2012 Ford Fusion Brake Testing With iPhone Accelerometer - Test # 5 On Bare Tar & Chip Surface

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This is the second in a series of four articles discussing the results of emergency braking tests performed by Gorski Consulting with a 2012 Ford Fusion passenger car. The first article introduced the instrumentation used in the testing as well as the description of the video project that was analysed to develop our test results. A third article will discuss our Test # 17 which involved our maximum braking while travelling partially onto a gravel shoulder. A fourth article will provide further study of that test.

The current test was performed while travelling northbound on Clarke Road north of Medway Road on the north-east outskirts of London, Ontario, Canada. The test was performed on a relatively mild, February 24th day in 2013 while the ambient temperature was near zero degrees Celsius. The pre-braking speed of the vehicle was 80 km/h. The photo below shows a northward view of the road just after the braking test was completed and the test vehicle was driven onto the right shoulder.

The photo below shows the view along the left skid mark which appears to be faint in the foreground but becomes more visible in the background.

Similarly, the photo below shows a northward view along the right skid mark.

The photo below shows the characteristics of the left skid mark after we have walked about halfway toward its point of termination. It can be seen that the skid mark becomes quite visible.

Similarly the photo below shows the right side skid mark from about its half-length. Again the skid mark is quite visible.

The photo below now takes us closer to the north termination point of the left skid mark.

And similarly, the photo below shows the right skid mark to the north end of its termination point.

The photo below shows a northward view of the left skid mark near its north termination point.

And the photo below shows the same northward view of the right skid mark near its termination point.

If you look closely at the last two photos you should be able to detect the evidence of our rolling tires as they move from the stop position of the brake test as we steer hard to the right to park our test vehicle on the right shoulder. This might be helpful to make a further comparison between a skid mark and a rolling tire mark that was made within seconds after the vehicle came to a halt from the braking test.

When looking at the characteristics of the braking skid marks one can appreciate that there is some evidence of pulsation of the anti-lock braking system as the black mark contains periodic darker and lighter segments along its length. We can indicate that, unlike older anti-lock braking systems this newer one did not give the vibration sensation of the brake pedal as it was in the anti-lock mode.

The video cameras installed around our vehicle recorded some interesting data which was visible in the Adobe Premiere project that was created from this testing. Below is a screenshot taken from our monitor showing the Premiere project with five camera views.

Details of the camera locations are discussed in our first article.

The above shot is taken precisely when the driver's foot began pressing on the brake pedal. The view of the driver's foot can be seen in the centre-top view.

In the upper left corner we can see the view from GoPro22 which shows the speedometer indicating "80 km/h" just before the vehicle began its deceleration.

The larger view in the lower left is taken from the camera mounted on the exterior of the driver's side window and we can see the roadway centre-line and front end of the vehicle. It is possible to compare the position of the centre-line to various contours of the vehicle to determine whether the vehicle is moving laterally or rotating during the braking test.

The image in the lower right of the screenshot shows the steering wheel and protractor attached to it. We can view this video to assess whether any steering what applied during the braking test and whether that might have affected the test results.

At the upper right of the screenshot is the display from the iPhone 4s which shows the tri-axial acceleration of the vehicle during the test. The first number ("-0.13) indicates the longitudinal acceleration or "deceleration" of the vehicle. The second number (0.20) indicates the lateral acceleration.

The third number (-0.73) indicates the vertical acceleration with a normal resting position indicating "-1.00" meaning that the vehicle is experiencing a -1.00 g acceleration from the earth's gravitational pull.

Below is the status at the first documented deceleration value at the beginning of the braking test. The driver's foot has now fully depressed the pedal and we see the "x" deceleration is "-0.42" whereas the other two (lateral and vertical) values show minor magnitudes. This condition is only about 0.10 seconds after the first contact of the brake pedal.

Below (top of Page 12) we show a screenshot about 0.53 seconds after initial brake pedal contact . Here we attain one of the spikes of high deceleration of "1.18" g.

And the screenshot below is of another spike when the deceleration reaches "1.24" g at about 1.73 seconds after the initial brake pedal contact. Here you can see that the speed has dropped to about 32 km/h.

Also, by comparing the location of the centre-line with respect to the edge of the driver's mirror, or perhaps the left side of the vehicle we can see that the vehicle has moved slightly to the right. Obviously this view could also have occurred if there was a slight rotation of the vehicle and one would have to examine other evidence to determine which of these actually occurred. This why it is helpful to have a number of different cameras to compare the vehicle's position to various land marks. The present set-up has used a minimal number of cameras however in other tests we have set up cameras at individual tires as well as a view from behind the vehicle by a camera attached from a bicycle rack.

The screen shot below is the status at the end of the braking test just as the vehicle comes to a halt.

Although the video cameras show that the motion of the vehicle has been completed the speedometer is still reading as speed of about 5 km/h. So such a delay in the response of the speedometer has to be kept in mind when using this as the only source of documenting speed. We have considered attaching a scanner to document the internal data being provided by the wheel speed sensors and this is something we may do in the future. For now it is useful to just document how the speedometer functions and how this relates to information from the other instruments/cameras.

If you look at the display from the iPhone you should be able to see the display of the raw data being graphed. It is not easy to see the full extent of these vibrations until we proceed past the end of the test so at the top of the next page (Page 14) we have shown a screenshot that is 1.0 second past the end of the braking test and here we can see how the graphing of the accelerations shows minimal vibrations to the left and right while in the middle we see the complete test.

In particular the red line shows the status of the "x" or longitudinal acceleration. It can be seen how that red line drops down during the test so that its values have migrated to the blue line which is showing the vertical acceleration. This condition is a little clearer in the close-up view shown in the screenshot below.

It is interesting that the lateral acceleration line is yellow before the test begins but then turns green as the vibrations of the test are displayed and then it returned to its yellow colour after the test is completed. Similarly we see a white line intermixed with the red line (longitudinal acceleration) and the blue line (vertical acceleration). It is not clear at this time if either the red line or the blue line is temporarily being displayed as white. The reason why these changes in colour occur is still being evaluated. However we see no reason to believe that the reliability of the displayed values is being compromised.

The summary sheet below shows the detailed results from our test and the decelerations that we obtained.

Skid Test # 5- February 24, 2013

Test Location	NB Clarke Rd
Speed of Skid Test (km/h)	80.00
Timecode at Start Brake Pedal Depression	00;26;43;12
Timecode at High-Mounted Brake Light Illumination	Unknown
Timecode at Taillight Brake Light Illumination	Unknown
Timecode At Vehicle Stop (Via Camera 28)	00;26;45;26
Total Braking Time (Seconds)	2.47

Timecode	G Value (x)
00;26;43;15	-0.42
00;26;43;20	-0.87
00;26;43;25	-0.85
00;26;44;00	-0.83
00;26;44;05	-0.94
00;26;44;10	-0.97
00;26;44;15	-0.92
00;26;44;20	-0.84
00;26;44;25	-0.80
00;26;45;00	-1.12
00;26;45;05	-0.89
00;26;45;10	-0.93
00;26;45;15	-0.78
00;26;45;20	-0.87
00;26;45;25	-0.91
Average G =	**-0.863**

Overall, we see that the values displayed by the iPhone accelerometer and application used to obtain that data (XSensor app) do not appear to be overtly erroneous. When we used the average deceleration (-.863 g) obtained from the accelerometer in a typical slide-to-stop formula the result is similar to the deceleration rate that would be needed to bring the vehicle to halt as observed from the video cameras.

There is some ambiguity about the starting point that should be used for documenting the first deceleration value and this has an effect on the deceleration calculations. For the present tests we have been starting to document the deceleration within a few milliseconds after the we observe that the driver's foot is pressing on the brake pedal but the pedal has not been pressed to its full down position. The result is that the first deceleration reading is rather low. When we are braking on a very aggressive surface and/or at a lower speed then the number of deceleration values we obtain from the test can be small since we have been documenting readings at every five frames. So, for example, the present test was completed in about 2.47 seconds and only 15 deceleration values were documented. If the first of those values is very low it may have an effect of causing an underestimation of the average deceleration, or it may simply reflect the reality that the deceleration takes time to develop. This is less of a problem when we are conducting braking tests over more slippery surfaces where the test might last for 7 seconds or more and thus the number of deceleration values that we obtain from the test is much larger. But these are just some of the pitfalls of using the instrumentation and procedures that we do.

The third and fourth articles in this series will provide a description of a test that we performed while driving the right side wheels on the right gravel shoulder of Medway Road which is a two-lane rural highway. The left side wheels remained on the bare asphalt surface. We will see some interesting counter-clockwise rotation of the vehicle during the test even though we apply some significant counter-steering to the right. Detailed photographs will be shown of the characteristics of the tire marks as this braking and rotation occurred. This will provide a means of comparing the results from the present test as the exact same instrumentation was used in both tests.