Bridge Weigh-in-Motion (BWIM)
Funded by ConnDOT

Nicole Prete
University of Connecticut
Topics

- Introduction to BWIM
- The Meriden Bridge
- Strain Sensors
- BWIM Outputs
- MATLAB Strain Output
- Accuracy of Estimated BWIM Weights
- Error Patterns
- CSI Bridges Model
Introduction to BWIM

- BWIM uses the dynamic response of the bridge to determine the weights and speeds of crossing trucks
  - Nothing on the Road WIM
- WIM data can be used for improvements in bridge design, bridge loading rate analyses, and overweight vehicle identifications
- Overweight trucks are harmful to bridges and cause them to fatigue, resulting in an increased need for repairs and replacements.
  - Costly
- BWIM allows a non-invasive and cost-effective way to identify these overweight vehicles
The Problem With Weigh Stations

- Weigh stations are not open for extended periods of time and they are usually not open for consecutive days.
- When they are open, they can cause the traffic stream to back up on the highway.
- Because of this, weigh stations can only be open for about 5 minutes at a time.
- Many overweight trucks avoid weigh stations.
The Meriden Bridge

Hartford → Meriden Bridge Location

Ariel View of Bridge and Weigh Station on I-91N

View of Baldwin Avenue

Road View of Bridge and Camera
Under the Bridge

Cabinet containing system components

Steel Girders and Underside of Bridge

NI Data Acquisition Modules
Sensor Configuration

- Girder 1
- Girder 2
- Girder 3
- Girder 4
- Girder 5
- Girder 6
- Girder 7
- Girder 8

Dimensions:
- 85 ft width
- 55 ft height
- 21.25 ft spacing

Legend:
- Green circle: Foil Strain
- Red square: Piezoelectric Strain
- Purple square: Piezoelectric Accel.
- Blue square: Capacitance Accel.
- Orange triangle: RTD

Orientation:
- 7 spaces of 7.28 ft = 51 ft
- I-91 Northbound
Strain Sensors

- There are 8 strain gauges mounted at mid-span on the 6 inside girders
  - Six gauges are on the bottom flange
  - Two gauges are on the top flange under lanes 1 and 2
BWIM Outputs

- Strain History to get:
  - Velocity
  - Axle Spacing
  - Gross Vehicle Weight
  - Individual axle weight

MATLAB Data Acquisition Toolbox
MATLAB Strain Output

Graph 1: Strain vs. Time for Lane 1

Graph 2: Strain vs. Time for Lane 1

Graph 3: Strain vs. Time for Lane 1

Graph 4: Strain vs. Time for Lane 1
% Error in Weight Compared to Recorded Speed

![Graph showing % Error in Weight Compared to Recorded Speed. The graph plots speed (MPH) on the x-axis and % Error in Weight on the y-axis. Two lines, one at 2σ and one at σ, are shown, with data points indicating variability in error.](image)
Measured GVW versus BWIM Calculated GVW

Average Accuracy = 0.74%
Standard Deviation = 13%
Percent Error Distribution

Number of Trucks

% Error in Weight

-26.73%  1
-20.26%  1
-13.79%  11
-7.32%  15
-0.85%  29
5.61%   19
12.08%  9
18.55%  3
25.02%  3
31.49%  2
More    4
Error Patterns

a) Back-to-Back

Frame 121
File Data 10-26-11
Truck #12 Recorded as 0

b) Side-by-Side

Unrecorded

Recorded

c) Staggered in Two Lanes

Frame 202
File Data 10-50-45
1st Truck Recorded as 0 at frame 201
2nd Truck NR

d) The working Staggered in Two Lanes case
Back-to-Back

Truck Recorded as 0

Frame 121
File Data 10-26-11
Truck #12 Recorded as 0

Strain [micromax]

Time [seconds]

Lane 1

Lane 2

Lane 1

Lane 2
Side-by-Side

Unrecorded

Recorded

Lane1

Lane2

Strain [microstrain]

Time [seconds]

0 5 10 15 20

12 13 14 15 16 17

Lane1

Lane2
Staggered in Two Lanes

Frame 202
File Data 10-50-45
1st Truck Recorded as 0 at frame 201
2nd Truck NR
The Effects of Strain on Other Lanes

- A truck driving over lane 1 will have an effect on the strain reading on lane 2, and vice versa.
- The effect of a truck traveling in lane 1 on the strain reading of lane 2 is 37%.
- The effect of a truck traveling in lane 2 on the strain reading of lane 1 is 43%.
- This effect must be removed from the strain of trucks traveling close to each other.
Distribution of Lane 1's Effect on Lane 2 Strain Reading

Number of Trucks

Percent of lane 2 strain from a truck traveling in lane 1

- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- More

- 0
- 2
- 4
- 6
- 8
- 10
- 12
- 14

More

20%
25%
30%
35%
40%
45%
50%

Percent of lane 2 strain from a truck traveling in lane 1

Number of Trucks
Distribution of Lane 2's Effect on Lane 1 Strain Reading

Number of Trucks

Percent of lane 1 strain from a truck traveling in lane 2
CSI Bridges Model

Defined Lanes on Meriden Bridge

Deformed Shape Under Moving Load
Conclusions

- There are three patterns that trucks commonly travel in which cause errors.
- Back-to-Back errors can be corrected by shortening the duration of the truck event.
- Side-by-Side can be corrected by recognizing both trucks, and subtracting the effect of strain they have on each other.
- Staggered in two lanes can be corrected similarly to Side-by-Side but considering the time difference.
- The BWIM method will have improved accuracy by correcting these errors, allowing for better estimations and more over weight trucks to be identified.