Investigating Pedestrian Impacts: An Engineering Perspective

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When a pedestrian is involved in an impact with a motor vehicle, the pedestrian inevitably ends up with serious or fatal injuries. The debilitating injuries typically suffered in a pedestrian impact, as well as the reverse onus on drivers to prove that they were not liable, generally necessitate a thorough investigation of the claim.

Issues that normally arise in trying to settle a pedestrian impact claim include the speed of the vehicle, the visibility of the pedestrian, the movement of the pedestrian and vehicle prior to impact and the extent to which the driver had an opportunity to avoid the impact.

Whether or not the vehicle impact speed can be determined, and with what degree of accuracy, depends upon the quality of the accident scene data available. An accurate estimate of vehicle speed usually requires that the "throw distance" of the pedestrian be known. The throw distance is the distance that the pedestrian is projected forward by the vehicle from the point of impact to final rest. Alternatively, some research efforts have attempted to show a correlation between vehicle damage patterns, pedestrian injuries and vehicle speed. At best, this methodology can only render a very general estimate of the magnitude of the impact speed, due to the wide range of vehicle shapes and sizes and the varying weights and heights of pedestrians. One other indication of vehicle speed is provided when the driver locks up the brakes on impact and leaves a distinct set of skid marks; this allows for a calculation of the vehicle speed based on the braking distance. With ABS brake systems becoming more common, one is less likely to find this type of data available at the accident scene.

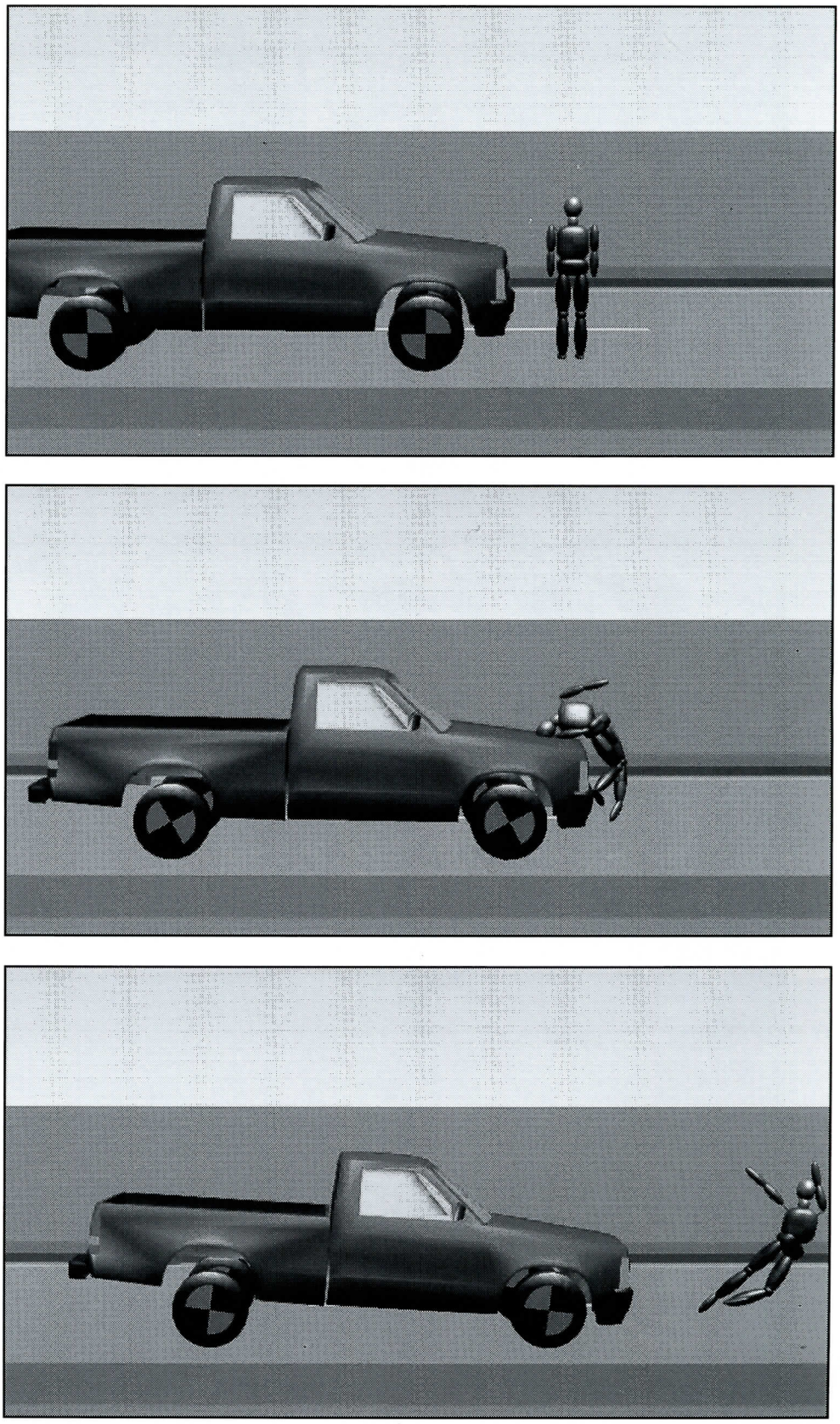
A number of mathematical models have been developed that can be used to estimate the vehicle speed based on the pedestrian throw distance. While it is usually possible to determine where the pedestrian ended up, the exact point of impact is not always clear. The pedestrian is typically projected forward on impact, and in most cases, there are no scuff marks on the roadway to identify the pedestrian's position at impact. Nevertheless, the point of impact can often be estimated within a reasonable range, based on vehicle debris deposited on the roadway at or

very near the point of impact. In addition, witness statements often indicate that the pedestrian entered the roadway at a particular point, such as a crosswalk, allowing the point of impact to be estimated with sufficient accuracy.

Once the pedestrian throw distance has been established, the vehicle impact speed can be calculated by applying the appropriate mathematical model. In addition to the traditional manual calculations commonly used by engineers, some computer simulation programs are now available that can model a pedestrian impact. The simulation program allows the input of a vehicle shape that can closely match the accident vehicle geometry, and the pedestrian model can be adjusted so that the height and weight accurately represent those of the pedestrian struck. One benefit of the simulation program is the graphical output, which can be used to verify that the pedestrian trajectory matches the scene evidence closely. In addition, the simulation can be viewed frame by frame to see whether the occupant contact points match the vehicle damage patterns observed on the accident vehicle (see Figure 1).

When a pedestrian impact occurs at night, the visibility of the pedestrian becomes a critical factor, as a driver cannot respond to something that he or she cannot see. Unfortunately, pedestrians are often of the belief that if they can see the vehicle headlights, then the driver must be able to see them. A pedestrian's clothing colour and the background against which they appeared will be key factors in assessing the extent to which the pedestrian was visible to the driver. Often a dark-clad pedestrian against a dark background is only visible to the driver for a few metres prior to impact. In these cases, the driver may not have sufficient time and distance

Figure 1. A computer simulation can provide a graphical analysis of how the pedestrian interacted with the vehicle on impact.



available to initiate a response, resulting in the often-heard statement that "I did not see the person until it was too late."

Light-coloured clothing can substantially increase visibility distance, as can retro-reflective materials. In one scientific study, the distances at which pedestrians could be detected at night, when wearing various types of clothing was measured. In this study, the mean detection distance from a pedestrian wearing dark clothing was only 21 metres, whereas that from a pedestrian wearing jeans and a white T-shirt was 68 metres. When wearing a retro-reflective jogging vest, the mean detection distance increased to 227 metres. A vehicle travelling at 80 km/h is moving at 22 metres per second, indicating that a pedestrian in dark clothing may only be detected within about one second before the vehicle reaches the pedestrian. A white T-shirt would increase that time to over three seconds and a retro-reflective vest to over ten seconds. Night visibility photographs taken under similar lighting conditions can be used to illustrate this concept (see Figure 2).

Other factors that can affect the visibility of a pedestrian at night include the presence of background glare, the number of other visual stimuli in the driver's field of view and the weather conditions. The glare from oncoming headlights can make it extremely difficult for a driver to see other, less conspicuous objects in the visual field. The amount of visual clutter in the driver's field of view due to the presence of commercial lighting, signs, other vehicles and traffic controls may cause a pedestrian to be obscured, preventing the driver from detecting the pedestrian until just before impact. Rain and other adverse weather conditions can further degrade the driver's visual

Figure 2. Three photographs of pedestrians taken under the same lighting conditions, showing the effect of clothing colour on visibility at night.

performance, especially at night. An analysis of the lighting and visibility conditions at the accident scene at night can provide vital information as to the visibility of a pedestrian.

The movement of the pedestrian prior to impact can have a considerable effect on the driver's ability to avoid the pedestrian. In some cases, general conclusions regarding the pedestrian's movement can be drawn from the damage pattern on the vehicle. A clothing transfer mark on the right corner of the vehicle, followed by a diagonal damage pattern across the hood, from the right front to the left rear of the hood would clearly indicate that the pedestrian was moving from right to left with respect to the vehicle when struck. This evidence may be useful to corroborate the statement of the driver or an independent witness.

Information as to whether the pedestrian was walking or running can be critical and will often be determined by independent witnesses. Published tables for the walking and running speeds of pedestrians, based on age and gender, can be used to calculate how long it would take the pedestrian to travel a particular distance. If the path of the pedestrian has been established, then the time taken for the pedestrian to cross in front of the vehicle can be determined. Often the time a pedestrian takes to move from the roadside into the path of the vehicle is very short, leaving the driver with insufficient time to respond.

One of the most difficult scenarios a driver can be faced with is a "dart out" situation in which the pedestrian suddenly enters the path of the vehicle from between two parked cars. In this situation, the time taken for the pedestrian to cross into the path of the vehicle is often only a fraction of a typical driver's perception-response time. In this type of collision, braking often starts some distance after the point of impact. When faced with a "dart out" type of impact, information regarding the exact path of the pedestrian and the location of parked vehicles should be carefully documented.

When investigating a pedestrian impact, the timeliness of the investigation may have considerable bearing on the ability of the engineer to properly reconstruct the accident. While vehicle-to-vehicle impacts often leave gouges in the roadway surface that remain visible for a long time, subtle evidence left by a pedestrian impact may fade away within a few days. Fortunately, in most cases the police conduct a thorough scene investigation when a pedestrian is involved, documenting the location of critical evidence. In the event that the engineer is called into the investigation late, a reconstruction may still be possible, based on police measurements and photographs made at the accident scene, when combined with witness statements, weather reports and the vehicle damage appraisal.

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