Understanding Issues in Roadway Infrastructure and WPT Integration

CERV Pre-Conference Tutorial
February 8, 2015
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TODAY'S AGENDA

- Describe prevalent pavement types
- Examine issues related to integrating WPT with those pavements
  - From a civil engineering and sometimes agency perspective
- Technical/Engineering Issues
  - Impacts of WPT on different pavement structures
  - Location of WPT cells within pavement
  - Installation and safety of WPT
- Economic/Societal Issues
  - Extent and cost of roadway network
  - Where will the funding come from?

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Technical/ Engineering Issues

How can we install WPT in pavement structures?

What must pavements and WPT withstand?

PAVEMENT SURFACE COURSES

- Safety
- Traffic Loads
- Environmental Factors
  - Temperature extremes
  - Moisture variations
- Other Considerations
  - Noise
  - Smoothness
  - Economics – Initial and Life Cycle
  - Traffic Disruptions

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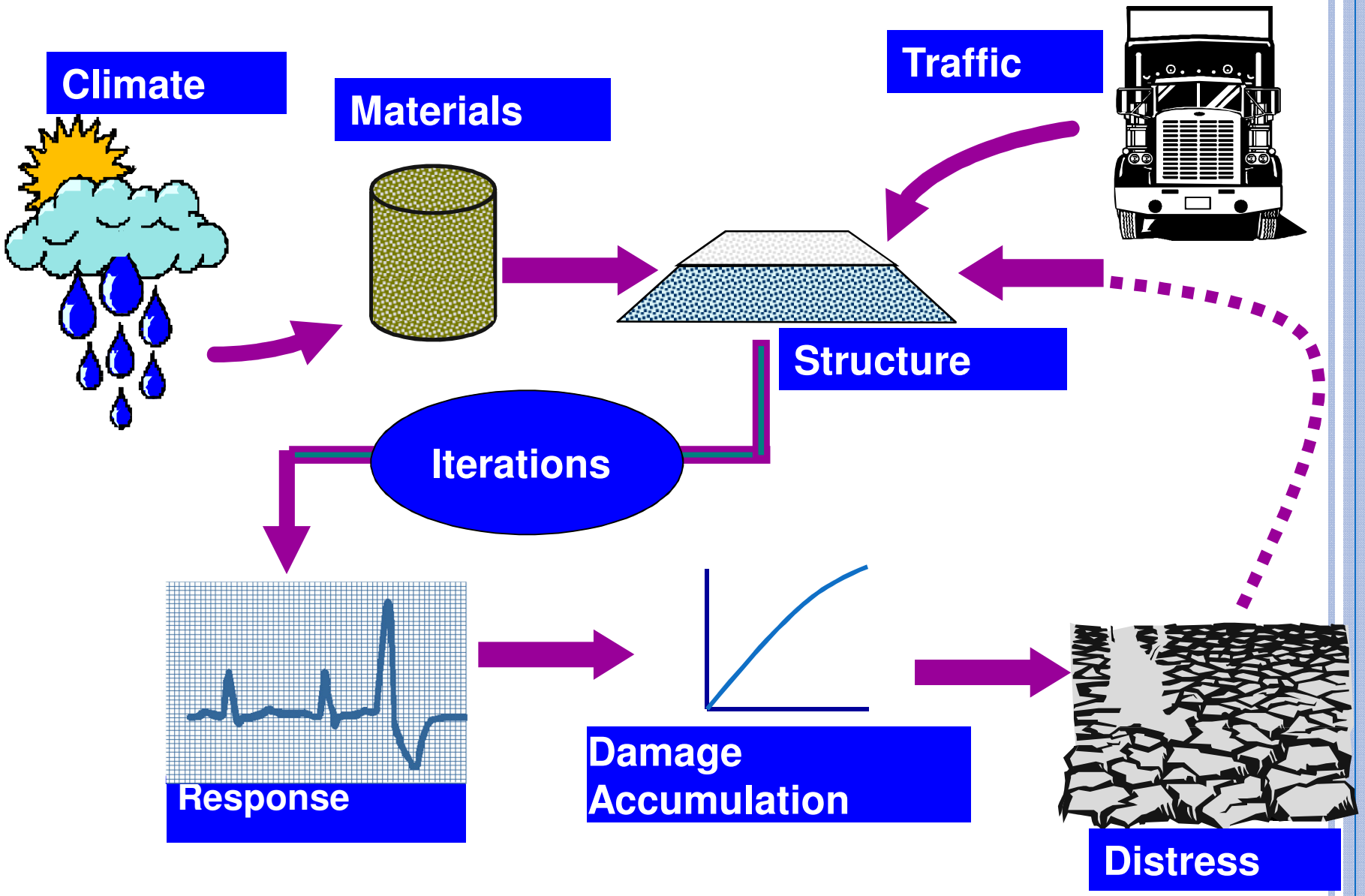
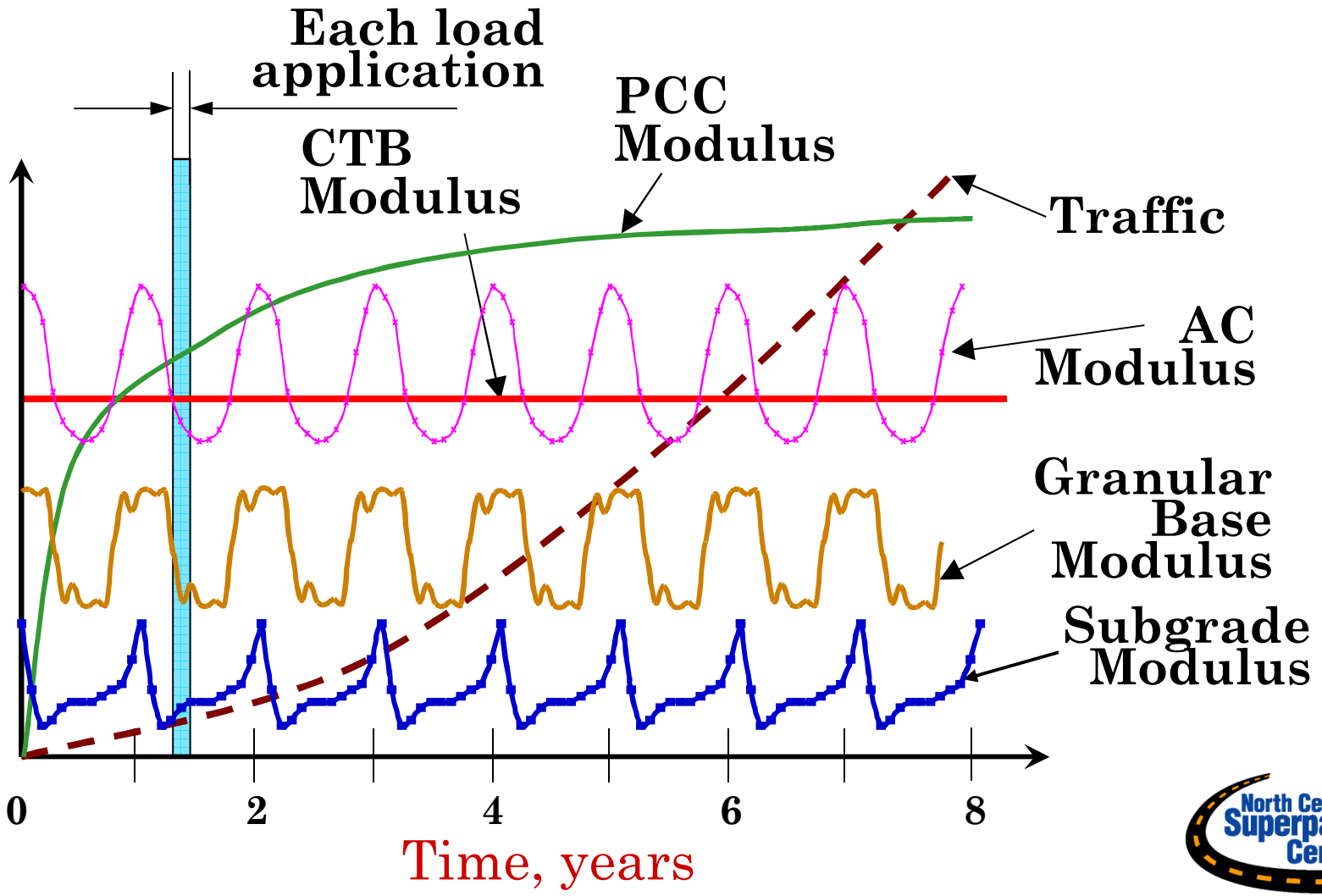
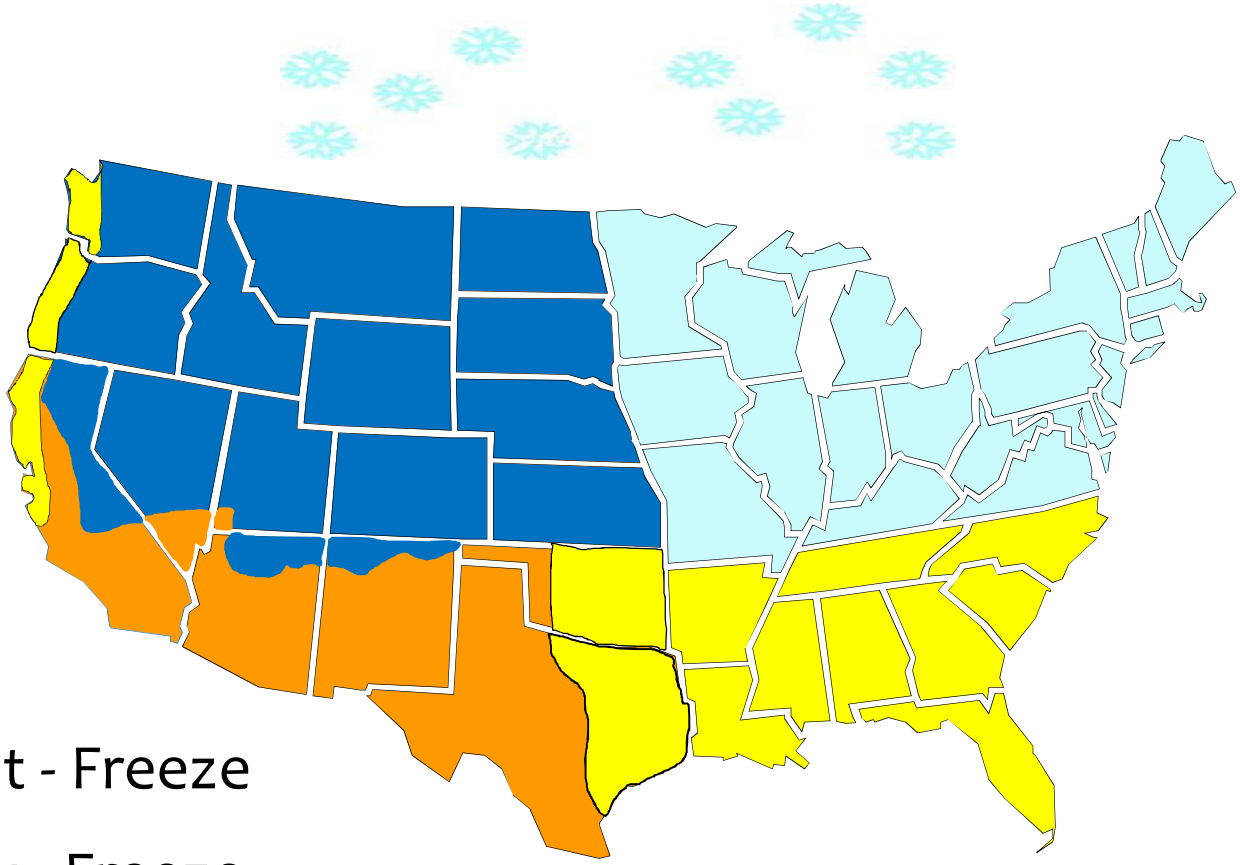
M-E Pavement Design Process



PAVEMENT PROPERTIES ARE NOT CONSTANT



Regional Climate Zones



Wet - Freeze

Dry - Freeze

Dry – No Freeze

Wet – No Freeze

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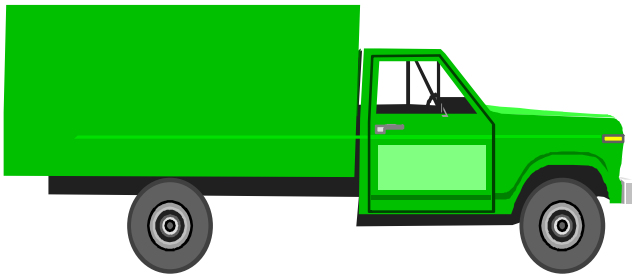
Traffic Loading

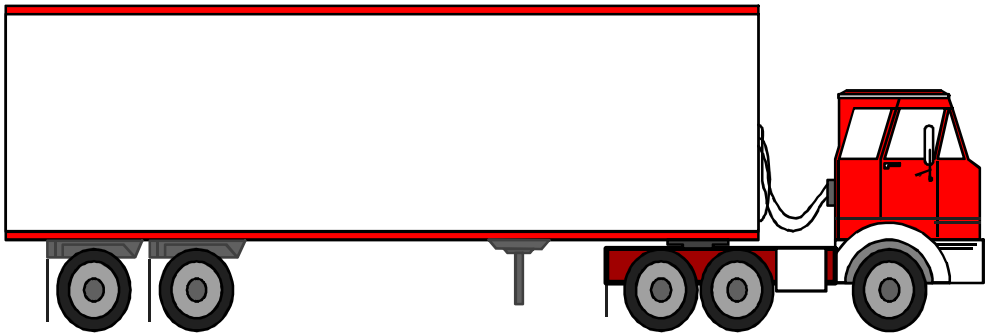


67 kN
15,000 lb
0.48 ESAL

+

27 kN
6,000 lb
0.01 ESAL

= 0.49 ESALs



151 kN
34,000 lb
1.10

+

151 kN
34,000 lb
1.10

+

54 kN
12,000 lb
0.19

= 2.39 ESALs

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Basic Pavement Types

- Unbound
- Flexible
  - Asphalt
- Rigid
  - Concrete
- Composite

Primary difference is in how loads are distributed to subgrade.

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Flexible Pavements

- Made up of multiple, fairly thin layers
- Each layer distributes load over larger area of layer below
- Pavement deflects under load
- Properties and behavior vary with time and temperature
- Typically asphalt
- Easily and routinely recycled
- Typical lives 15-20 years (to first rehab)

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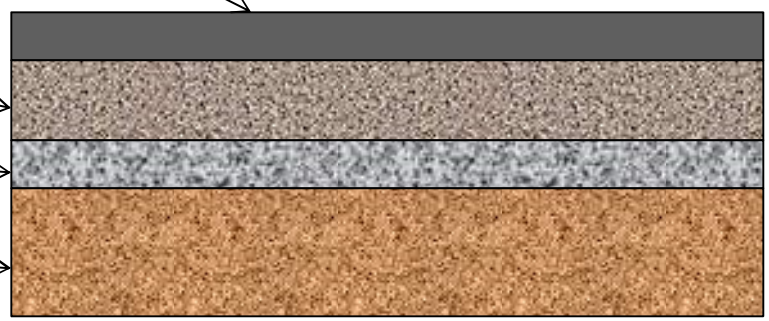
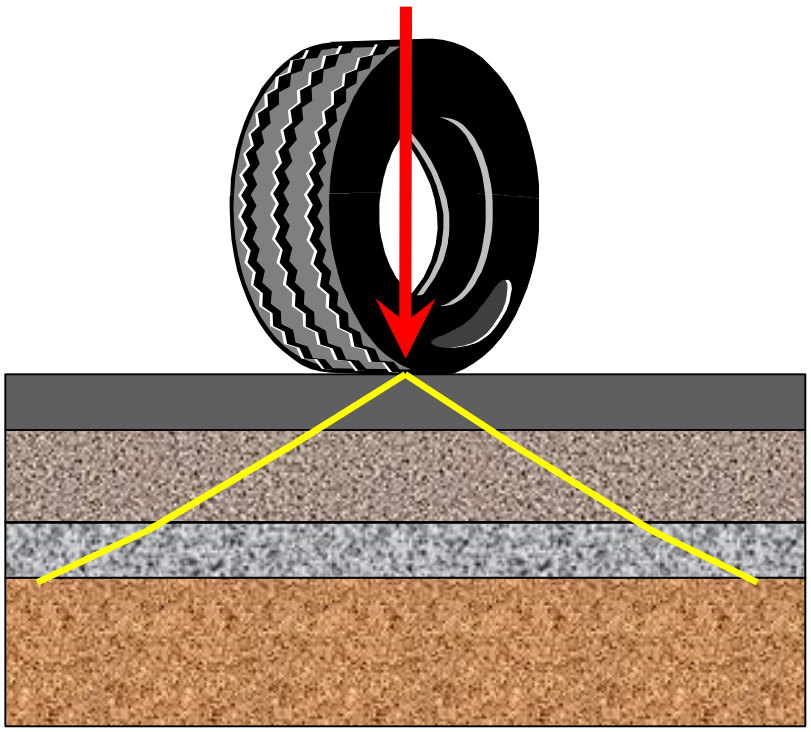
TYPICAL FLEXIBLE PAVEMENT LAYERS

- Wearing course or surface
- *Base course*
- *Subbase*
- Subgrade
  - Compacted or Stabilized
  - Natural



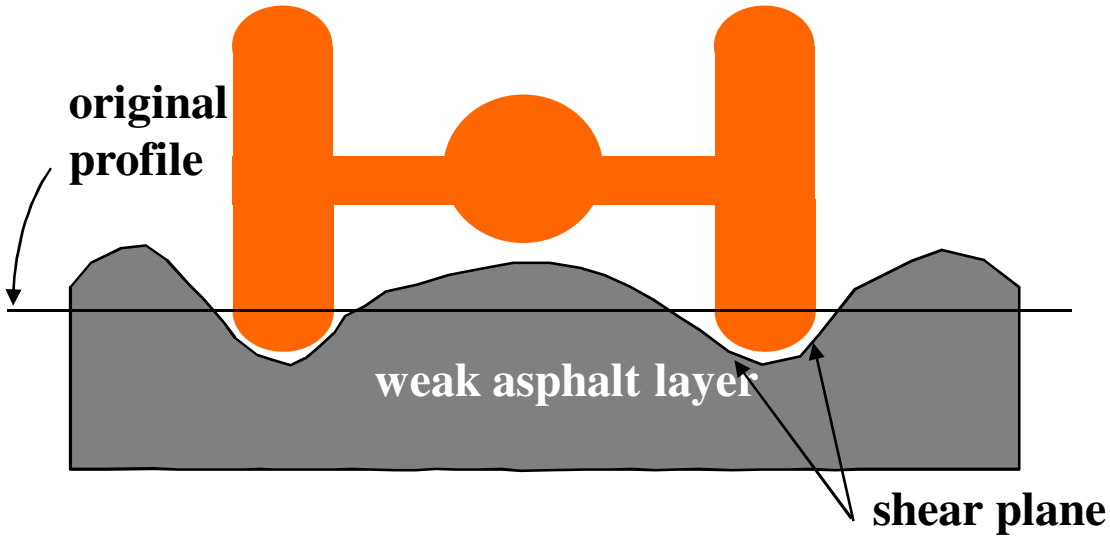
Flexible Pavements



- Pavement layers bend
- Each layer spreads load to next layer
- Loads over a smaller area of subgrade

Surface Course Distress

- Rutting mainly controlled by choice of materials and design of surface mixes
  - Highly related to temperature
- Surfaces also must be resistant to cracking



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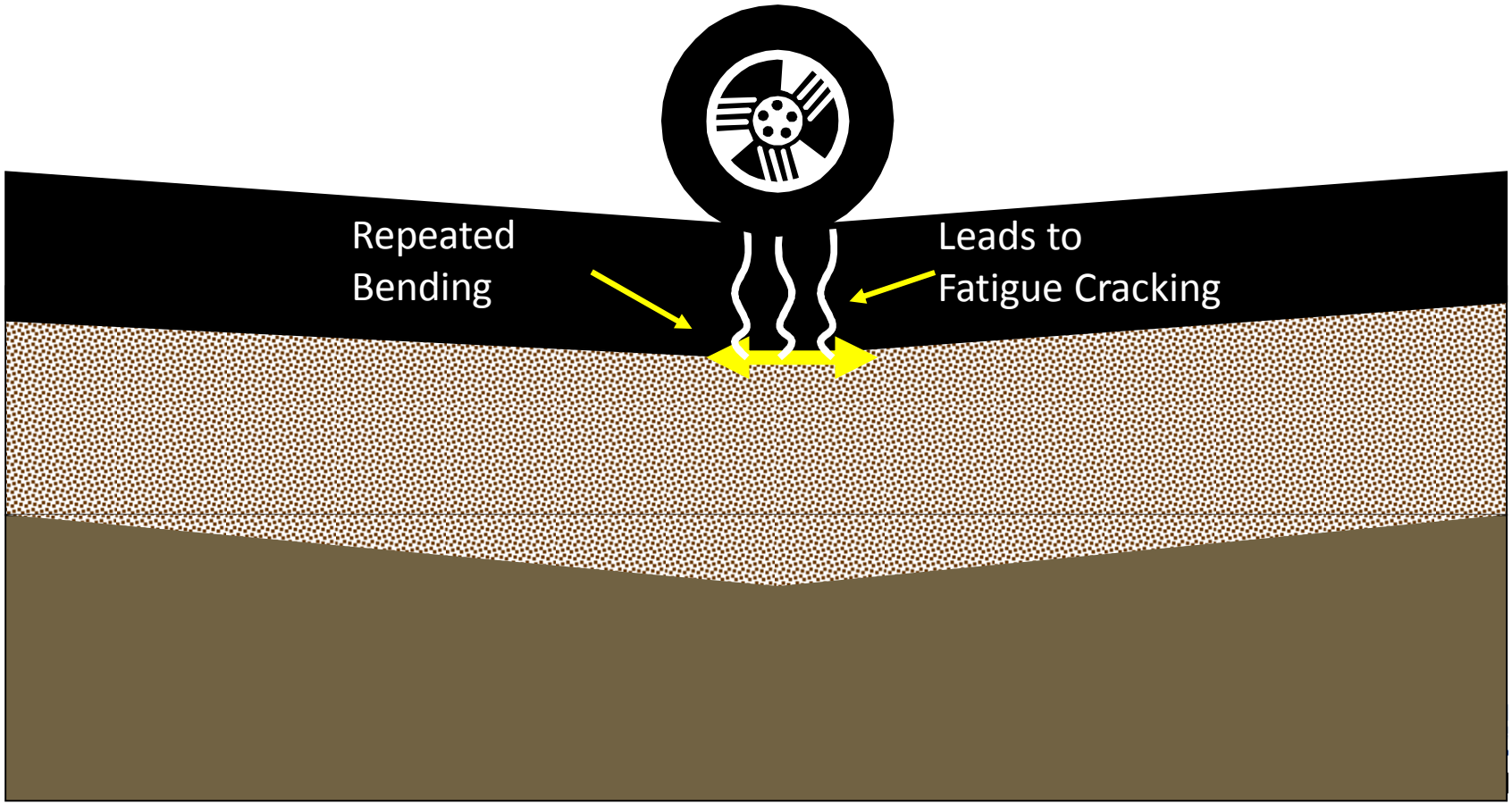
Fatigue Cracking



Rigid Pavements

- Generally stiff – may have reinforcing steel
- Distributes loads over relatively large area of subgrade
- Contract and expand with changes in temperature and moisture
- Portland cement concrete
- Can be recycled, but less common
- Service lives 20-40 years (to first major rehab)

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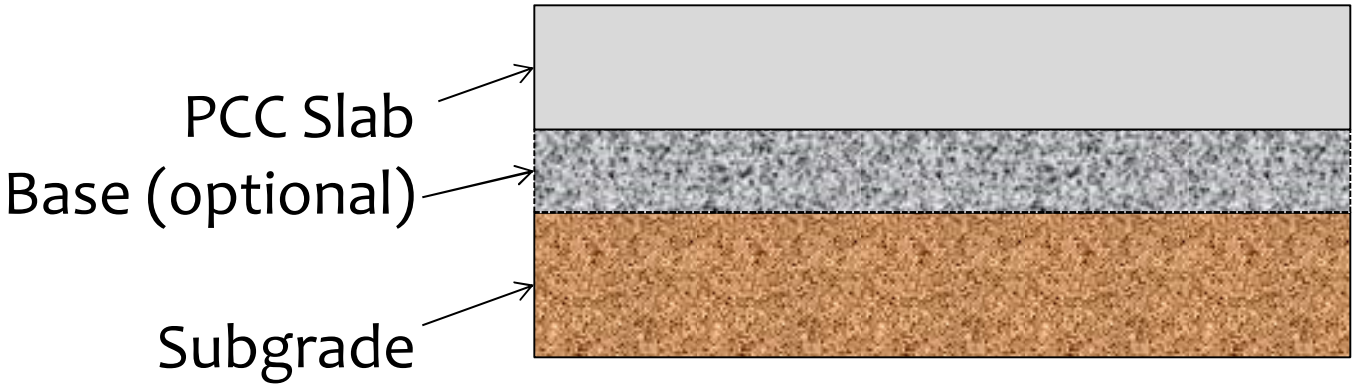
Typical Rigid Pavement Layers



- High volume traffic lanes
- Freeway to freeway connections
- Exit ramps with heavy traffic

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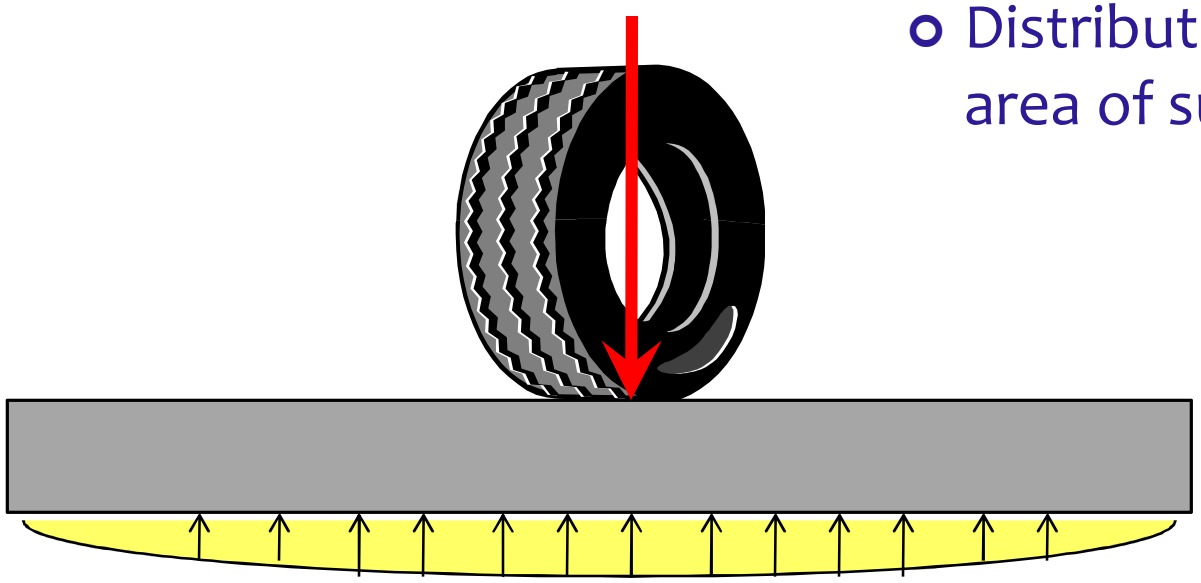
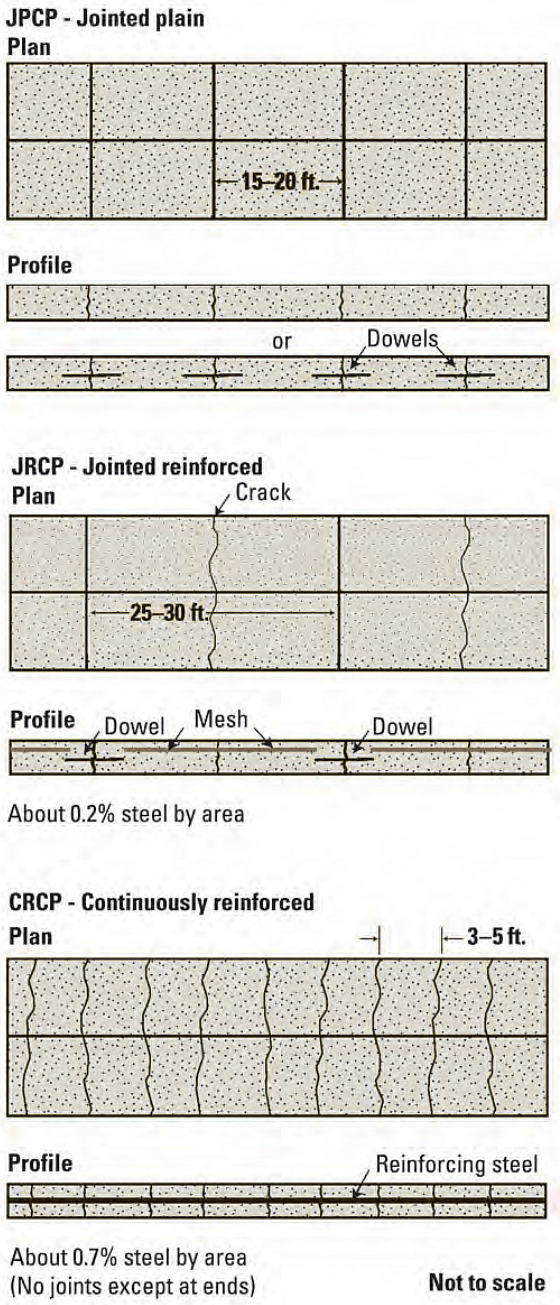
RIGID PAVEMENTS



- Stiff pavement layer
- Little bending
- Distributes load over larger area of subgrade

Concrete Pavement Types



Jointed Plain Concrete Pavement (joints: with dowels or without)

Jointed Reinforced Concrete Pavement (with dowels and mesh)

Continuously Reinforced Concrete Pavement (no joints)

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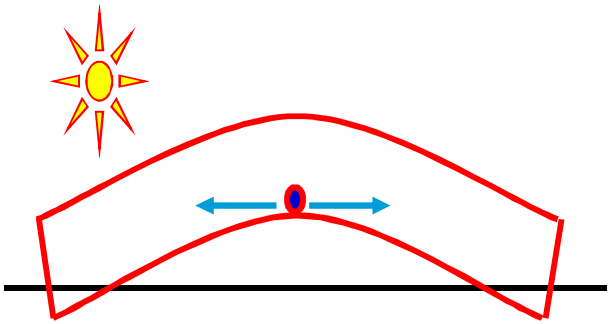
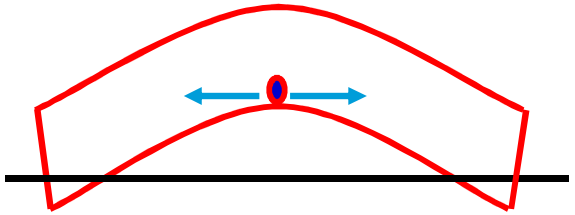
Concrete Slab Temperature and Moisture Gradients

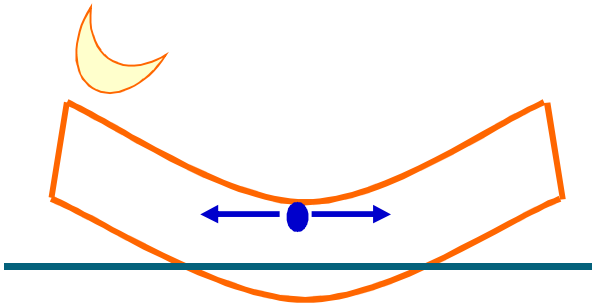
Curling



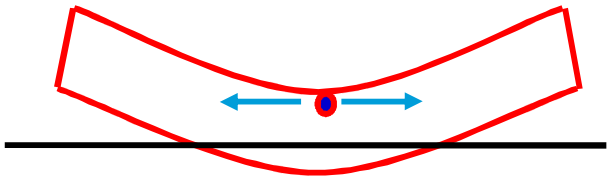
Warping

Slab wetter on top





Slab dryer on top



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Steel in Concrete Pavement

- Depending on type of concrete pavement, there can be significant amounts of steel.

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Composite Pavements

- Commonly asphalt over concrete
  - Sometimes concrete over asphalt (whitetopping) or over concrete
- Less flexing of pavement surface
- Increased risk of:
  - Rutting of asphalt overlay at high temperatures
  - Cracking, if concrete is cracked or jointed

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Surface Types

Public Roads

- Unpaved 1,393,651 miles
- Asphalt 768,961 miles
- Concrete 50,369 miles
- Composite 98,758 miles

Urban Interstates

- Unpaved – none
- Asphalt – 6,912 miles
- Concrete – 4,534 miles
- Composite – 4,246

We will have to be able to install in asphalt, concrete and composite pavements. Very little new roadway construction – will have to be able to "retrofit"

WPT Installation

- Depending on how WPT is encased and where it must be placed:
  - May need to be able to accommodate deformation of pavement
  - May need to withstand high, dynamic traffic loads
  - Likely will need to withstand environmental loads (variations in temperature and moisture)

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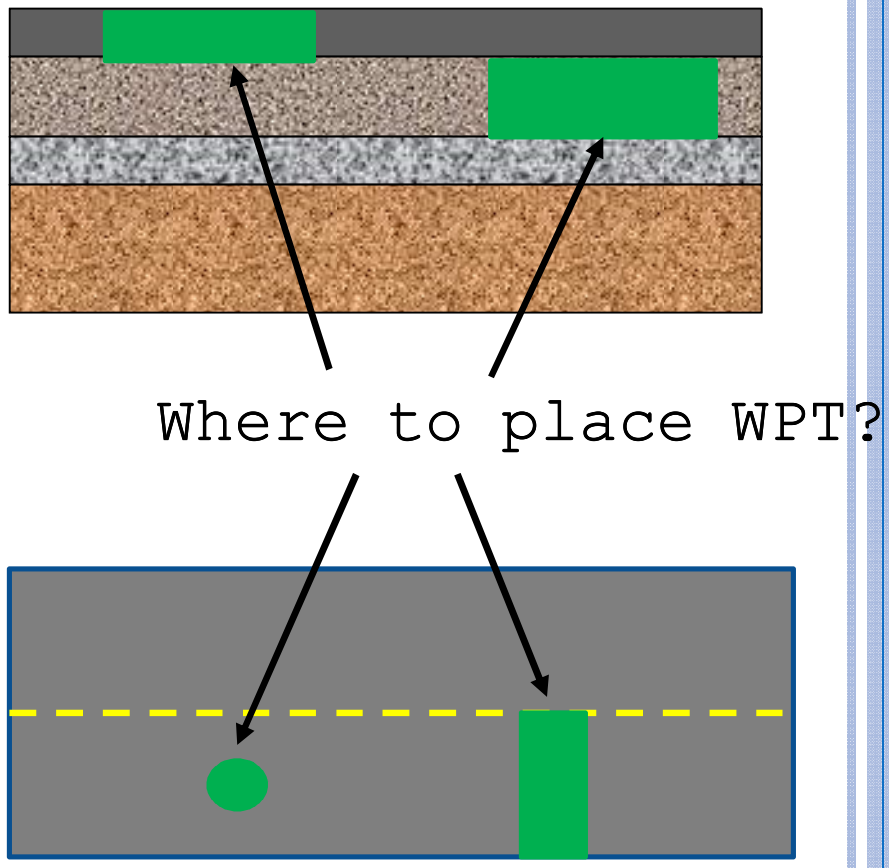
LOCATION OF WPT CELLS

- Depth in pavement?
  - Deeper is better
- Center of lane or full width?
  - Full width avoids alignment problems
  - Automated vehicles may help
- Shape of cell/enclosure?
- Longitudinal spacing?
  - Affects costs and risk



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How Can We Install WPT in Pavements?

- Put in enclosure (concrete box or vault)?
- Anchor steel plates into pavement?
- Square versus round?
- Lessons learned from Weigh in Motion systems?

CONCERNS ABOUT WPT IMPACTS ON PAVEMENT

- Must maintain safe, durable roadways (adequate friction and smoothness)
- WPT cell must remain in place while pavement deforms
- WPT installation may increase cracking (stress concentrations at corners)
- Heat generated by WPT may cause increased pavement deformation
- Effects of WPT on steel reinforcing or steel slag aggregate (and vice versa)
- How long will cells perform?

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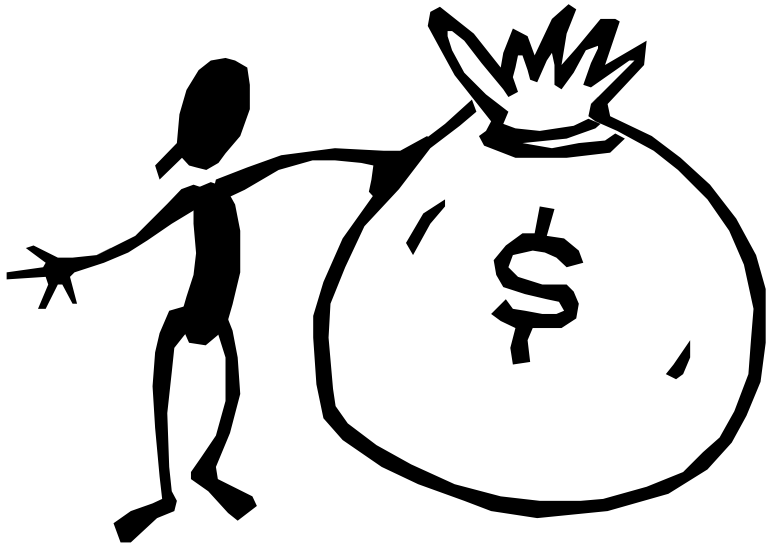
Economic/Societal Issues

WPT Network Needs

- WPT network must be large enough to justify costs of vehicles and infrastructure



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EXTENT OF NETWORK

- National Highway System
  - Network of roads critical to economy, defense and mobility
    - Interstates, other principal arterials, intermodal connectors, strategic corridors (for defense, emergencies)
  - 223, 668 miles (4% of US roads)
  - Over 780,000 lane miles
  - 58% of traffic
  - 90% of US population lives within 5 mi of the network.

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HIGH TRAFFIC URBAN AREAS?

- May be better targets
- Lots of commuter traffic
- Smaller network mileage to construct
- Less distance from electrified roadway to home or work location

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CRUMBLING INFRASTRUCTURE

- American Society of Civil Engineers 2013 Report Card rates:
- Roadway conditions – D
  - Congestion and condition problems
  - Federal, state and local budgets investing $91 billion per year
  - FHWA estimates funding needs at $170 billion annually
- Bridges – C+
  - One in nine bridges rated structurally deficient
- President's FY2016 budget calls for six-year, $478 billion transportation reauthorization program

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HIGHWAY TRUST FUND

- Federal funds for highway construction
  - Many projects 80% Federal, 20% state or local
- Funds come from Federal gas tax of 18.3 cents per gallon of gasoline and 24.3 cents per gallon diesel.
  - Last increase in 1993
  - Plus 0.1 cents per mile for mass transit
- Nearing insolvency → delayed construction

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Economic Climate

- Reduced mileage and more efficient vehicles reduce Highway Trust Fund income
- Electric vehicles further reduce income
- Under these conditions, hard to justify increased costs to build roads
- Must convince state agencies, FHWA of value of WPT infrastructure

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REALISTICALLY

- WPT is a great idea with many benefits
- But, it will be a hard cell in cash-strapped highway agencies
- How can we overcome the reluctance of agencies to implement the technology?

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