# Lessons Learned From Tire Marks On Freshly Re-Graded Gravel Shoulders

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Evaluation of loss-of-control collisions on rural highways requires that the investigator understand the meaning of tire marks on a gravel shoulder. In many instances gravel shoulders are hard-packed such that the impressions and imprints from tires are difficult to detect. One can gain some knowledge about the interaction between tires and gravel by studying tire marks left on freshly re-graded gravel shoulders because under this condition the tire marks are most visible. The following scenario presents examples of tire marks on freshly re-graded gravel as well as the characteristics of tire marks caused during maximum braking.

Figure 1 shows the northward view of an east gravel shoulder that was freshly re-graded about 2 hours before the photo was taken. The tire mark visible in the middle of the shoulder was produced by the right side tires of the road grader that passed through the site and re-graded the shoulder. The softness of the gravel can be appreciated by noting the imprint of the shoe of an investigator next to that tire mark, as shown in Figures 2, 3 and 4 on the following pages.

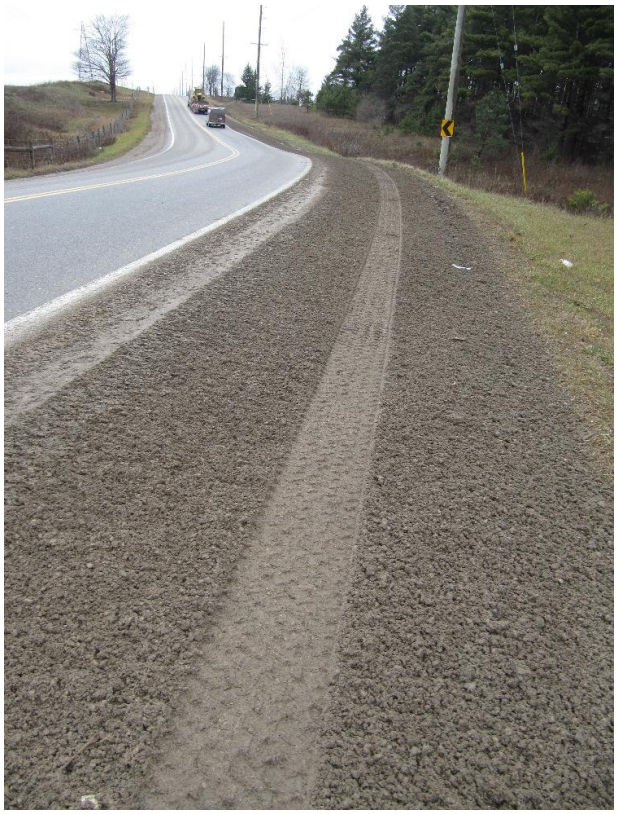

Figure 1 - Tire mark of road grader on freshly re-graded gravel shoulder

Figure 2

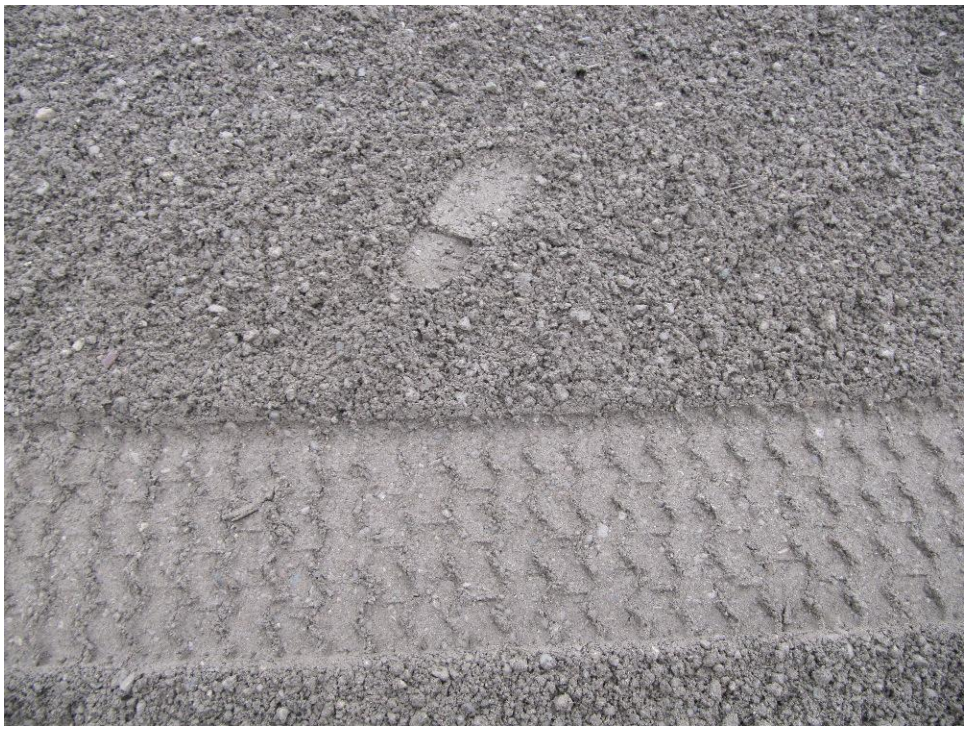

Figure 3

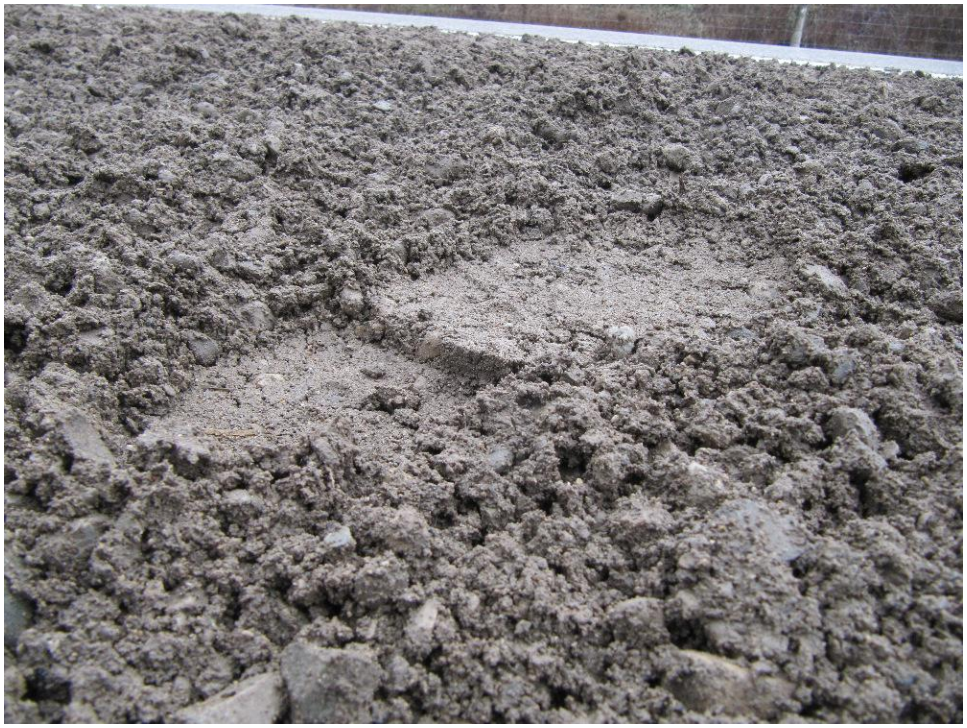

Figure 4

A few hours after these photos were taken we returned to this location and performed a test by purposely driving our test vehicle onto the shoulder, applying hard braking to a stop, and then steering off the shoulder to a parked position on the east roadside. Figure 5 shows the general scenario, looking north along the path of the test vehicle, just after the test was completed and our test vehicle can be seen in the background.

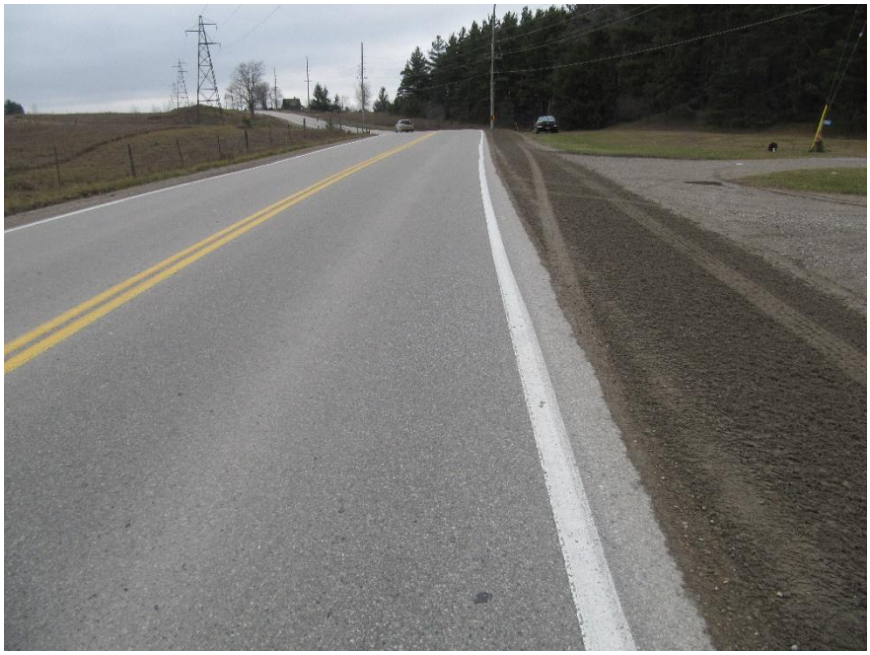

Figure 5

Figure 6 shows a southward view with our test vehicle shown parked on the roadside after it was steered off the shoulder.

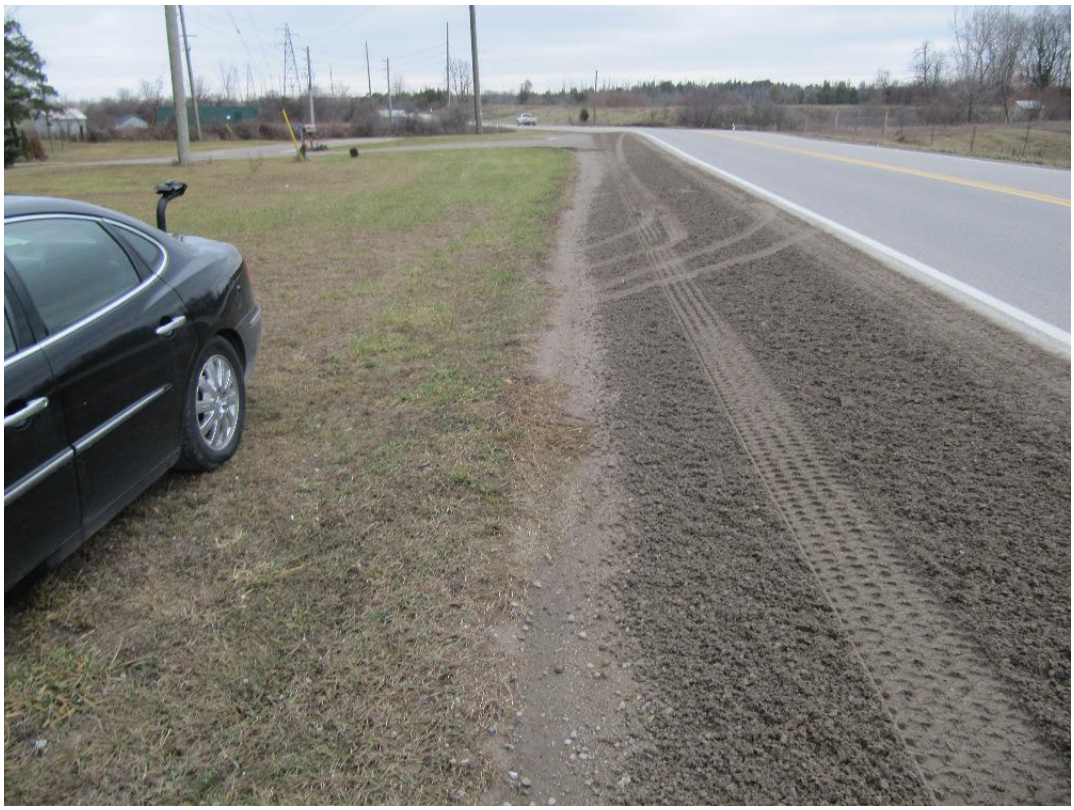

Figure 6

The brake test was performed in such a way that the left side wheels of the vehicle were still on the asphalt pavement such that only the right side wheels were on the loose gravel. The test was performed at a speed of 45 km/h.

Figure 7 shows the mark  produced by the right side tires of the vehicle shortly after it had been steered onto the shoulder and before any braking occurred. Not unexpectedly the loose gravel has been compressed down as the tires rode over it and we can see the imprint of the individual pattern of the tire tread. Note also that the gravel has not be disbursed (sprayed) to the left and right of the tire mark as this would be one of the signs indicating that sliding was taking place between the tire and gravel.

As we proceed further north along the tire mark we pass by a local driveway and we see in Figure 8 how the tire mark from our test vehicle has ridden over the diagonal tire marks caused by previous vehicles that entered/exited the driveway. The straight tire mark from our test vehicle can be seen on the left (west) while the straight tire mark from the road grader can be seen on the right (east) portion of the gravel shoulder.

Figure 7

Figure 8

It should not be difficult to comprehend that, studying the area in Figure 8 where the tire marks intersect, one can easily distinguish between which tire mark was caused first by noting how the tire mark from our test vehicle has removed the features of the crossing tire marks while the features from our tire mark remain in those areas of intersection. Figure 9 provides a close-up of one of those areas of intersection and we can see how our tire mark has erased the features of the diagonal tire marks that were caused previous to our test.

Figure 9

Progressing further northward we can see how the tire mark from the right side of our test vehicle continues to veer toward the right and closer to the tire mark of the road grader in the background. The braking test did not take place until much closer to the resting position of the test vehicle in the background so the characteristics of our tire mark in the foreground are of a rolling tire on loose gravel.

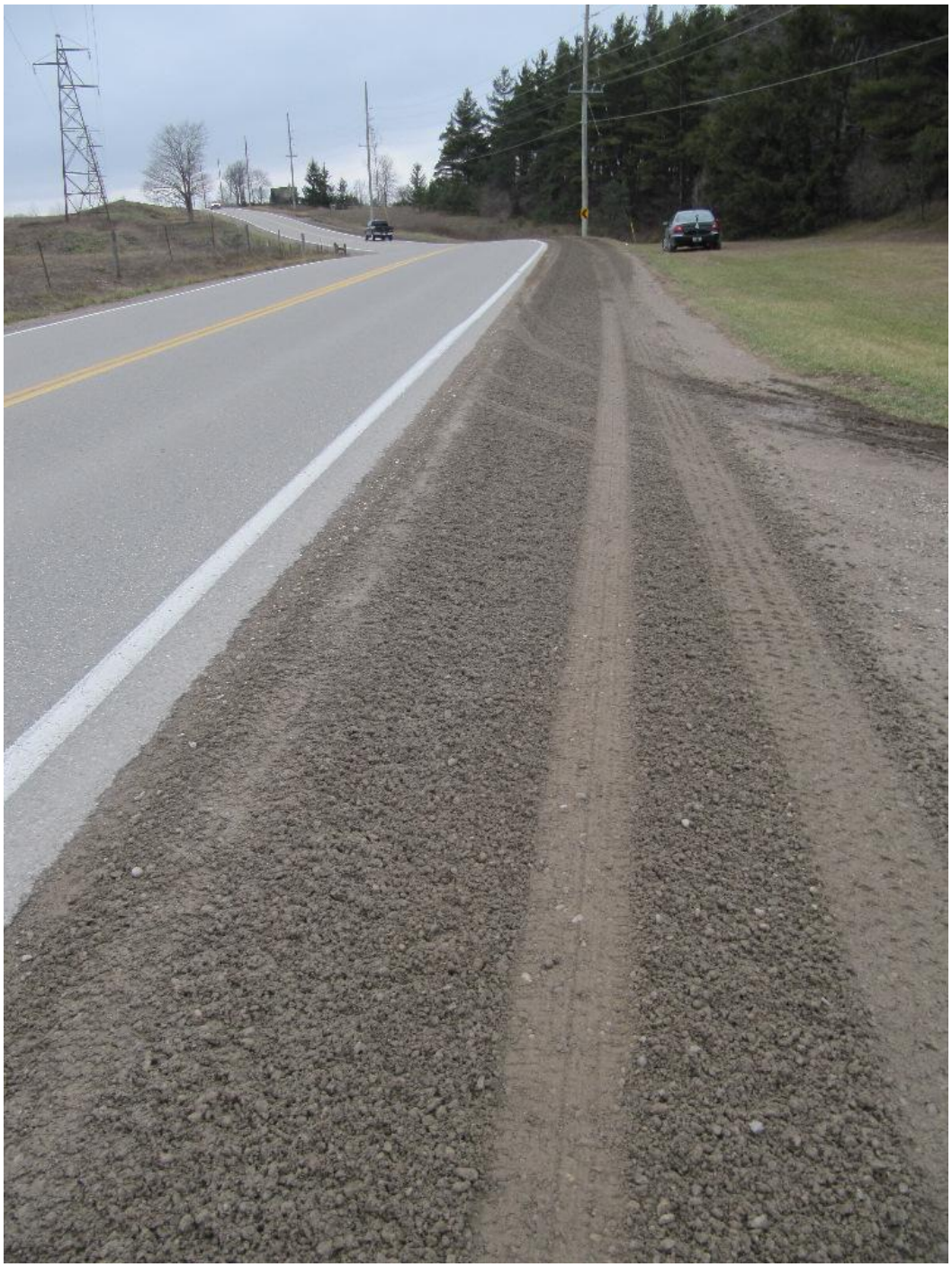

Figure 10

As we approach closer to the point where the braking commenced we can see in Figure 11 that the right side tire mark of our test vehicle comes right along side of the tire mark from the road grader. However, the tire mark from our test vehicle is still to the left (west) and the mark from the road grader is to the right (east).

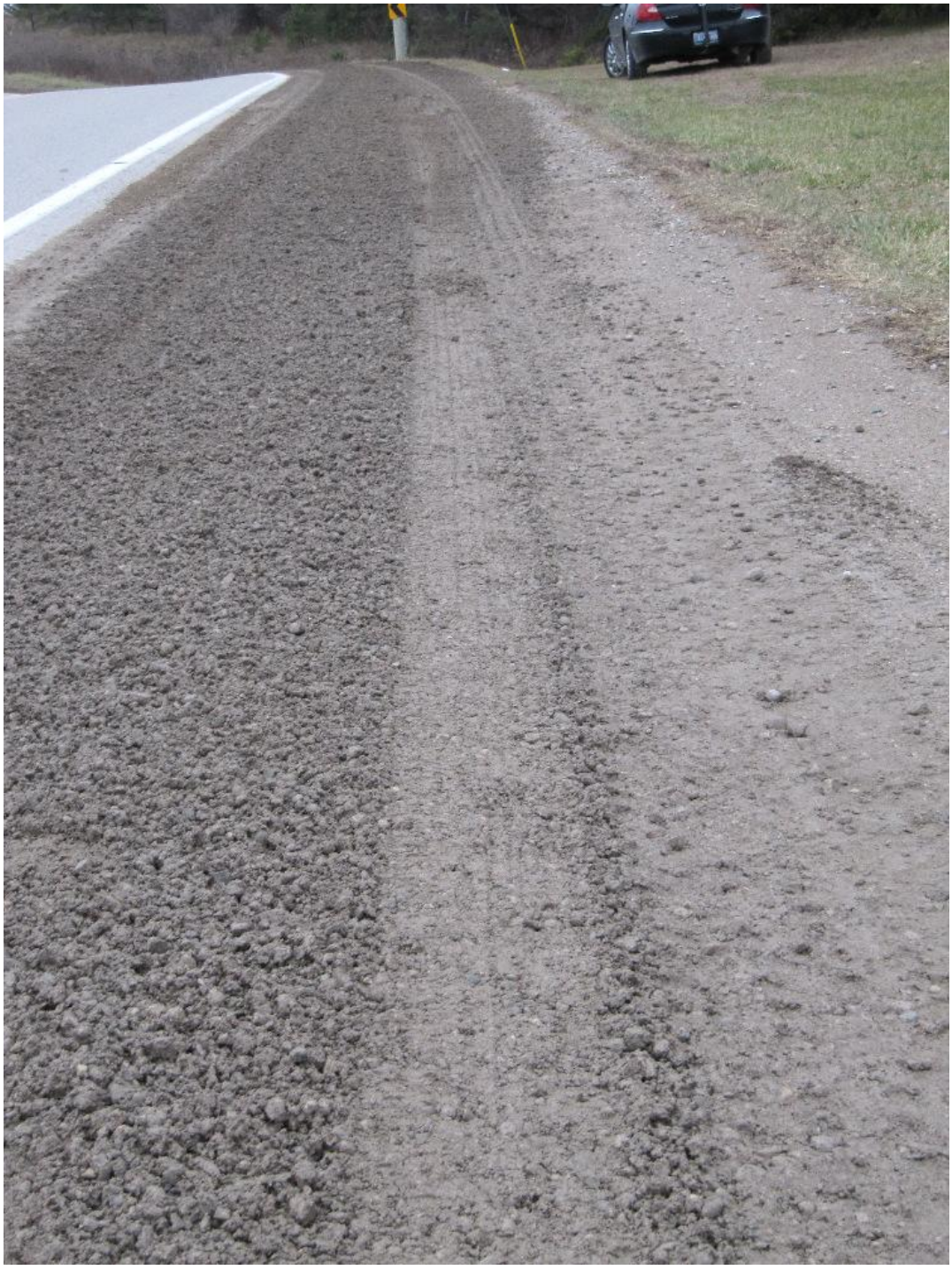

Figure 11

However, as we look closer in Figure 11 at the tire mark from our test vehicle you should be able to see that the tire mark changes its character and direction at the point where the braking occurs. Figure 12 below shows a closer view of the point where this change in the tire mark occurs. The tire mark from the test vehicle begins to show some "roughening" or displacement of the gravel within the tire mark and the tread of the tire print is no longer clearly visible. The tire has also travelled partly onto the tire mark caused by the road grader.

Figure 12

What may be difficult to detect is that the right rear tire of our test vehicle has begun to move to the right during the brake test and no longer tracks along the same path as the right front tire. Thus, if you look toward the very top of Figure 12 you might be able to see a portion of the right front tire mark which contains some of the characteristics of a rolling tire while the right rear tire mark passes between the right front tire mark and the tire mark of the road grader. So this is evidence that our test vehicle has begun to rotate slightly counter-clockwise during the braking test as our rear wheels began to lock and our front wheels continued rolling. This occurrence was despite the fact that our test vehicle (2007 Buick Allure) was equipped with anti-lock braking.

The extent of the counter-clockwise rotation during braking can be seen more clearly in Figure 13 which takes us close the point where our vehicle came to a stop at the end of our brake test. The curved tire marks show how we turned our steering wheel after the vehicle stopped and then rolled onto the grass where we parked our vehicle. The stop position of our vehicle at the end of braking can be detected by noting the mounds of gravel that were built up and sprayed or squished to the side near the stop location of each tire.

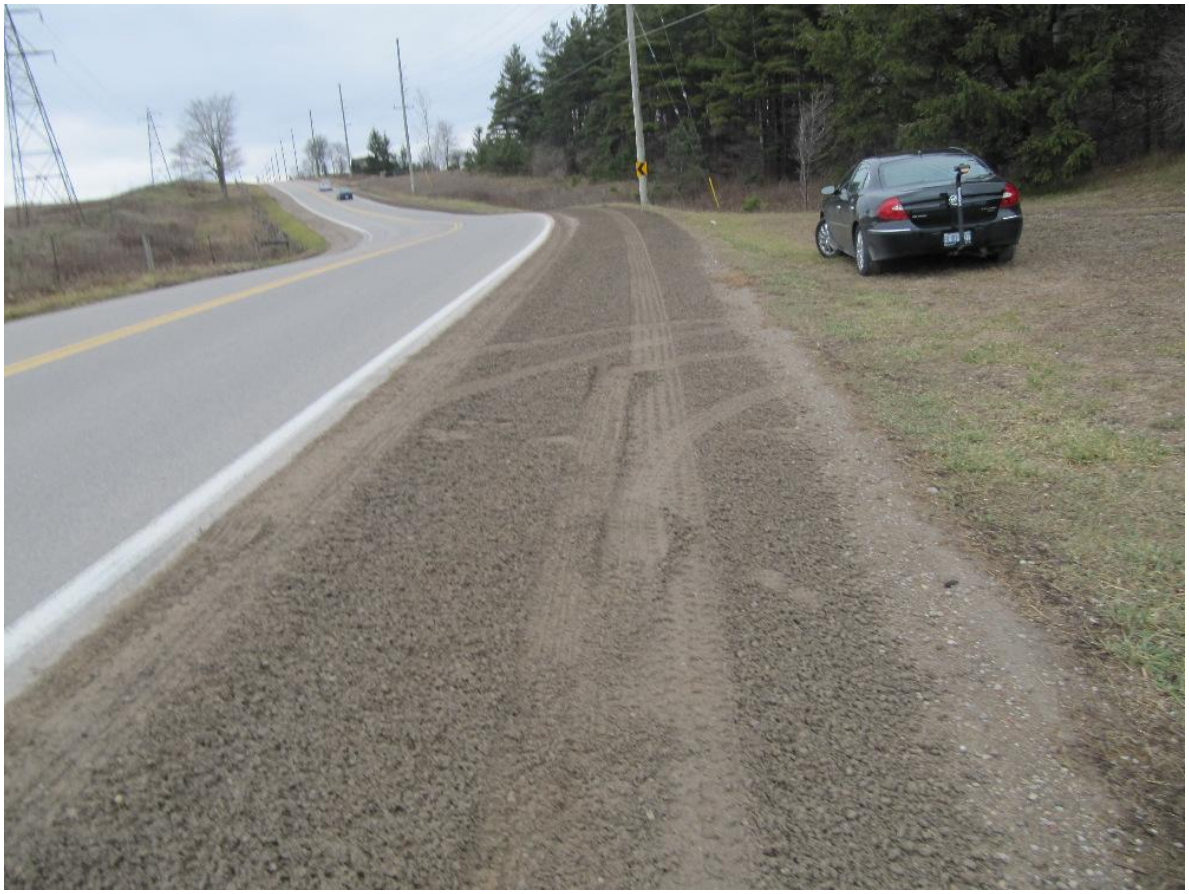

Figure 13

Note in Figure 13 how the right rear tire mark has followed a path more to the right (east)of the path of the right front tire mark indicating that our vehicle began to rotate counter-clockwise during the braking  test.

Figure 14 below shows a closer view of the tire marks near the point where the vehicle came to a halt. Note how the left rear tire also slid to the right such that it came off of the asphalt pavement and began to slide on the loose gravel while the left front tire continued to slide on the asphalt, albeit near the edge of the pavement.

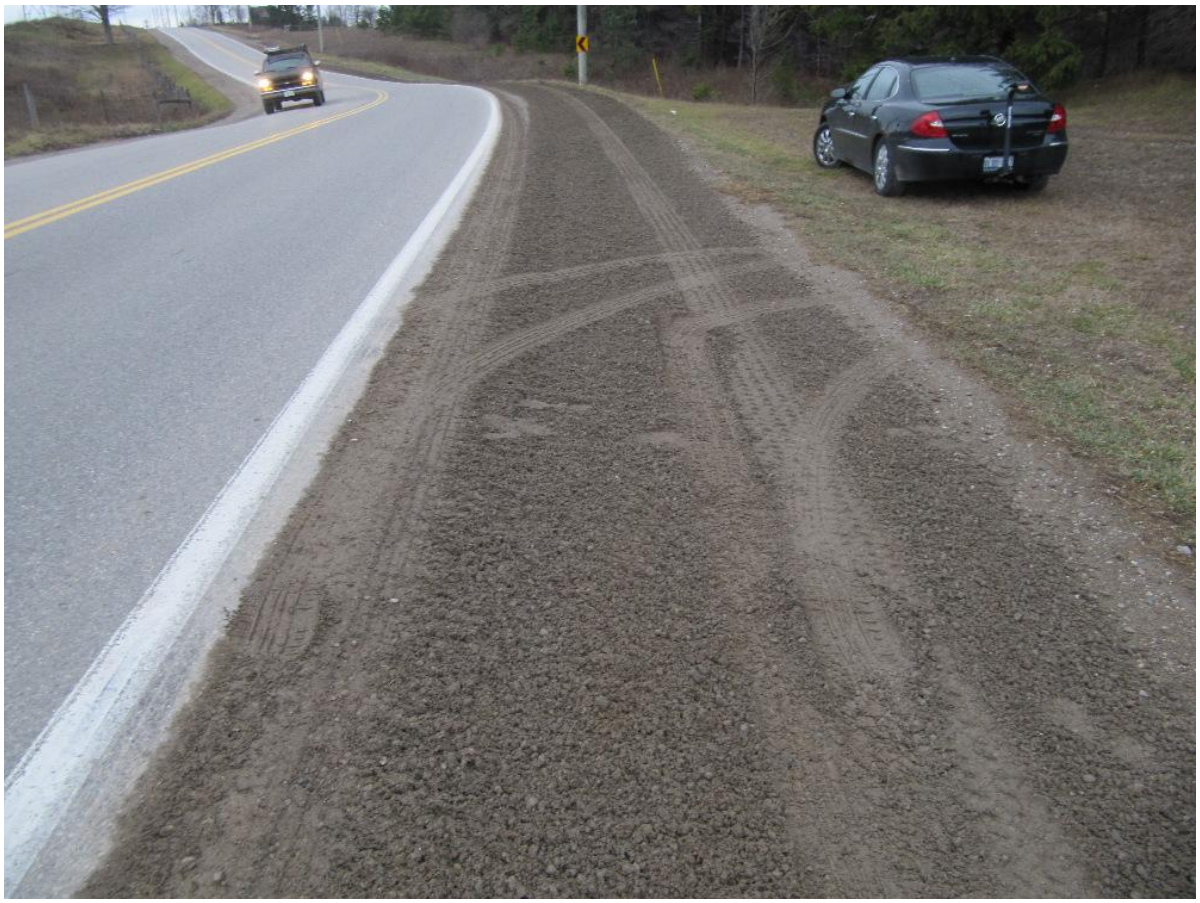

Figure 14

Figure 15 shows a closer view of the marks caused by the two right side tires of the vehicle and we can clearly see how the right rear tire followed a path to the right of the right front tire near the point where the vehicle came to rest. The curved tire marks continuing from  that rest position are simply those that were created after the test was completed and the vehicle was steered to the right and onto the grass roadside.

The tire mark caused by the road grader can also be seen in Figure 15 travelling in a straight line next to the tire marks from the braking test and we can see how the features of that tire mark have been erased in the intersection where our test vehicle passed over the tire mark.

In Figure 16 we can see a close-up view of the point where the right rear tire mark came to rest and how the loose gravel was built up and disbursed to the sides of the mark. Figure 17 provides a southward view of the tire marks at the end of braking test.

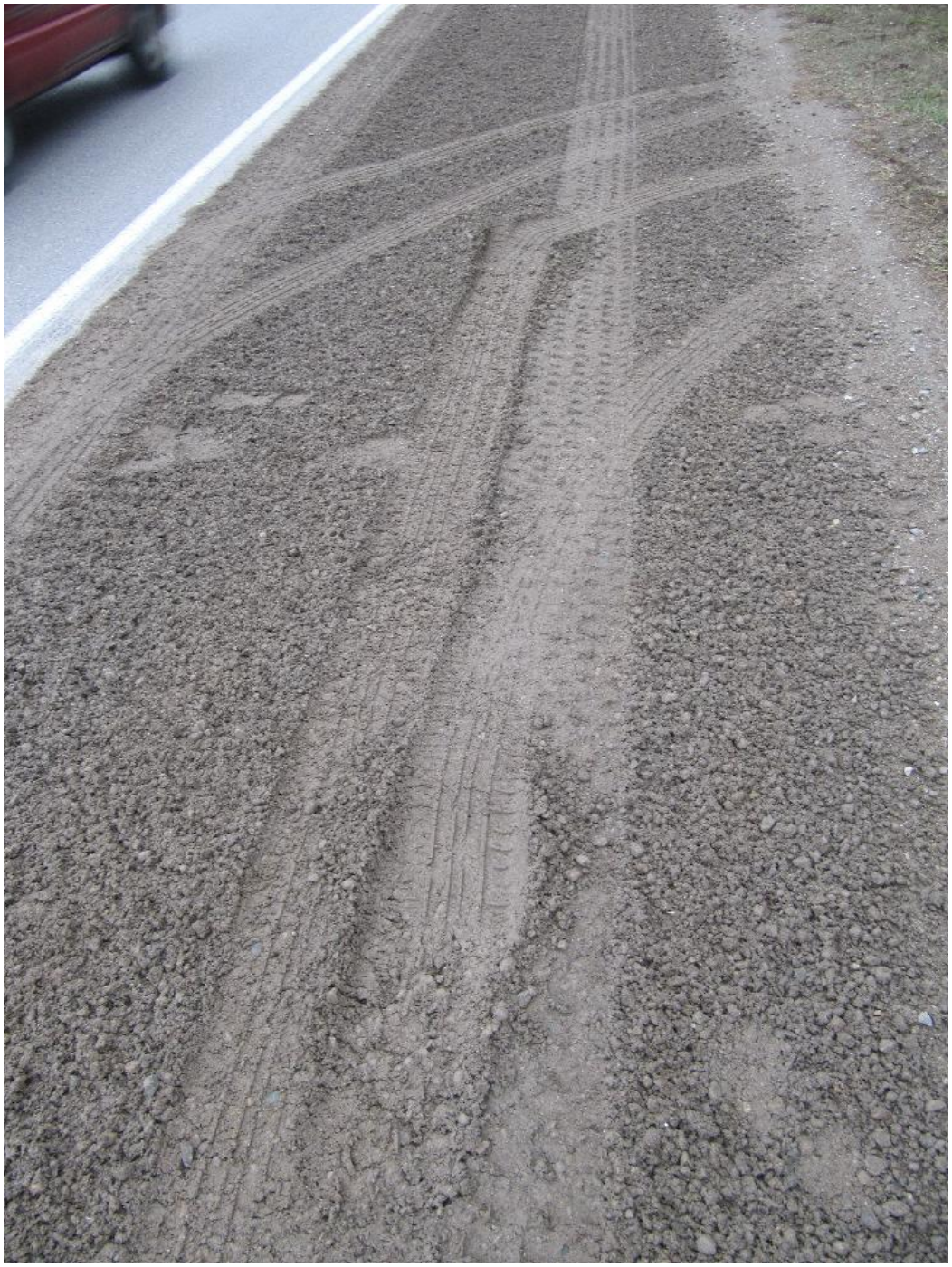

Figure 15

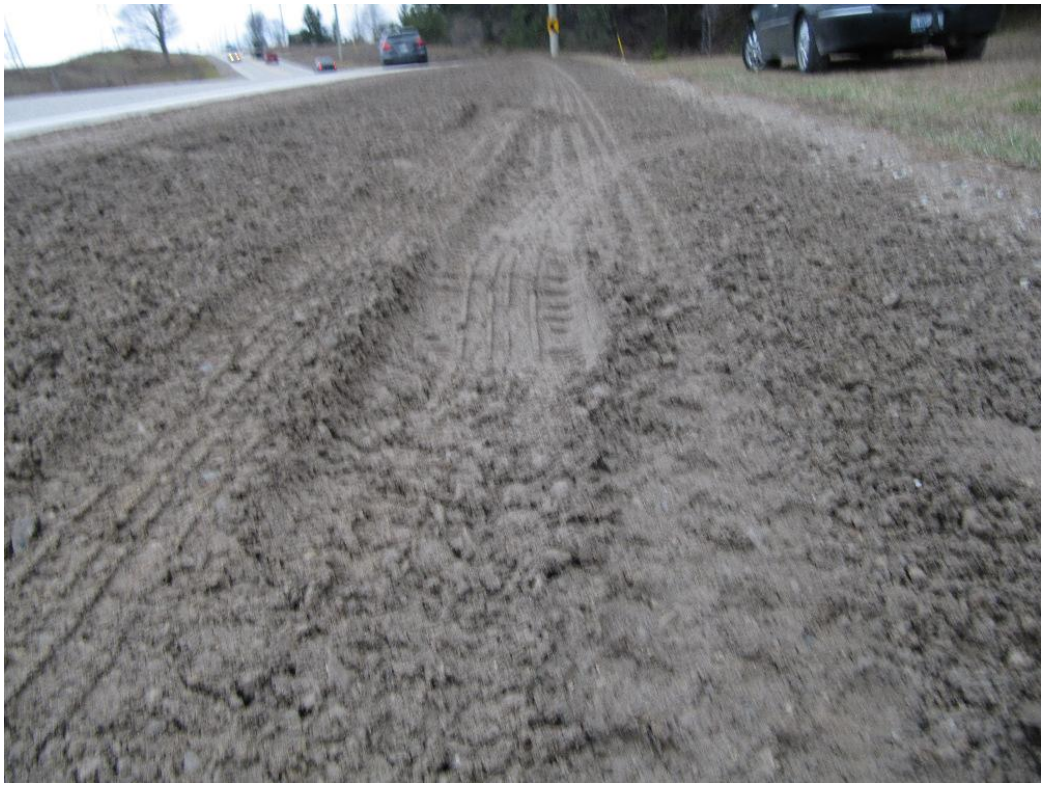

Figure 16

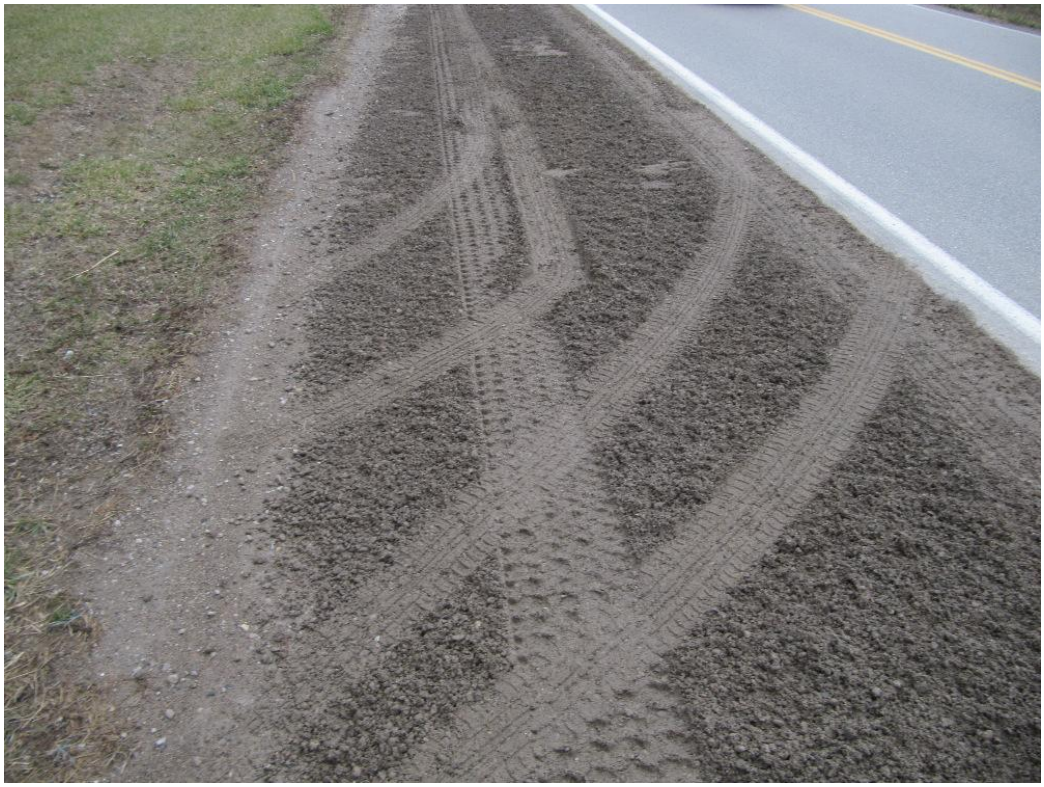

Figure 17

Figure 18 clearly shows the black skid mark on the edge of the pavement caused by the left front tire while it can be seen that the left rear tire had moved to the right and was sliding on the gravel near the end of the brake test. The tire mark caused by a previous vehicle can also be seen passing straight through on the gravel near the edge of the pavement.

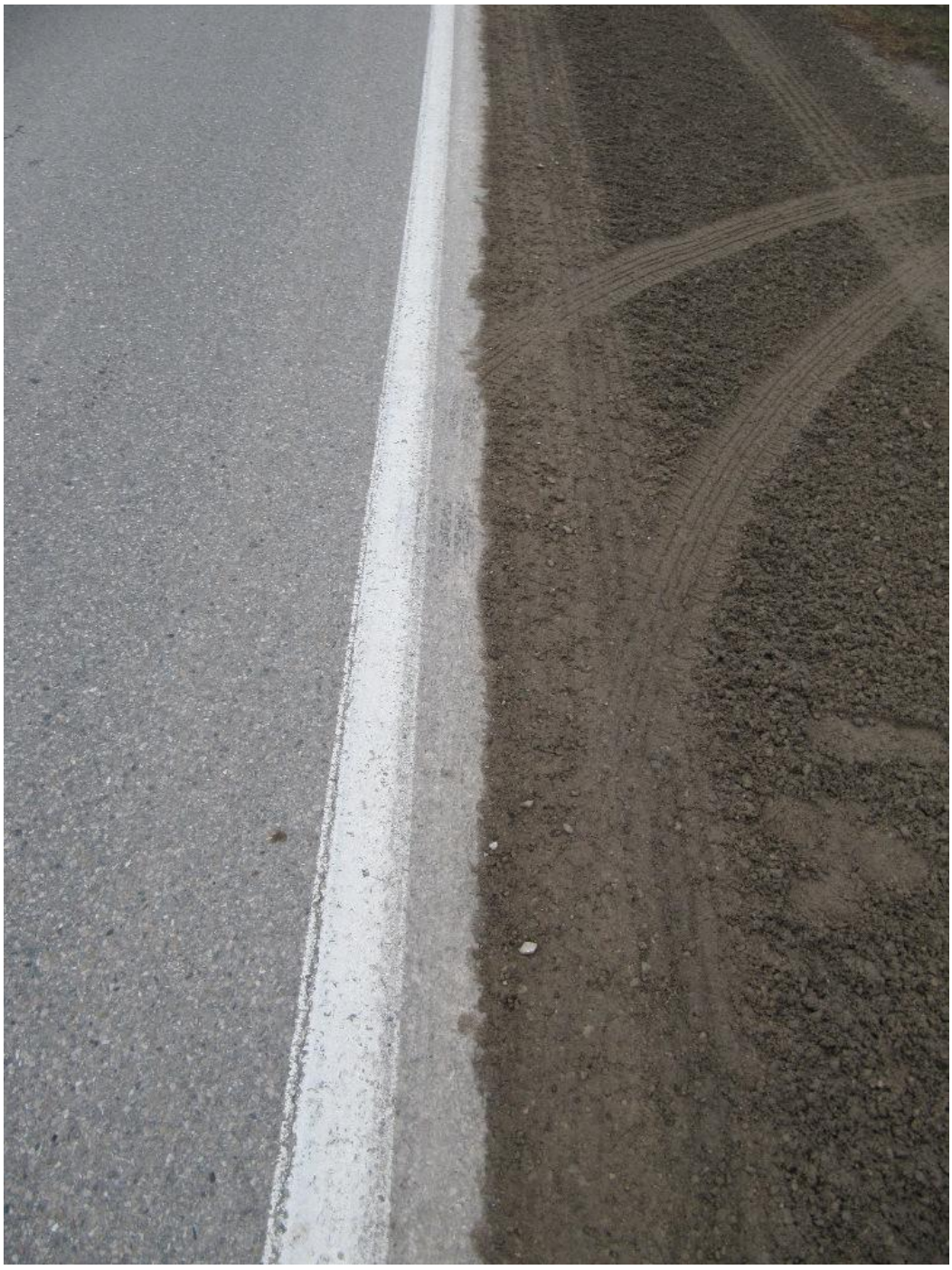

Figure 18

What is clear from our braking test is that our test vehicle began a counter-clockwise rotation even though we performed a straight-line braking test. Note that this rotation occurred at a slow speed of only 45 km/h. What could we expect in an accident scenario where a vehicle might be travelling at the speed limit of 80 to 90 km/h, or perhaps speeding at 100 km/h or higher? We would expect the extent of this counter-clockwise rotation to be magnified. But why did this occur and what importance does it have with respect to vehicular loss-of-control?

Our point is that, historically, researchers have conducted testing to determine how drivers lose control of their vehicles and they came to the conclusion that much of it had to do with the right side wheels of a vehicle exiting the pavement at an edge drop off. It was hypothesized that the inboard side of a tire scraping against the edge of the pavement during the driver's attempt to return to the pavement is what caused a lateral force that was suddenly released when the vehicle mounted the edge drop off and therefore this is what caused the rotation and loss of control. While that mechanism might be one way that a loss-of-control might occur, we believe there has been too much emphasis placed on this single possibility without sufficient proof. Our example, presented in this article, provides an additional explanation that has been essentially ignored.

In our experience, a vehicle exiting a roadway pavement often does so only with its right side tires, as demonstrated in our test. When this happens at highway speed the right side tires experience a deceleration by plowing over the gravel. The deceleration is larger on the right side tires than the left side tires which remain on the smooth pavement. This deceleration is experienced by the driver as a pull to the right or toward the shoulder. At this time the driver may have the urge to counter this by steering to the left, and/or to brake. As demonstrated in our test, applying hard braking has the opposite effect of riding on the gravel since the right side tires will experience less deceleration on the gravel and the left side tires will experience more deceleration on the pavement, and a counter-clockwise rotation is induced. Therefore we suddenly move from a situation where the vehicle wants to rotate clockwise while rolling over the gravel during the initial phrase, to counter-clockwise rotation in the latter phrase when braking and a left steering action are employed by the driver. This is what we believe could be an alternative explanation to why some vehicles enter into a counter-clockwise rotation and their vehicle proceeds into the opposing lane where a crash occurs or, where no opposing vehicle exists, the loss-of-control vehicle continues off the roadside on the opposite side of the road. Little discussion exists of this possible phenomenon.

Regardless of the importance of this theory, this article has also presented the physical evidence that could be expected when vehicles travel onto a shoulder containing loose gravel. In most accident scenarios gravel shoulders will contain a hard-packed characteristic or some of the gravel may even be removed near the asphalt edge. As a result tire marks would be less visible under these conditions. It is a difficult task because in many investigations of loss-of-control on a rural highway it is very important to capture the point where the vehicle first encountered a problem and this is often near the point where the vehicle enters a gravel shoulder for the first time. The evidence of this egress is very fragile and is often destroyed by others who stop their vehicles on a

shoulder in order to assist or by police and other emergency vehicles that stop on a shoulder without realizing that they are destroying important evidence. An observant investigator who knows where to look and what to look for can sometimes uncover the crucial facts that lead to how and why a loss-of-control collision occurred.

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