

Technical Information

S E R I E S

THE "9,600 TO 1" NUMBERS GAME: BAD MATH, NOT A MEASURE OF DAMAGE

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A time worn phrase and concept used fondly by trucking industry critics is that "one truck does more road damage than 9,600 automobiles." The origin of this statement is murky, but its analytic basis is just plain wrong. The "9,600 to 1" ratio may have first been used in a 1979 General Accounting Office report to Congress on truck weight and highway damage. Others suggest that the numbers are rooted in the misuse of the 1958-59 AASHO (American Association of State Highway Officials) Road Test Project, which was, to many observers, the most comprehensive highway field test ever attempted. But whatever its origin, "9,600 to 1" is an improper interpretation of the relationship between trucks and roads.

AASHO, now AASHTO (American Association of State Highway and Transportation Officials), is a highly regarded organization, and its road tests were a significant milestone in the history of pavement design. The Road Test Project was undertaken to discover how different thicknesses and designs of asphalt and concrete pavement would perform under controlled loading conditions. *The majority of the test sections were deliberately under-designed so that pavement failure could be achieved during the tests.* The few pavement sections that were designed to full, modern standards withstood hundreds of thousands of axle loads, with some axle loadings greatly exceeding the limits allowed by any state.

From these many tests, graphs were developed showing a geometric relationship between axle loads and pavement effects. The results indicated that a small increase in axle loads had a relatively large effect on pavement wear. Conversely, a small increase in pavement strength or thickness would accommodate a large increase in axle loadings. These relationships provided a better understanding among engineers of how

to determine load-related pavement requirements. On the other hand, non-engineers have sometimes incorrectly used some of these study relationships.

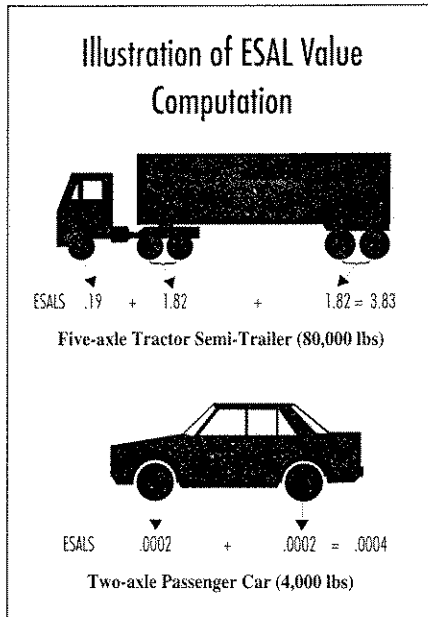
In the years following the test, to make this information useful to highway design engineers, the relative effects of a full range of single and tandem axle loads (including many not tested) were mathematically converted to 18,000 pound equivalent single axle loads (ESALS). In other words, an 18,000 pound single axle load was assigned a value of 1.00; a lighter axle, 16,000 pounds, for example, had a value of 0.62, as shown in the table.

Axle Weights and ESAL Values

(Rigid Pavement, $p = 2.5$, $D = 7$ in.)

Single Axle Weight	ESAL Value	Tandem Axle Weight	ESAL Value
2,000 lbs	0.0002	10,000 lbs	0.01
12,000 lbs	0.19	24,000 lbs	0.46
14,000 lbs	0.36	28,000 lbs	0.85
16,000 lbs	0.62	32,000 lbs	1.44
18,000 lbs	1.00	34,000 lbs	1.82
20,000 lbs	1.52	36,000 lbs	2.27

To illustrate the expected ESAL contribution for a particular vehicle, the ESAL values for the individual and tandem axles are added.



Using these numbers, it has been “simplistically” assumed that one five-axle tractor semi-trailer has about the same effect on concrete pavement as 9,600 passenger cars ($3.83 \div .0004 \approx 9,600$).

But it's not that simple. AASHTO's numbers for flexible (asphalt) pavement, rather than rigid (concrete) pavement, would show that the same truck had the effect of “only” 5,900 cars. And more recent research, including a thorough reworking of the original AASHO results in 1991, indicates that a more realistic relationship between axle weights and pavement wear might be expressed as *one truck is equivalent to 800 to 1,000 cars.* The relationship is far from clear.

Certainly, if a pavement designed for a 20-year life begins to show distress after

12 to 15 years, and if traffic and truck weight studies show that the volumes and weights of trucks were underestimated in the original design, it may be appropriate to attribute part of the reduced service life to trucks. On the other hand, all else being equal, simply adding one inch of concrete slab when building (or reconstructing) a highway would allow twice the number of ESAL applications without lowering highway life.

In 1979, the Transportation Research Board (NCHRP 198) said that “when a highway is properly designed...it will not be damaged by the traffic it is designed to support. This is an important point because there are prevalent misconceptions that trucks damage pavements more than passenger cars. This is only true when (1) the pavements are under-designed for the amount of truck traffic that is actually using them; (2) trucks, through overloading generally, are imposing heavier axle loads than anticipated; or (3) other factors not properly evaluated in design have affected the ability of pavements to support traffic.”

So the concept and practice of taking AASHTO's nearly 40-year old equivalency values out of a highway design context and using them as a reliable indicator of highway damage is flawed science. As is recognized today, the number of applications of specific axle loads is only a part of the reason for highway failure. Such other factors as underlying soil, roadbed design, pavement type and thickness, weather effects and deferred maintenance also affect highway life. The point is simple: there are too many variables influencing pavement performance to

attempt to apply a decades-old design formula as a measure of wear.

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