The Road Forward **Climate-Conscious** Pavement Design

RESILIENCE OF PERPETUAL PAVEMENTS

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Perpetual pavements are well known for sustainability benefits, but did you know that they also provide substantial benefits with respect to resilience? The Federal Highway Administration (FHWA) defines resilience as the ability to anticipate, prepare for, and adapt to changing conditions, as well as to withstand, respond to, and recover rapidly from disruptions[1].

WHAT ARE PERPETUAL PAVEMENTS?

The layers of a perpetual pavement are each designed for a specific function (Figure 1)[2,3]. The bottom layer is designed to be fatigue resistant to prevent bottom-up cracking; the intermediate layer provides rut resistance and additional structural capacity; and the top layer resists abrasion and top-down cracking.

HOW DO THEY WORK?

The unique layered structure allows a perpetual pavement to endure heavy traffic loads over an extended period (typically more than 50 years) without significant structural damage. This durable design provides perpetual pavements with the absorptive capacity to handle changing conditions with respect to traffic and environmental loads.

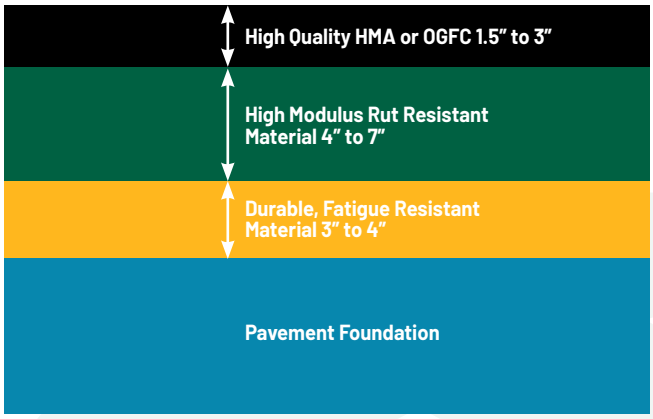

Figure 1: Perpetual Pavement schematic (adapted from Newcomb et al., 2020[3])

Perpetual pavements are designed to confine distresses to the top few inches of the pavement and to avoid structural issues like fatigue cracking and

[1]Statutory Definition of "Resilience" at 23 U.S.C. § 101(a)(24). Section 11103 of the Bipartisan Infrastructure Law, enacted as the Infrastructure Investment and Jobs Act, Pub. L. 117-58 (Nov. 15, 2021)
[2]Newcomb, D.E., J.R. Willis, and D.H. Timm (2010). Perpetual Asphalt Pavements: A Synthesis (IM-40). Asphalt Pavement Alliance, Greenbelt, Maryland.
[3]Newcomb, D.E., M. Buncher, and I.J. Huddleston. 2000. Concepts of Perpetual Pavements. Transportation Research Circular No. 503. *Perpetual Bituminous Pavements*. Transportation Research Board. Washington, DC. pp. 4-11

rutting in the lower layers. In this way, the structural integrity of the pavement is maintained over time and deep structural repairs, rehabilitation, or reconstruction are not needed. The materials used in the top layer are easily altered during regularly required surface-layer maintenance to adapt to changing environmental or traffic conditions (e.g., using a different type of binder grade or modified binder).

WHAT'S THE CLIMATE BENEFIT?

The thickness and deeper structural design of perpetual pavements mean the pavement can withstand higher moisture conditions in the unbound layers and subgrade. The perpetual pavement structure can maintain the ability to carry normal traffic loads during major flooding events without sustaining accelerated damage, providing resilience from extreme events.

Perpetual pavements also provide for quick recovery of surface damage due to extreme weather or other events. The rapid repairability of the surface layer enhances the overall road network's resilience to disruptions by allowing a quick return to fully functional service.

Perpetual pavements have been shown to have quantifiable benefits with respect to costs and environmental impacts. Life cycle cost analysis (LCCA) of a perpetual pavement in Iowa showed cost savings of up to 28% over a conventionally designed and maintained pavement structure[4]. Life-cycle assessment (LCA) of the same pavements showed the perpetual design resulted in more than 20% fewer environmental impacts compared to conventional design.

THE TAKEAWAY

A resilient pavement is one that is built and managed to handle anticipated and unanticipated stresses while maintaining functionality, ensuring safety, and providing a return on investment throughout its intended lifespan. The resilience of perpetual pavements lies in their ability to sustain long-term performance with minimal deep structural damage, lower maintenance requirements, and rapid recovery after events that cause surface distress. This makes them a robust choice for critical and heavily trafficked roads.

[4]Improved Asphalt Pavement Sustainability through Perpetual Pavement Design (FHWA-HIF-19-080). Federal Highway Administration. 2020.

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