Ask the EXPERT

If you have just entered the field of claims adjustment and have claims related questions that you were too afraid to ask, our experts can help. Send your questions to Brett Colville at brett.colville@crawco.ca and we will get an answer for you.

Q Wouldn't a heavier vehicle take longer to stop?

Respondent:
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A The notion that a heavier vehicle will take longer to stop is satisfying on an intuitive level. Indeed, many people, both technical and non-technical, readily accept this conclusion as true. Unfortunately, it is incorrect: heavier vehicles do not necessarily take longer to stop. The confusion is caused by an oversimplification of the problem.

Vehicle braking is a process in which the kinetic (or "motion") energy of a vehicle is converted into heat and dissipated to the surrounding environment. The kinetic energy possessed by a vehicle depends on its mass and the speed at which it is travelling. The ability of the braking system to convert this energy to heat and transfer it to the surrounding air depends not only on the mass and speed of the vehicle but also on the performance of the brake system.

As a result, it is not uncommon to see test results in which stopping distances are not directly correlated with vehicle weight. For example, independent testing of the 2002 Mini Cooper and the 2004 Volkswagen Phaeton, using expert drivers, showed that the Mini required 15 feet more than the Phaeton to come to a stop, despite the fact that the Mini is only half the weight of the Phaeton.

In the case of accident reconstruction, the problem is often greatly simplified. In emergency situations, many drivers respond by "slamming" on the brakes, causing the wheels to lock. As a result, the stopping vehicle generally leaves skid marks at the collision site.

When a vehicle's wheels are locked, the mechanism by which the vehicle is brought to a stop changes. Rather than having the kinetic energy be transferred into heat by the braking system, and having that heat dissipated to the surrounding air, the locked wheel transfers energy to the ground via the forces between the tire and the road surface. This change reduces the complexity of the problem by eliminating many of the unknown variables associated with the normal braking process.

Now take a deep breath: a bit of technical jargon is coming!

Newton's Second Law of Motion states that a vehicle's mass will decelerate at a rate proportional to the net external force resisting its motion. For the sake of simplicity, we will ignore aerodynamic effects, road grades and the effects of an anti-lock braking system. In essence, the Law states that the *braking force is equal to the mass of the vehicle multiplied by its deceleration rate.*

In the case of locked-wheel braking, the braking force is the result of two factors:

- the load supported by the tire (i.e., the vehicle's weight)
- the nature of the interface between the tire and the surface it is skidding across

The nature of the interface is quantified by a "drag factor." The relationship between these variables is such that the *braking force is equal to the drag factor multiplied by the mass of the vehicle and a gravitational constant.*

Combining the two relationships, one arrives at the conclusion that the mass of the vehicle multiplied by its deceleration rate is equal to the mass of the vehicle multiplied by the drag factor and a gravitational constant. Hence, the effect of vehicle mass cancels out: one is left with the result that the deceleration rate is equal to the drag factor multiplied by a constant.

Therefore, it is solely the drag factor-a property of the interface between the tires and surface-that determines the stopping distance of a vehicle under locked-wheel braking. Because the main ingredient in most passenger vehicle tire compounds is the same (namely, vulcanized rubber), the drag factors for most tire models on a given surface are quite similar, and can be predicted by consulting relevant testing.

As a result, two vehicles undergoing the process of locked-wheel braking on the same surface will take the same distance and time to come to a stop, regardless of their relative masses. Simply stated, heavier vehicles can generate more braking force, and this completely offsets the disadvantage of being heavier.

There are, of course, exceptions to this general trend. One of particular note is the case of vehicles equipped with air brakes, such as buses and tractor-semi-trailers. These vehicles have longer stopping distances, due to the inherent performance of their braking systems. These unique systems are beyond the scope of this discussion.

In any case, one must have a good understanding of the performance of a given braking system and a knowledge of the vehicle's speed to determine its stopping distance. In the field of accident reconstruction, however, it's the other way around: that is, a stopping distance is used to calculate a vehicle's speed.

One can appreciate that proper analysis of scene evidence and a thorough understanding of a vehicle's braking system is required to accurately predict the speed of a vehicle based on its stopping distance. As shown, these results will not necessarily be dependent on the mass of the vehicle in question.

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