International Association of Chinese Infrastructure Professionals

THE 13th IACIP Annual Workshop:
Adaptive Infrastructure under Climate Change

Development of Performance Assessment Method and Decision Support Framework for Post-Flooding Pavement

Xiao Chen[1], PhD Candidate, Rutgers University, xc299@scarletmail.rutgers.edu
Hao Wang[2], Associate Professor, Rutgers University, hwang.cee@rutgers.edu

Introduction

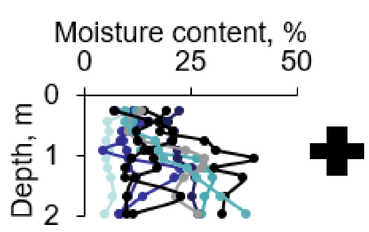
Flooding due to hurricane or extreme precipitation can cause severe damage on transportation infrastructure, and the frequency and intensity of flooding are increasing in recent decades. It is difficult to decide whether the roadway can be open or remain closed because of the uncertainty of flooding impact.

Currently, many post-flooding pavement performance assessment methods are available, including empirical approach, layer elastic analysis, numerical model, falling weight deflectometer (FWD) test and so on. However, without specific information on moisture content after flooding, the empirical, analytical or numerical approach cannot be used for practical roadway operation. Moreover, the backcalculated modulus from FWD testing is not always reliable because the result can be affected by many factors. Therefore, it is necessary to propose a reliable method to evaluate the post-flooding pavement performance for roadway operation.

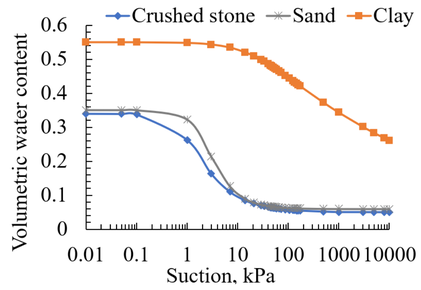
Objective

- Develop an assessment method for post-flooding pavement performance based on numerical modelling and field FWD test.
- Develop decision-making framework for roadway operation considers the variation of pavement damage and recovery after flooding.

Model development



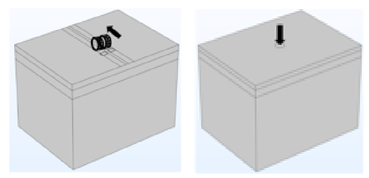
Various in-situ moisture content distributions from LTPP database



Soil-water-characteristic curves of different unbound materials

$$M_r = k_1 P_a \left(\frac{I_1 - 3\theta fh}{P_a}\right)^{k_2} \left(\frac{\tau_{oct}}{P_a}\right)^{k_3}$$

Non-linear modulus model considers:
1. Stress state
2. Moisture content
3. Matric suction

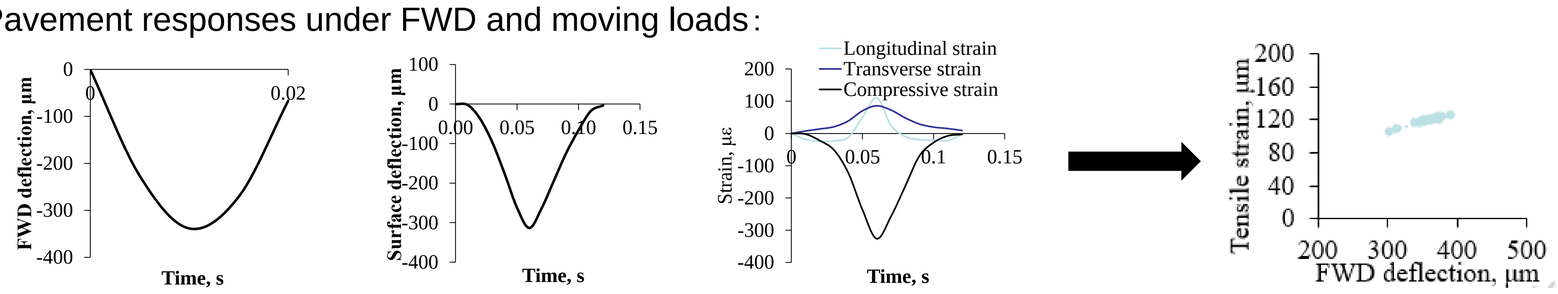


Moving load *FWD load*

Finite element model

Relationship Between Pavement Responses and FWD Deflections

Pavement responses under FWD and moving loads:

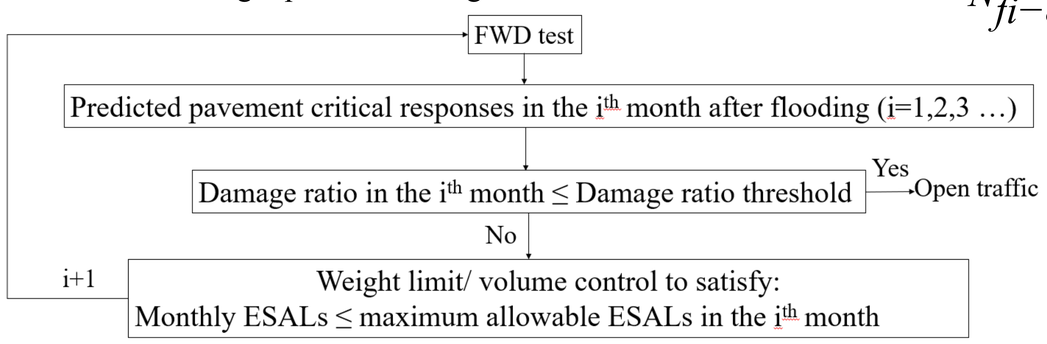


Regression parameters:

Pavement Structure	Traffic load, kN	Tensile strain (με) = a*FWD deflection (μm) + b			Surface deflection (μm) = c*FWD deflection (μm) + d		
		a	b	R^2	c	d	R^2
15cm HMA + 25cm crushed stone + Sand	80	0.12	78.02	0.97	0.80	49.07	0.99
15cm HMA + 25cm crushed stone + Clay	80	0.17	64.32	0.98	0.82	67.46	0.99
20cm HMA + 30cm crushed stone + Sand	80	0.10	59.29	0.95	0.72	24.82	0.97
20cm HMA + 30cm crushed stone + Clay	80	0.15	60.39	0.97	0.79	52.84	0.99

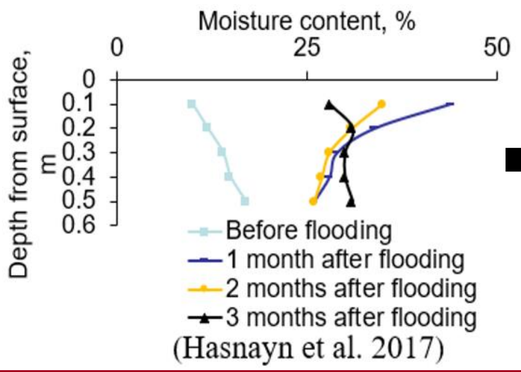
Decision Support Framework For Roadway Operation

$$\text{Damage ratio } D_i = \frac{\text{Traffic load repetitions in the ith month after flooding}}{\text{Allowable loading repetitions during the ith month}} \rightarrow D_i = \frac{ESALs}{N_{fi-80}}$$



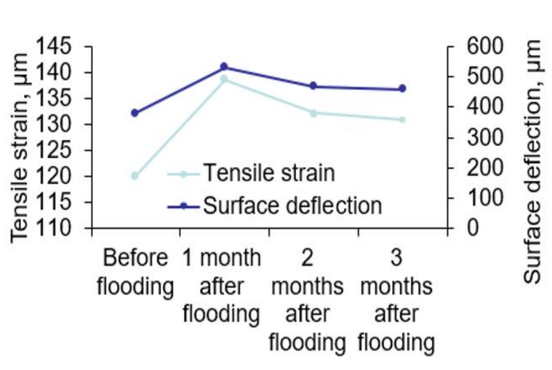
Case Study

1. Post-flooding pavement moisture content

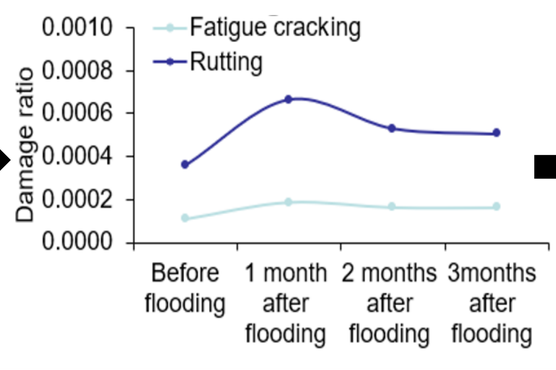


(Hasnayn et al. 2017)

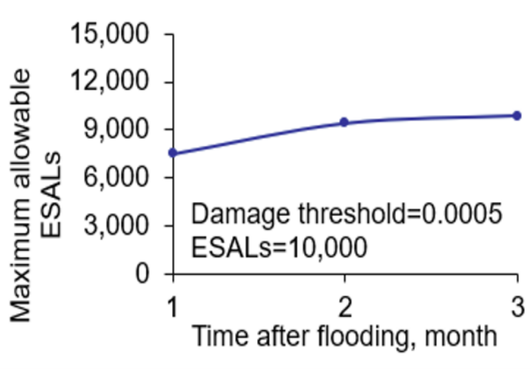
2. FWD-pavement responses



3. Pavement damage



4. Roadway operation



Conclusion

- Based on existing pavement deterioration models and regression parameters, the performance of post-flooding pavements can be evaluated using FWD tests.
- FWD deflections linearly correlated with traffic-induced pavement surface deflections and tensile strain.
- With traffic information and post-flooding pavement performance, the pavement damage ratio can be calculated and compared to the agency-determined threshold. If the pavement is considered as unsafe for normal traffic, the roadway operation such as weight limit or traffic volume control can be implemented.