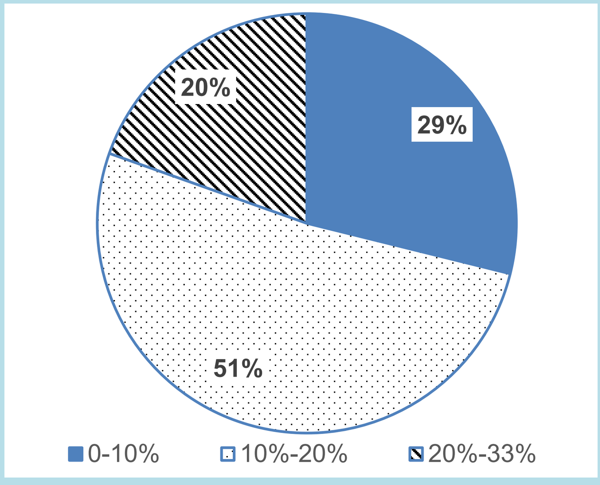
❖ *IM formula was developed for Oklahoma bridges: considering the influences of bump from approach slab and bridge deck.*

$$IM_{App/Deck} = \begin{cases} 0.1 * \frac{IRI_{max}}{1200} & IRI_{max} \le 1200 \\ 0.1 + \frac{IRI_{max}-1200}{1200} * 0.1 & 1200 < IRI_{max} \le 2400 \\ 0.33 & IRI_{max} > 2400 \end{cases}$$

$$IM_{Bridge} = IM_{App} * \frac{L_{App}}{L_{App}+L_{Deck}} + IM_{Deck} * \frac{L_{Deck}}{L_{App}+L_{Deck}}$$

❖ Summary of the estimated IM for the 98 bridges

Bridge ID	Length (ft)		IM		
	App.	Deck	App.	Deck	Bridge
1	36	218	15%	13%	13%
2	31	286	5%	13%	12%
3	60	312	13%	11%	12%
4	36	247	9%	13%	13%
5	50	240	33%	14%	17%
6	100	704	6%	16%	15%
7	64	1924	16%	33%	32%
8	32	285	12%	10%	10%
9	22	152	4%	11%	10%
10	20	143	18%	15%	16%
11	21	143	33%	11%	14%
12	21	151	33%	19%	21%
13	30	771	7%	11%	10%
14	30	112	6%	20%	17%
15	60	323	33%	18%	20%



Distribution of estimated bridge IM

Conclusions

❖ Using 1 ft as the interval for IRI calculation generates a detailed IRI distribution on approach/departure slabs, which can better identify bumps at the end of bridges.

❖ 1,200 in/mi and 2,400 in/mi are selected as the IRI thresholds to define "Good", "Fair", and "Poor" riding surfaces based on the investigation of maximum IRI and corresponding 2D/3D images with different distresses and severity levels for these bridges.

❖ Locations with IRI larger than 2,400 in/mi are identified as poor bumps, which are recommended to be fixed to reduce their impact on public safety and bridge structures.

❖ By measuring faulting on 3D images, a strong linear relationship between faulting and corresponding IRI was observed along (1) the beginning joint of approach slab and (2) the ending joint of departure slab: higher IRI numbers happened at locations with larger faulting numbers.

❖ Per the proposed Equations (2) and (3), bridge IM can be empirically estimated via the roughness condition and lengths of bridge approach slab and deck.3D images and WIS from the Pave3D 8K system can be used to identify locations with high IRI.

Acknowledgements

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