Selected impacts of riding quality on vehicle and cargo damage

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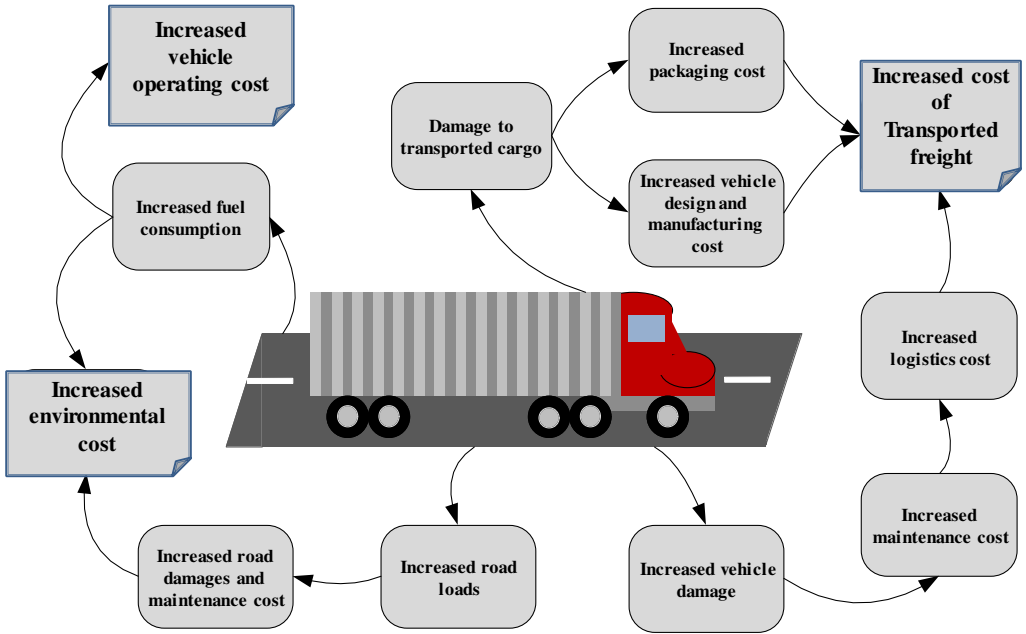
Background

- Road riding quality indicative of road condition
- Affects condition of vehicles and cargo
- Direct cost link between riding quality, VOC and cargo damage costs
- Can be alleviated through improved road condition management and maintenance
- Recent Caltrans study
  - riding quality and dynamic response of typical vehicles and cargo traveling on these routes
- Data supported existing riding quality / VOC models and dedicated riding quality / operating speed models

V-PI at UP

- Various studies and research projects focusing on V-PI
- Evaluation of effects on road, vehicle and cargo
- Public sector, private sector, research



Caltrans project background

Task 3
Road inventory

Task 4
Vehicle inventory

Task 5
Existing models and studies

Cal PMS

Cal WIM

CTA

CSFP

GMAP

San Joaquin

Cal-B/C

MIRIAM

CIRIS

SOL

Task 7
Truck simulation

Task 8 Field measurements

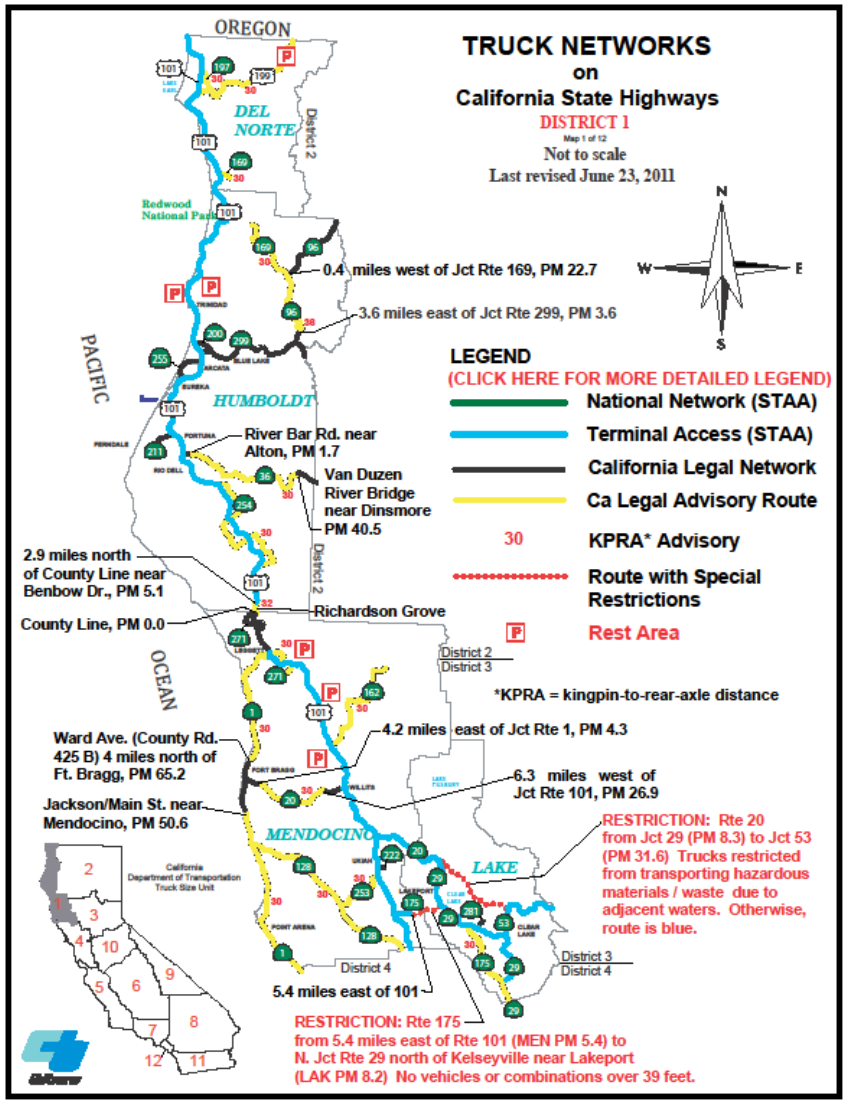
Logistics analysis

Economic models

Task 9 Map

Task 10
Relationships

Task 11
Environmental links



- PMS database with road numbers, profiles and riding quality
  - Routes identified, database containing actual road profiles and riding quality data available

District	Number of sections	Miles of sections
1	358	4 102.8
6	473	5 900.1
10	299	3 381.3
Total		**50934.0**

Process

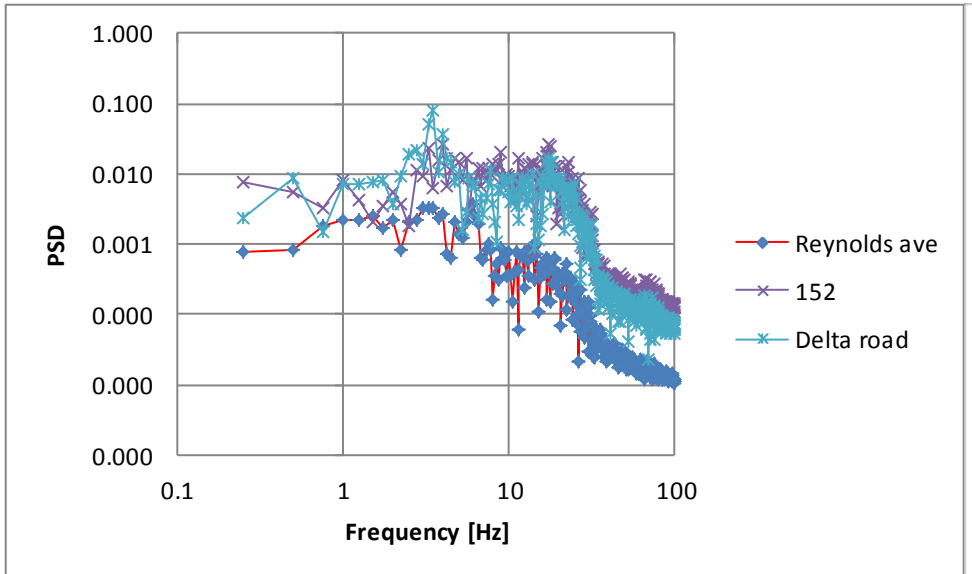
- Measure truck accelerations
- Identify dominant frequencies
- Vibrate crate of tomatoes in laboratory
- Determine stiffness / firmness of tomatoes in laboratory using σ/ε test
- Compare actual stresses to σ/ε test data to determine stress ratio during test
- Estimate percentage of damage

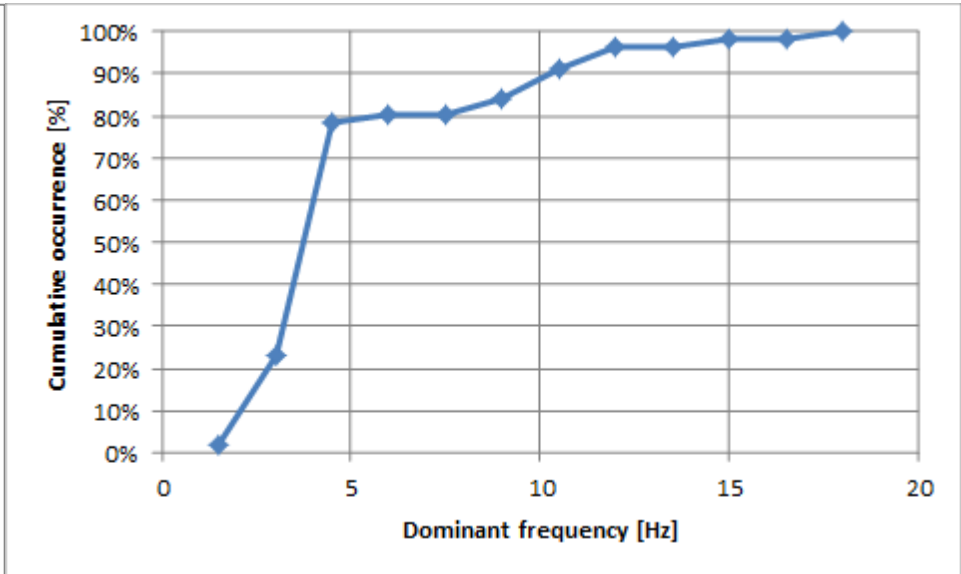
Field measurements

- Actual vibration accelerations
- Determine potential damage to tomatoes due to road conditions

Truck accelerations

- PSD analysis of accelerations
- Identify dominant frequencies
- Calculate bandwidth with highest PSD area - correlates with roughness
- Evaluate tomatoes at this frequency band





Mapping of parameters

Roughness

Tire loads; Emissions;
Vertical acceleration; Fuel consumption

Tire wear

Repair and maintenance

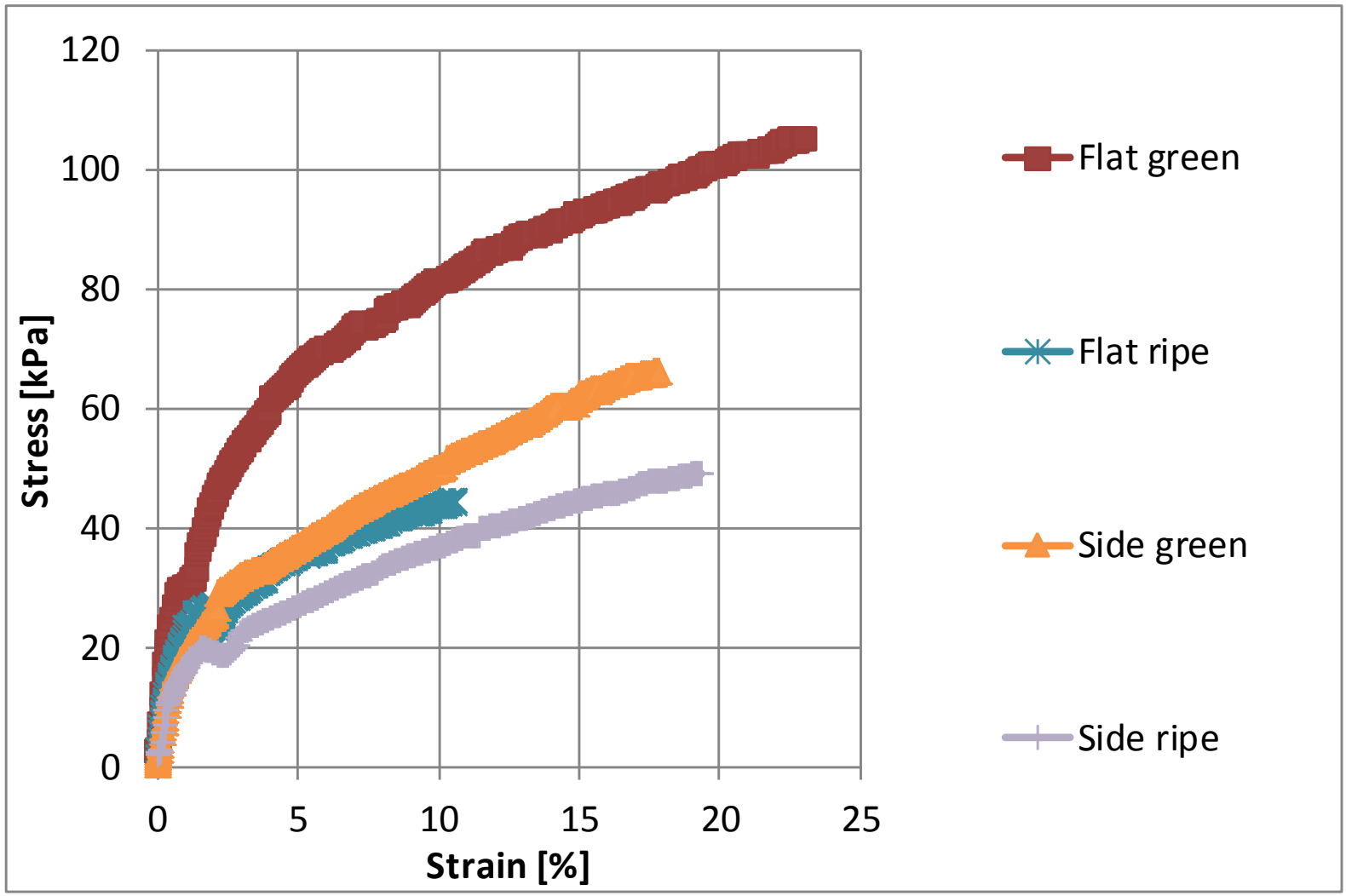
Sensors

- Acceleration sensors
  - Measures accelerations
  - Similar to sensors used on trucks
- Pressure mats
  - Measures contact σ
  - In-between layers of tomatoes
- Video
  - Keeps track of changes and progress

Test conditions

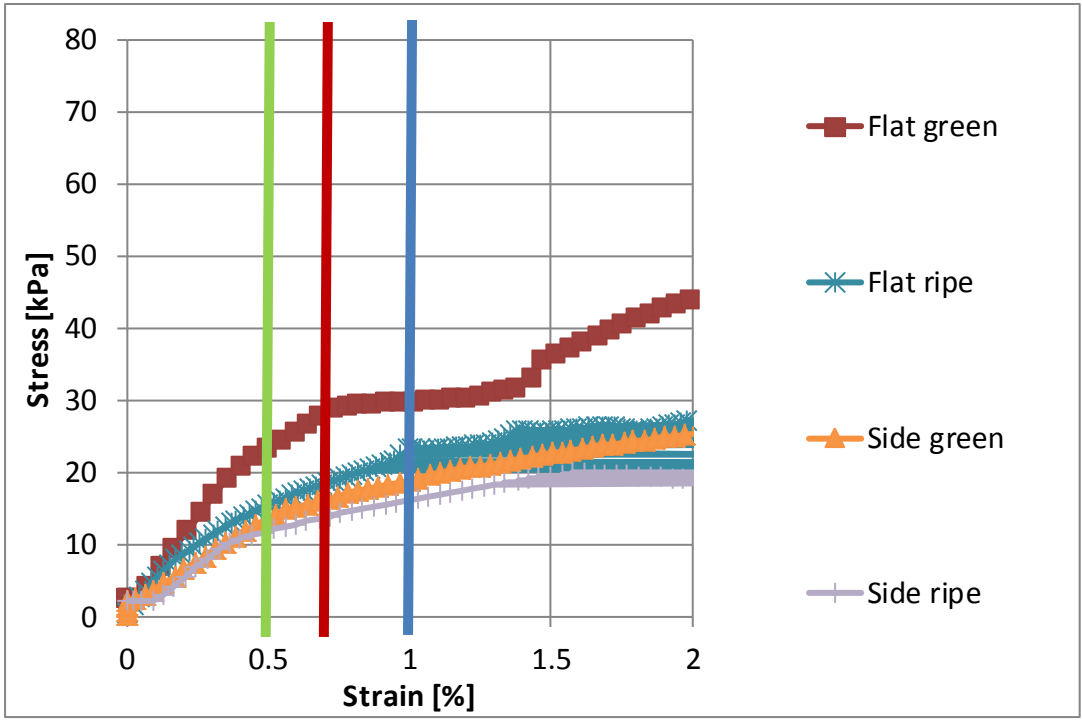
- Frequency
  - As per measured frequencies from trucks
- Duration
  - Short-term tests – around 20 seconds per test
- Location of measurement
  - Middle lower and middle upper level of tomato crate
  - One layer of tomatoes below bottom sensor
  - 2 layers of tomatoes on top of upper sensor

σ/ε relationship – simplified



σ/ε relationship – defined damage condition

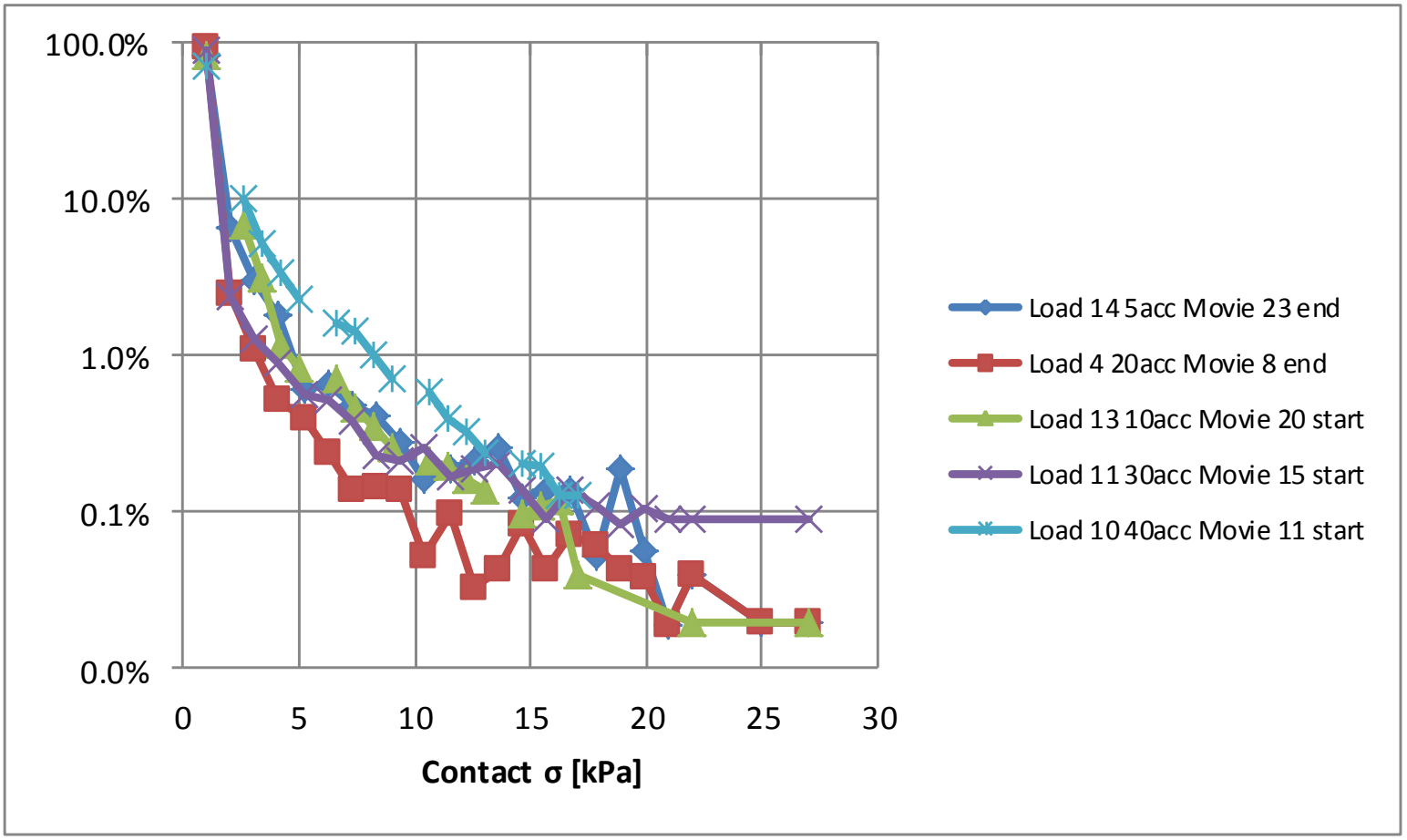
- Linear elastic part of σ/ε relationship
  - Flat green – 28 kPa
  - Flat ripe – 23 kPa
  - Side green – 13 kPa
  - Side ripe – 11 kPa



Damaged tomatoes after test

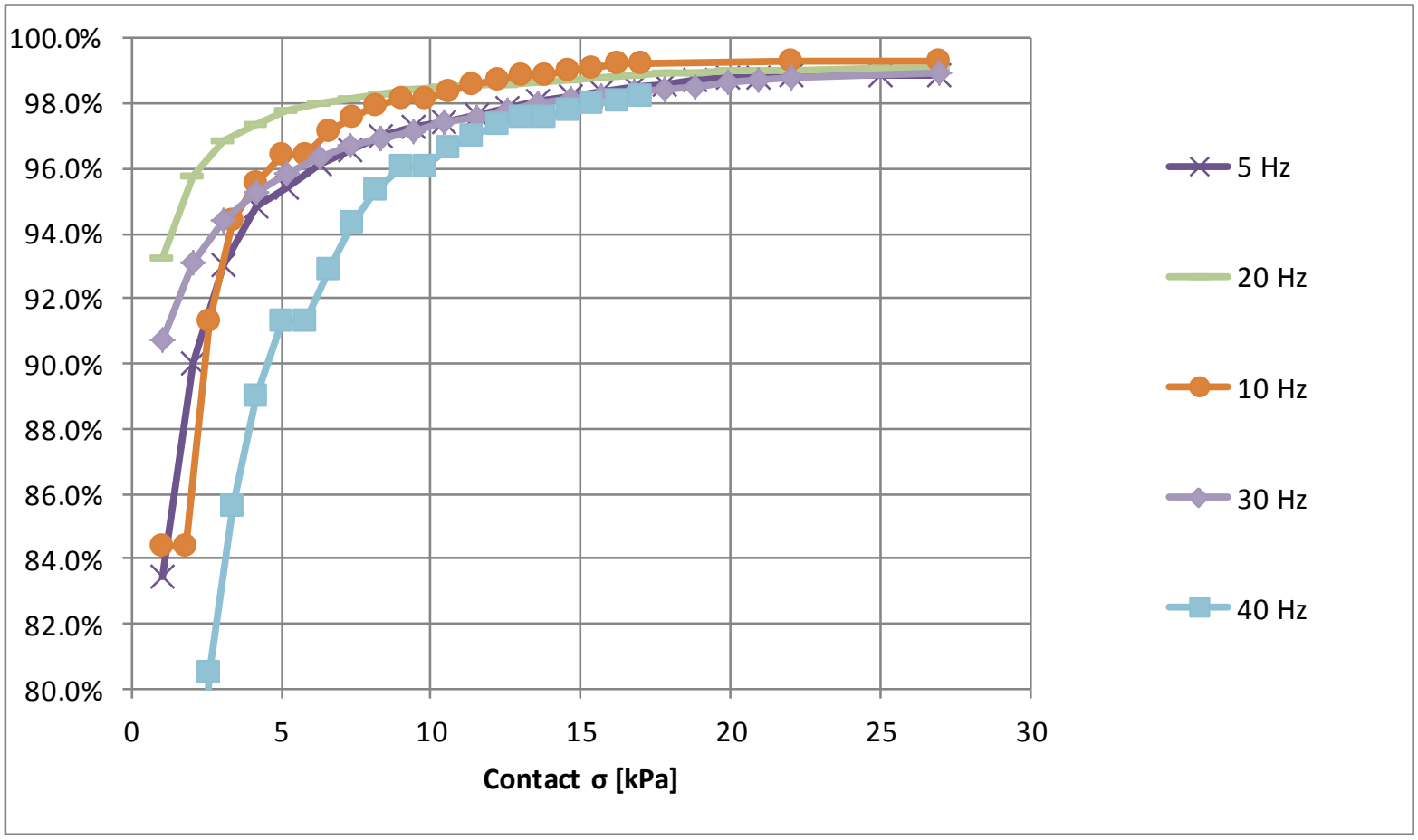
Measured contact stresses

- Typical contact σ histogram
- Majority of σ-values relatively low



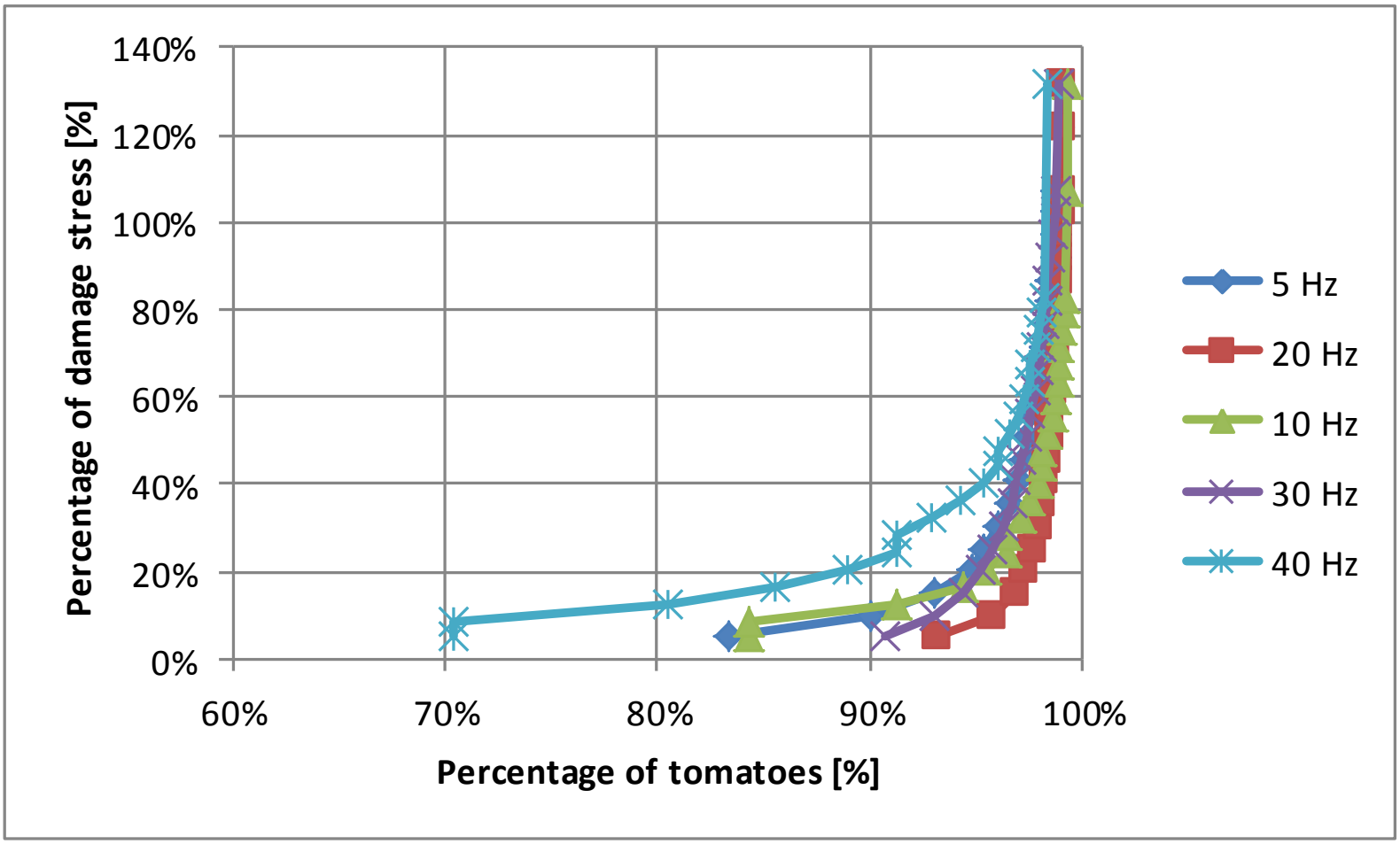
Measured contact stresses

- Cumulative contact σ distribution
- For 5 major frequencies tested



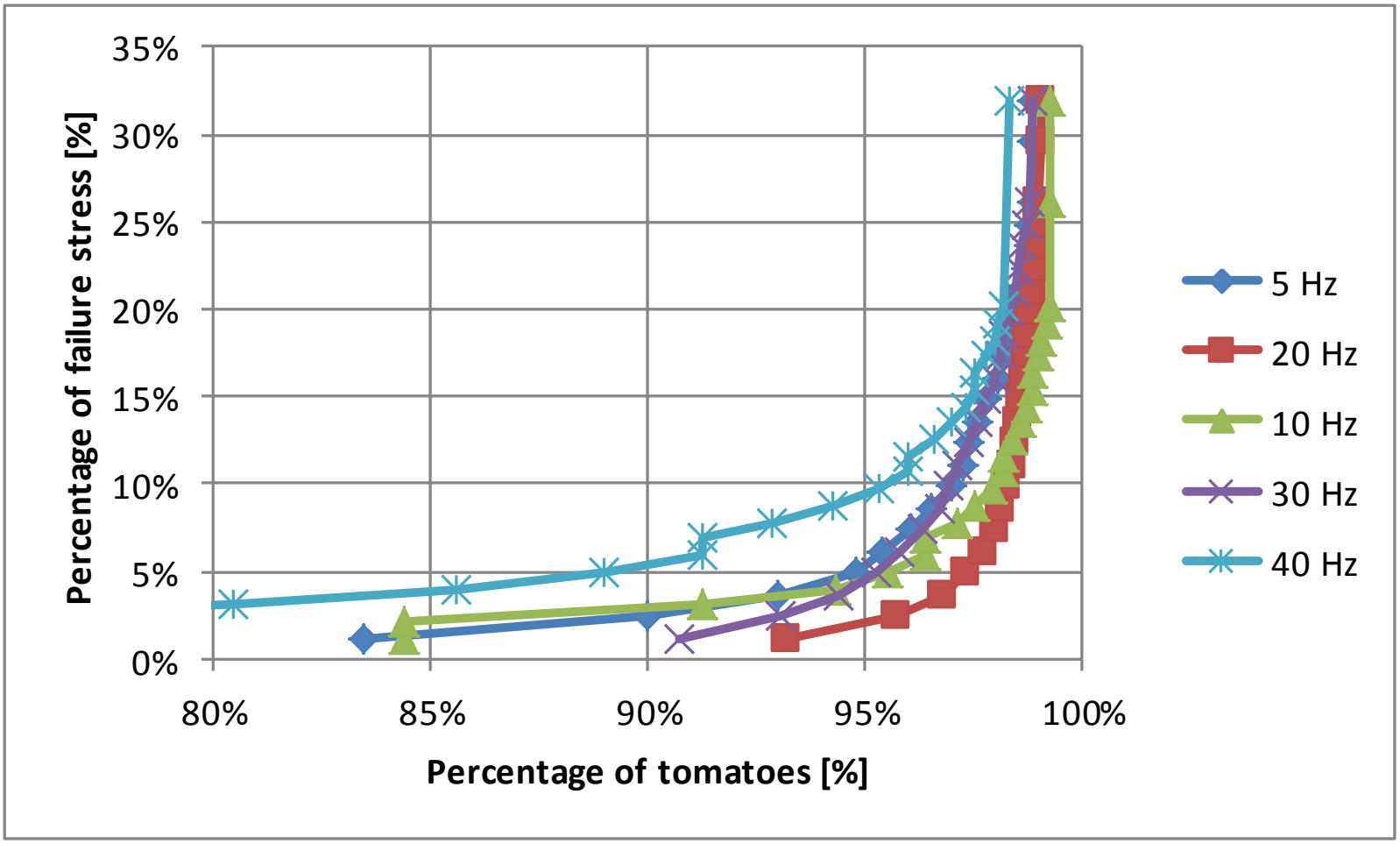
Measured contact stresses

- % of tomatoes at % of **damage** σ



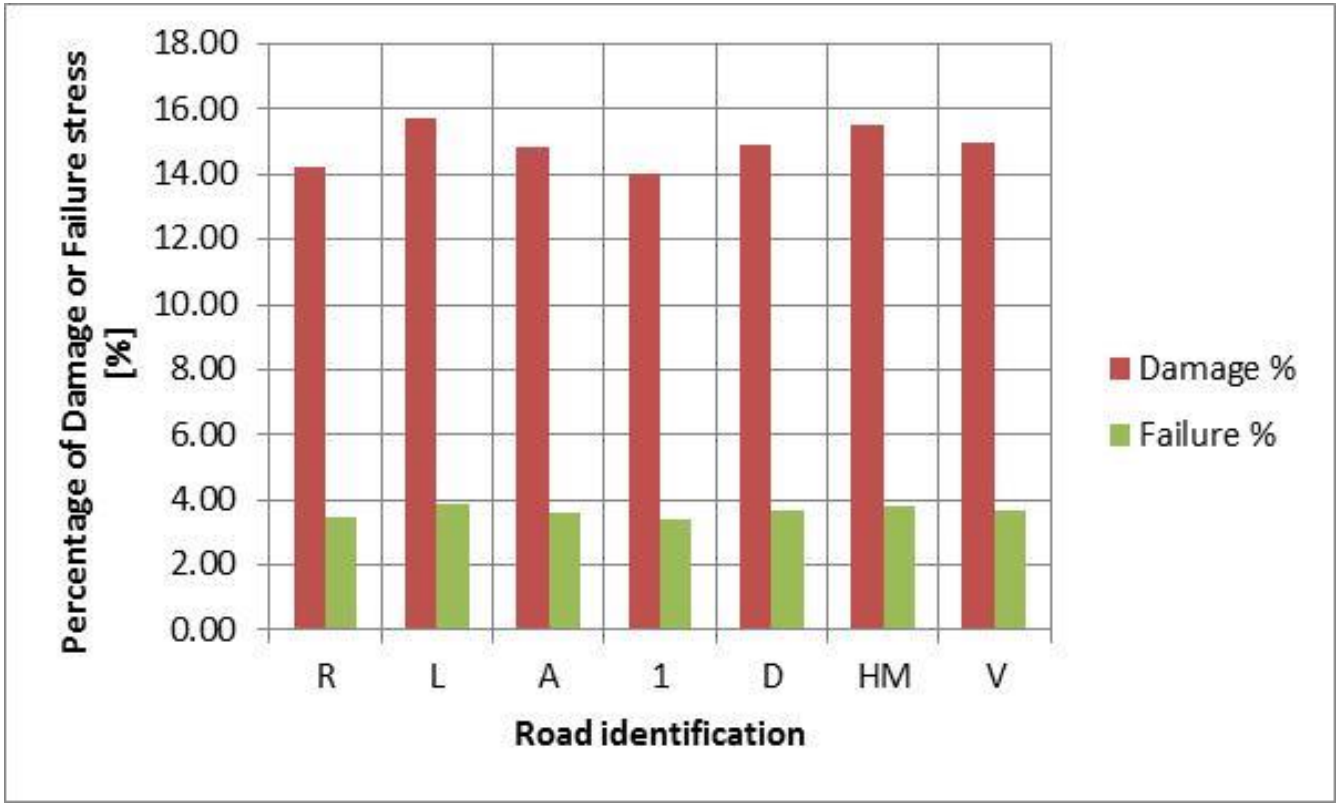
Measured contact stresses

- % of tomatoes at % of **failure** σ



Measured contact stresses

- % of tomatoes at 95% of damage or 95% of failure σ for different roads
- Similar analysis to be done for other locations



Limitations

- Range of tomato types
- Ripeness of tomato
- Speed effects
- Long duration trips
- Scaled model – differences on full truck – location of tomato etc.?
- Other types of fruit / vegetables
  - Avocado, peaches, etc.

V-PI Conclusions

- Road roughness data + appropriate models and relationships = **evaluate economic effect of road use**
- Use relationships (road roughness + various parameters) - select optimal routes where VOCs / damage are minimized – **Road users**
- Evaluate effect of different levels of construction and maintenance quality control on infrastructure condition + general transportation costs / infrastructure deterioration rates as affected by road roughness – **Road owners**

Continuation

- Actual on-board stress measurements in SA environment currently
- Relationships between stress conditions and riding quality / road condition

Acknowledgements

- Caltrans as project sponsor
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