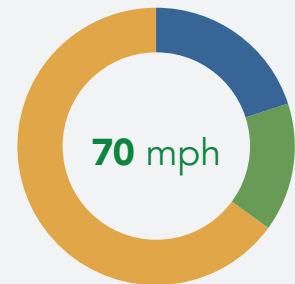
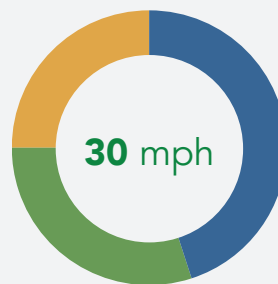


# How **Pavement** influences vehicle **Fuel Economy**

**About 75 percent of the oil consumed** in the United States is used as vehicle fuel.<sup>1</sup> Despite increases in vehicle fuel economy over the past few decades, fuel costs remain a significant budget item for the public and businesses alike. Numerous factors influence the fuel economy of a vehicle from its aerodynamic properties, engine, tire pressure, and air temperature; however, just three basic forces impact fuel economy: vehicle internal friction, air drag, and rolling resistance. While these three forces always affect fuel economy, they vary in importance based on the vehicle speed.<sup>2</sup> For example, when a vehicle is traveling at 30 miles per hour, 45 percent of the energy needed to move the car is used to overcome rolling resistance, but at 70 miles per hour, the rolling resistance only comprises about 20 percent of the energy requirement.

### Vehicle Energy Consumption by Speed<sup>2</sup>

	30 mph	70 mph
Rolling Resistance	45%	20%
Internal Friction	30%	15%
Aerodynamic Drag	25%	65%



The rolling resistance forces a vehicle must overcome to maintain speed are linked to its suspension system, bearings, transmission, tire pressure, and in part, the properties of the pavement. Three pavement properties are commonly understood to influence rolling resistance:



**Surface texture**  
the roughness of the aggregate materials in a pavement



**Smoothness**  
surface unevenness that affects perceived ride quality



**Pavement stiffness**  
how the pavement deflects under a vehicle's weight

Pavement surface texture influences fuel economy through the interaction of the tire and the contacted area of the pavement. As a tire deforms, energy is converted into heat, which is lost to the rest of the tire and the atmosphere. Higher texture leads to additional fuel consumption.<sup>3,4,5,6</sup> While it is important to consider the relationship between texture and fuel consumption, one must remember that pavement texture is key to ensuring safe driving conditions, particularly on wet roadways.

Numerous field and modeling efforts have been undertaken to understand the effect of pavement stiffness on fuel economy. Some theorists suggest that when tires and pavements interact, the pavement compresses causing the tire to continually drive “uphill.”<sup>7</sup> Despite efforts, research has provided conflicting results as to the importance of pavement stiffness of fuel economy. Some studies based on modeling and measured results have shown there is no practical difference,<sup>8,9,10,11</sup> while others have shown the differences could range from small to significant.<sup>12,13,14</sup> An honest evaluation of current knowledge shows that researchers and engineers are still struggling to quantify the true impact of pavement stiffness on fuel economy.

What science has consistently shown is that pavement smoothness always has an impact on vehicle fuel consumption. The smoother the road, the less fuel the vehicle consumes.<sup>15,16,17</sup> As a vehicle travels along a roadway, energy is lost by the shock absorbers, suspension, and tires as these devices try to make the ride more comfortable for drivers and passengers and reducing vehicle wear and tear.<sup>21</sup> If a vehicle bounces less, the energy lost through this action is minimized.

According to FHWA, “Roughness as measured by IRI generally has the greatest effect on fuel economy for typical ranges of IRI on U.S. highway networks.”<sup>18</sup> The best way to provide the driving public with the greatest possible fuel economy from the pavement infrastructure is to construct and maintain smooth roadway networks. In addition to aiding the driving public, smoother pavements increase pavement longevity and require less maintenance than rougher roads.<sup>19</sup> For more details, a recent literature review by the National Center for Asphalt Technology outlines the current state of knowledge surrounding pavement–vehicle interactions, as well as current limitations based on the available studies.<sup>20</sup>

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