Broad approaches to addressing pavement resilience
Southern Plains Transportation Center

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The importance of what we’re talking about today...
[resilience] and [adaptation] defined

[resilience] “the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions”
  - FHWA Order 5520 (2014)

[adaptation] “Adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative effects.”
  - FHWA Order 5520 (2014)
[adaptation]

• So we need to **adapt** to changing conditions
  • Temperature swings [record highs/lows and rapid changes]
  • Wild fires
  • Hurricanes
  • Major non-tropical precipitation events
  • Tornados
  • Sea level rise
  • Drought
The need for resilience

U.S. 2018 Billion-Dollar Weather and Climate Disasters

Western Wildfires, California Firestorm Summer–Fall 2018
Rockies and Plains Hail Storms August 6–7
Southwest/Southern Plains Drought 2018
Colorado Hail Storm June 18–19
Texas Hail Storm June 6
Southern and Eastern Tornadoes and Severe Weather April 13–16
Hurricane Michael October 10–11

Central and Northeast Severe Weather May 1–4
Northeastern and Eastern Winter Storm January 3–5
Hurricane Florence September 13–16
Central and Northeast Severe Weather May 13–15
Northeast Winter Storm March 1–3
Central and Eastern Tornadoes and Severe Weather July 19–22

This map denotes the approximate location for each of the 14 separate billion-dollar weather and climate disasters that impacted the United States during 2018.

The need for resilience

The need for resilience

U.S. 2020 Billion-Dollar Weather and Climate Disasters

Graphic: NOAA 2021

https://www.ncdc.noaa.gov/billions/

This map denotes the approximate location for each of the 22 separate billion-dollar weather and climate disasters that impacted the United States during 2020.
Difference between sustainability and resilience

“...resilience concerns the capacity of an urban system – including its natural, built, social and economic elements – to manage change, learn from difficult situations and be in a position to rebound after experiencing significant stress or shock, while sustainability questions whether or not certain aspects of our daily activities, and the systems in which they operate, can be continued indefinitely into the future, again from a social, economic, and environmental perspective.”

- Newton and Doherty (2014)
Resilience is *not* sustainability

**Sustainable + Resilient Practices or Attributes**
- Use of recycled materials
- Cold Recycled Asphalt
- Asphalt mix and plant optimization

**Sustainable Practices or Attributes**
- Warm Mix Asphalt (low emissions + increase in haul distance)
- Porous pavement systems (stormwater management + nuisance flooding)
- Perpetual Pavement Design
- Deep reconstruction of pavement (increase deep layer moduli)
- Rapid construction
- Ability to adjust pavement design to climate / climatic events to extend pavement life

**Resilient Practices or Attributes That Are Not Sustainable**
- Use of novel materials with unknown environmental or safety risks
- Use of climate adaptable materials when the social and environmental benefits do not outweigh the costs (e.g., use of polymer modified binders for low volume roads)
- Over-designing for low-risk catastrophic events

*Figure 1. Venn Diagram of Sustainable, Resilient, and Resilient + Sustainable Practices and Attributes for Asphalt Pavements*

What effect might this have on pavements?

• Flood inundation and rising groundwater tables leading to premature pavement deterioration
• Extreme temperatures lead to rutting, cracking, buckling
• Destruction of materials production plants due to a climate event/disruption
• Rerouting of trucks or demolition removal damaging pavements after the disruption [cascading event]
Example Tornado Cascading Effect

Potentially vulnerable roads

Vegetation Burn Pit

Path of the Beauregard EF-4 Tornado

Tornado Path, 3/3/2019
To be resilient we need to...

• Understand our vulnerabilities
  • Where are the weak points in your asset or system?
  • How might these be impacted by an event like a natural disaster?

• Assess the risk associated with those vulnerabilities
  • What level of risk can you assume?
  • What are the consequences?

• Adapt
  • Use tools to adapt the system from its original design to account for the resilient needs
...so what do we do?
Hardening

**WHAT IS IT?** This is when we strengthen, rebuild, or protect our pavement to withstand any probable event the pavement might subjected to, eliminating or nearly eliminating disruption potential.

Adaptation through modification

**WHAT IS IT?** This is when we make adjustments to our pavement as it is, perhaps not completely hardening the system, but giving it a higher probability of surviving the disruption.

Accepting and planning

**WHAT IS IT?** This is when we accept that we will have a complete failure, account for the risk, and plan for funds to be made available to address the problem.

Abandonment

**WHAT IS IT?** This is when we take an honest look at the situation and decide that it makes more financial sense to completely abandon the route.
Hardening

• We need to *strengthen* the system to withstand flooding, wave action, rerouting of traffic, cascading events, etc.

• This may take many forms:
  • Build protective structures [such as levees]
  • Elevate the system
  • Build perpetual asphalt pavement systems
  • Stabilize the base of the pavement
Example: Iowa [flooding]

• Experienced significant flooding of the Missouri River
  • First in March, 2019
  • A second flood event in May, 2019
• Caused by rapid snowmelt and heavy rainfall
• This was the second 500-year flood in 10 years

Credit: Bill Rosener formerly of Asphalt Pavement Association of Iowa and Scott Schram of Iowa DOT
What happened | How was it addressed?

- Undermining beneath the shoulders and in some cases the pavement structure itself
- Iowa DOT noted that road closure = $200,000 / day in user costs
  - Needed to open ASAP
- 2011 rigid concrete section faired well in first 2019 flood, so alternate design/build reflected that section
  - Flexible section designed to be structural equivalent
  - Used PerRoad perpetual pavement design software to determine HMA thickness
Adaptation through modification
Adaptation through modification

• We may not be able to afford reconstructing or building new pavements / protective structures that are hardened, but we can make changes help withstand disruptions

• This may take many forms:
  • Use of climate adaptable materials in future maintenance treatments
  • Utilization of Natural or Nature Based Features (NNBF) along the route
  • Innovative site specific additions to slow/prevent future deterioration [e.g., drainage addition]
Example: Back to Iowa!

- Undermining became an obvious challenge
- This was despite the fact that there were guards in place [rightmost picture]

Credit: Bill Rosener, Asphalt Pavement Association of Iowa
• To prevent future issues, contractor paved an extra shoulder width
• Asphalt wedge also placed over erosion mat to help ensure it stays in place
• Underdrains installed at edge of mainline [note: Not at edge of shoulder]
Accepting and planning
Accepting and planning

• The most fiscally responsible thing to do for a given route may be to accept the risk, knowing that failure may be imminent, and plan for recovery

• This may take many forms:
  • Understanding routes risk and prioritizing them in accordance with appropriate resilient approaches
  • Developing a coordinated plan within the agency / industry regarding details of a response – a process.
  • Putting in place rapid contracting options for rapid response
Example: Alaska

• Alaska experiences many extremes...
  • Temperature
  • Water [Snow & Flooding]
  • Earthquakes

• In 2018 Alaska was impacted by a Magnitude 7.0 earthquake
Example: Alaska

- Response time was only 4-days – repairs within hours
- DOT was writing contract as the contractors worked
- Time + Materials based on normal times/materials data

Credit: Amanda Gilliland, The Transtec Group | Mahear Abou Eid, Alaska DOT | Photos: Knik Construction
Abandonment
Abandonment

- The most fiscally responsible thing abandon the route all together
- This may take many forms:
  - Complete abandonment, ultimately forcing the community to relocate
  - Abandonment of the route and re-routing around the area of disruption
Abandonment

• Sea Level Rise puts communities at risk... When do they move?
Keys to building resilience...

- **Partner** – Agencies and industry need to build partnerships
  - Communication and trust before, during, and after a disruption is crucial

- **Plan** - Come up with solutions *now* for how we adapt and respond
  - Perform a network *vulnerability study*
  - For various routes, determine the best adaptation “philosophy” to use
  - Build “resilience thinking” into maintenance and rehabilitation schedules
  - Identify alternative routes if an asset is compromised
  - Consider rapid contracting options
  - Consider how we might address materials production facility resilience
Keys to building resilience...

• Think about the **tools** we **already have**...

<table>
<thead>
<tr>
<th>Tool</th>
<th>Application</th>
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<tbody>
<tr>
<td>Rapid Construction</td>
<td>Construction techniques that can be used to rapidly get the system moving again [e.g., Warm Mix Asphalt]</td>
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<tr>
<td>Pavement Design</td>
<td>Use existing design tools and pavement systems that resist distress [e.g., Perpetual Pavement]</td>
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<tr>
<td>Climate adaptable materials</td>
<td>Materials designed to handle extreme temperatures</td>
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<tr>
<td>Maintenance Schedules</td>
<td>Leverage the existing maintenance schedule to thicken the structure and/or incorporate new materials</td>
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<td>Porous pavement</td>
<td>Manage stormwater</td>
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<td>Recycling</td>
<td>Key when considering supply chain disruption during recovery</td>
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<tr>
<td>Deep reconstruction with Full Depth Reclamation</td>
<td>Cost effective way to strengthen the pavement base with an asphalt overlay</td>
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What do we need?

• **Funding**
  - Funding to build resilience into the system
  - Funding for emergency response + resilient rebuilding

• **Guidance**
  - Best practices, methods for building resilience into the system

• **Research**
  - Incorporating climate models into design
  - Understanding “new” types of failure so we can design around them
  - Development of new techniques/technologies to help adapt
  - Building resilience into decision making (LCCA or LCA?)
Want to learn more?


Download here: https://member.asphaltpavement.org/Shop/Product-Catalog/Product-Details?productid=%7b6399F00E-2392-EB11-B1AC-000D3A9A6645%7d

• Forthcoming: NCAT Report 21-02 “Asphalt Pavement: A Critically Important Aspect of Infrastructure Resiliency”

Download when available at www.ncat.us
Questions?

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