Innovative Recycling Technology to Achieve Resource Conservation

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OUTLINE OF PRESENTATION

• CPATT Background
• Key Sustainability Issues
• Flooding Impacts on Pavement Infrastructure
• Lessons Learned
CPATT BACKGROUND

1. CPATT’s initiative involves an integrated program of field and laboratory research.
2. Focus on emerging and innovative technologies.
4. Train and educate next generation.
5. Sustained partnerships.
6. Provide national and international leadership.
CPATT VALUES

1. Commitment to high quality research that advances theory and contributes to engineering practice or policy development.

2. Foster a community that supports multidisciplinary and interdisciplinary research.

3. Promotes research and development of students, faculty and partners.

4. Facilitate commitment to making research findings and their implications available in formats that target the needs of different audiences.

5. Be responsive to research needs.
CPATT RESEARCH AREAS

• Advanced Pavement Materials
• Greening Roads for Sustainability
• Improving Recycling and Material Characterization
• Be Proactive on Climate Change
• Design to mitigate Natural Disasters
• Innovative and New Designs
• Design and Build Safe Smart Long Life Pavements
## BACKGROUND

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<th>Planning and Programming</th>
<th>Design</th>
<th>Construction</th>
<th>Maintenance, Preservation and Rehabilitation</th>
<th>In-Service Evaluation</th>
<th>End of Service Life</th>
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<td>Traffic and Environmental data information</td>
<td>Information on materials, traffic, costs, environment, etc.</td>
<td>Environment during construction</td>
<td>Standards</td>
<td>Periodic monitoring of structural adequacy, roughness, surface distress, and surface friction</td>
<td>Recycling and reuse of materials for reconstruction</td>
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<td>Assess network deficiencies</td>
<td>Design alternatives</td>
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<tr>
<td>Establish priorities</td>
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<td>Priorities</td>
<td>User costs</td>
<td>Quality control/quality assurance</td>
<td>Records</td>
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</tbody>
</table>

**“Working” Management**

Information

Database

Information

Research

Loop

Loop
BACKGROUND

[Image of a diagram showing the relationship between Environment, Structure, Construction, Traffic, and Maintenance with measures of serviceability or deterioration over age.]

[Tighe 2007]
KEY SUSTAINABILITY ISSUES

- Virgin Material Usage
- Alternative Material Usage
- Program for In-Service Monitoring and Management
- Air Quality/Emissions
- Water Quality
- Noise
- Energy Usage
KEY SUSTAINABILITY ISSUES

- Cost
  - Conventional Pavement
  - Recycled Pavement/Using By-Products
  - Pervious Pavement

- Environmental Impacts

(Tighe, 2010)
KEY SUSTAINABILITY ISSUES

- Safe
- Sustainable
- Quiet
- Cost Effective
- Smart
- Renewable
Climate Change and Extreme Precipitations

- Climate change → More intense and frequent rainfall events

- Very likely (90% certain), mid-latitude land masses will have more intense and frequent extreme precipitation events (Intergovernmental Panel on Climate Change, 2014)
Flooded Pavement

Hurricane Harvey struck Houston, August 27, 2017; Heavy rains wallop Houston area, causing widespread 1 in 500-year flooding.

Riverside Drive area in Ottawa, ON, Canada, October 30, 2017

A vehicle drives down the flooded runway at Rockhampton Airport, Australia, January 1, 2011

Credit: Hydro Ottawa
Credit: Mark Blinch
Credit: AP photo/David J. Phillip
The Need to Build Climate - Resilient Infrastructure

- Climate change induced flood hazards post threat to critical infrastructure
- Pavement damage can jeopardize safety, mobility, comfort, functionality, and accessibility resulting in advert social and economic implications.
- Reducing costs by understanding the risk and taking adaptation actions
The Pathway to Build Resilient Pavement Networks

01 Risk Assessment
- Flood Hazard Analysis
- Pavement Damage Analysis
- Fragility, vulnerability & Risk Analysis
- Need Identification

02 Risk adaptation
- Adaptation Prioritization
- Alternatives Appraisal
- Budgeting and Implementation

03 Monitoring Pavement Resiliency
Objective

- Establish methodologies for assessing the pavement flooding damage and risks in the changing climate
- Develop climate change adaptation strategies
- Advance pavement design and management for dealing with flood hazards
Research Methodology

- Incorporation of climate change projections into pavement design and management
- Analysis of flooded pavement performance change/damage for asphalt pavements and concrete pavements
- Pavement fragility, vulnerability and risk estimation
- Pavement network risk mapping and spatial analysis
- Enhancement of pavement asset management for floods
- Climate change adaptation strategies for pavements
- Technologies for building climate resilient pavement
Framework for risk assessment (project level)

Part (i) Risk Assessment (Project Level)

- **Hazard Analysis**
  - Occurrence of Events
  - Flood Extent under climate change
  - Hazard exposure

- **Vulnerability Analysis**
  - Flooded pavement performance
    - (pavement flood damage analysis)
  - Fragility Analysis
    - (Probability of exceeding certain damage given an event)
  - Consequence
    - (Potential loss of assets)

- **Risk of occurrence**
  - (Annual exceedance probability)

- **Risk of losses**
  - (Expected Annual losses)
Flood hazard exposure and hazard curve analysis

- Projection of future flood hazards
  - Future extreme precipitations: General Circulation Models (GCM) and Regional climate models (RCM)
  - GCMs: Selected Coupled Model Intercomparison Project Phase 5 (CMIP5) projection models
  - Intensity-Duration-Frequency (IDF): updated to indicate future rainfalls

![Flood hazard exposure and hazard curve analysis](image-url)
Flooded Pavement performance analysis

Flood loads on pavement structure

Pavement performance trend after flooding

Pavement damage pattern analysis

Pavement damage impact factors analysis

- Flood load characteristics
  - Flood depth, duration, debris, velocity, etc.

- Geology
  - Underlying soil type (e.g., clay), plasticity index

- Geography
  - Proximity to river or lake, water table, topography, etc.

- Pavement Conditions
  - Condition, age, cracks, joints, etc.

- Pavement Design
  - Thickness, slope, subbase, etc.
Pavement climate change adaptation: Pre-Flood Management

• Reduce hazard exposure
  • Decrease the chance of the overlap of floods and road infrastructure;
  • Options could be pavement relocation, increasing pavement elevation, choose rigid pavement, increasing drainage capacity, and improving structural defences.
Pavement climate change adaptation: Pre-Flood Management

• Reduce fragility of pavement structure
  • Improve pavement structural designs;
  • Maintain pavements at a good level of performance (ie. Less cracking);
  • Applying innovative technology and adjusting design standard/code and management timing.
Pavement climate change adaptation: Pre-Flood Management

• Reduce the cost associate fragility
  • Reduce economical, social and environmental consequences;
  • Incorporate risk assessment and spatial planning in pavement management;
  • Increase redundancy of the road network system at higher elevation.
Pavement climate change adaptation: Flood Event and Post Event

• Flood event management
  • Ability to provide real-time information, quick recovery actions is critical.
  • Often road closure and warning, communication, pavement flooding monitoring, and alternative road usage suggestions.
Pavement climate change adaptation: Flood Event and Post Event

• Post flood management
  • Efficient management aims to reduce the short-term road disruption and long-term accelerated deterioration of the pavement structures.
  • Road open time decision making
  • Quick pavement condition assessment, damage pattern identification, life cycle cost revaluation, post-flood cleaning, and pavement maintenance, rehabilitation and reconstruction decisions after floods.
LESSONS LEARNED

• Structural/Environmental data fundamental

• Two staged process: lab testing/field testing

• Experimental Design Essential!!!

• Adoption of New Materials and Designs

• Consider Climate Change