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# THE EFFECT OF TIRE PRESSURE ON THE DECELERATION OF A MOTORCYCLE UNDER APPLICATION OF THE REAR BRAKE ONLY

By Louis Peck, Eric Deyerl and Nathan Rose

## INTRODUCTION

The testing reported in this article examined the effect of tire pressure on the deceleration rate of a non-ABS motorcycle with full application of the rear brake only. This testing was conducted for a single motorcycle and for a single make and model rear tire. In general, the contact pressure (or contact area) between a tire and the roadway will depend on the following variables: load on tire, inflation pressure, tire carcass stiffness and shape, and the tire surface rubber depth and softness. This study utilized the variable of tire pressure to accomplish variation in the contact pressure and area.

McIsaac and Garrott [2002] examined the effect of tire pressure on the peak and slide friction coefficients of friction for a passenger car tire, using a skid trailer (Figure 1) to test the tire at 35 psi and 17 psi. They found that the peak coefficient of friction decreased by an average of 7% when the inflation pressure was lowered from 35 to 17 psi, while the slide coefficient of friction showed little or no influence of inflation pressure. This finding is generally consistent with other testing that utilized a skid trailer [Collier, 1980], but contrary to studies that have utilized full-scale vehicle testing.

Baumann, for instance, performed full-scale vehicle testing using a Mercedes Benz CLK to examine the effect of tire pressure on tire marks and deceleration rates produced during emergency braking with three different tires (summer, winter, and run-flat) [2009]. For the summer and winter tires, the pressures were varied between approximately 19, 33, and 48 psi. For the summer and winter tires, the highest deceleration rates were achieved with the lowest tire pressures. For the winter tire the lowest deceleration rate occurred at the middle pressure, whereas for the summer tire, the lowest deceleration rate occurred at the highest pressure. For the run-flat tire, the pressure was varied between 33 and 0 psi and deceleration at 33 psi was higher than that at 0 psi.

Rievaj, Vrabel, and Hudak [2013] conducted full-scale vehicle testing with a Citroen C6 equipped with Michelin Primacy tires and examined the effect of tire pressure on the deceleration rates produced during emergency braking on dry asphalt. The initial speeds for their tests were approximately 31 mph (50 kph). The tire pressures were varied between 20% underinflated, inflated according to the manufacturer recommendation, and 20% overinflated. They found the highest deceleration rates occurred with the underinflated tires and the lowest deceleration rates occurred with the overinflated tires.

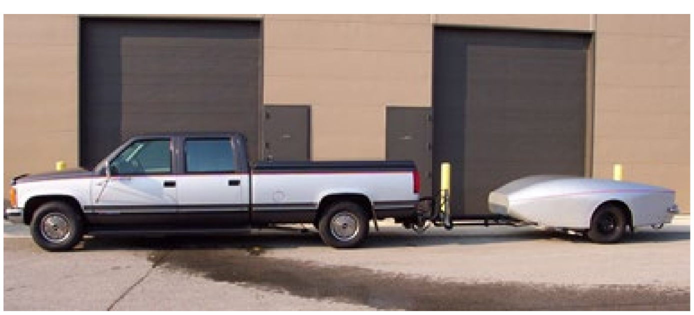

*Figure 1 – Skid Trailer used by McIsaac and Garrott*

## MOTORCYCLE AND RIDER

This testing utilized a 2003 Suzuki GSF1200S Bandit equipped with Michelin Pilot Road radial tires (Figures 2 and 3). The Suzuki is equipped an independent, non-ABS braking system with hydraulic dual-disc brakes on the front and a single hydraulic disc brake on the rear. During testing, the motorcycle was operated by an expert rider and the combined weight of the motorcycle and rider was 724 pounds (391 lbs front / 333 lbs rear). The front-to-back weight distribution was documented with the rear tire at 40 psi and at 20 psi, and there was no change.

## TEST LOCATION AND SETUP

This testing was conducted on April 18, 2017, at around 6 p.m. on a dry asphalt roadway in the 5800 block of Uplander Way in Culver City, California, depicted in the Google aerial photograph below, where north is up (Figure 4). The braking tests were run from a nominal speed of 30 mph, all eastbound, with rear tire pressure at 40 psi for three tests and 20 psi for three tests. The front tire was inflated to the manufacturer recommended tire pressure of 36 psi for all tests. The accelerations and speeds during these tests were documented with a Racelogic VBOX Sport, which records at 20 Hz.

Prior to running the tests, the effect of inflation pressure on the size of the rear tire contact patch, sans rider, was documented. This was accomplished by suspending the rear tire of the motorcycle over a sheet of paper using a rear swingarm stand (as depicted in Figure 5). The tire pressure was then set to either 20 or 40 psi and white paint was applied to the tire (see Figure 6). The tire was then lowered onto the paper leaving a paint impression of the contact patch on the paper. Figure 7 shows a scan of the impressions next to a scale.

*Figure 2 – 2003 Suzuki GSF1200S Bandit*

## RESULTS

Figure 8 shows the rear tire contact patches for the two tire pressures. The size of the rear tire contact patch was 46% larger at 20 psi than at 40 psi.

Figure 9 is a speed time history for each test, where a time shift has been applied to each curve to ensure each test is independently visible. Table 1 summarizes the initial speed and overall deceleration for each test. For the tests at 40 psi, the three tests yielded the following deceleration rates (g's): 0.324, 0.321, 0.327. This results in an average deceleration of 0.324 g's. For the tests at 20 psi, the three tests yielded the following deceleration rates (g's): 0.341, 0.339, 0.338. This results in an average deceleration of 0.339 g's. Thus, the average deceleration rate was 5% greater at 20 psi than at 40 psi. These deceleration rates were calculated by dividing the change in speed by the change in time for the steady state portions of these curves.

Figure 10 shows rear-wheel skid marks from all six braking tests reported here. In this figure, the skid marks have been labeled with their test number and their approximate visible length. These tire marks vary in length between 52½ and 59½ feet.

*Figure 3 – Rear Tire on the Motorcycle*

*Figure 4 – Roadway used for Testing (Culver City, CA)*

## DISCUSSION AND CONCLUSIONS

For the tests reported here, the deceleration rate produced by locked-wheel, rear-brake only braking was higher at the lower tire pressure than at the higher tire pressure. For both tire pressures (20 psi and 40 psi), the level of deceleration achieved in the tests was in the range of those reported by other studies that have examined rear-wheel only braking, though perhaps on the low-end of those other studies.

Fries, Smith, and Cronrath [1989] performed testing with five different motorcycles and reported deceleration rates from rear-wheel only braking between 0.31 to 0.52g. Hunter [1990] reported braking tests conducted by the Washington State Patrol on a dry, level roadway with Kawasaki 1000 police motorcycle. For deceleration tests with rear braking only, Hunter reported deceleration rates between 0.35 and 0.36g. Bartlett [2000] reported testing with four motorcycles. For tests that utilized only the rear brake, the maximum deceleration rates between these four motorcycles varied between 0.38 to 0.46g. Bartlett, Baxter, and Robar [2007] reported hundreds of brake tests from reconstruction classes conducted at the Institute of Police Technology and Management (IPTM) between 1987 and 2006. The data set in this study included 275 rear brake only tests, which resulted in a range of deceleration rates with a mean of 0.37g and a standard deviation of 0.06g. Dunn [2012] reported and analyzed braking test data and tire marks for three motorcycles and reported deceleration rates for rear-wheel only braking between 0.345 and 0.416. It is worth noting that, in some of these studies, the authors reported if a rear tire skid mark was deposited, but in others this was not reported. This sampling of test data could include tests where the rider maximized their braking effort, but did not lock the rear tire or

**TABLE 1 – Summary of Brake Test Results**

| Test Number | Tire Pressure (psi) | Speed at Onset of Braking (mph) | Average Deceleration Rate (g) |
|---|---|---|---|
| 1 | 40 | 28.5 | 0.324 |
| 2 | 40 | 26.9 | 0.321 |
| 3 | 40 | 28.4 | 0.327 |
| 4 | 20 | 26.4 | 0.341 |
| 5 | 20 | 27.0 | 0.339 |
| 6 | 20 | 26.0 | 0.338 |

*Figure 5 – Rear Wheel of Motorcycle Suspended on Stand Above Paper*

*Figure 6 – Paint on Tire After Lowering it Onto the Paper*

generate a skid mark. Such tests would generally produce higher deceleration rates than tests where the rear tire locked.

Other studies have reported findings consistent with the subject finding that the motorcycle deceleration rate was influenced by the inflation pressure of the rear tire. That said, this study examined only a single motorcycle with a single tire. Further testing would be necessary in order to draw generalized conclusions applicable to any motorcycle and any tire. The difference in deceleration rate with the different tire pressures was small enough in this testing that reconstructionists would be warranted to continue applying a range of deceleration rates, simply recognizing that the tire pressure is one of the variables that goes into the mix of creating the range, originally. Realistically, the reconstructionist will not know the actual tire pressure for a motorcycle involved in a collision in most instances.

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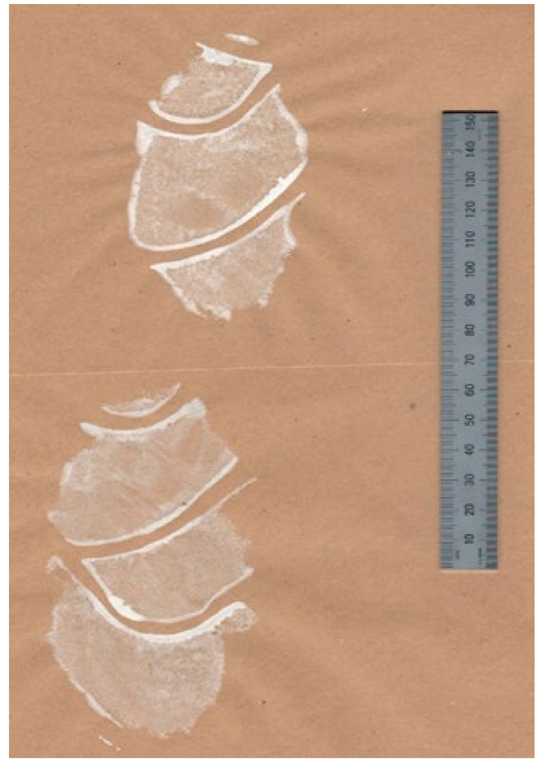

*Figure 7 – Scans of the Paint Marks from the Tire Contact Patches*

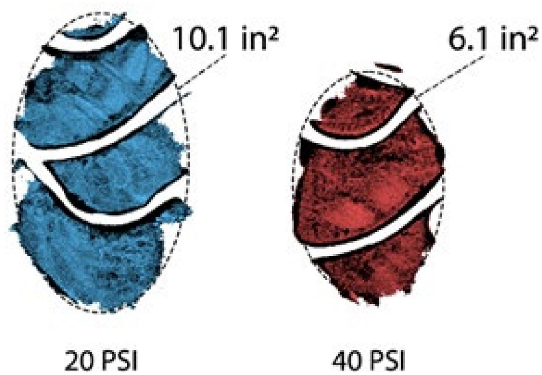


*Figure 8 – Contact Patch Sizes at Different Pressures*

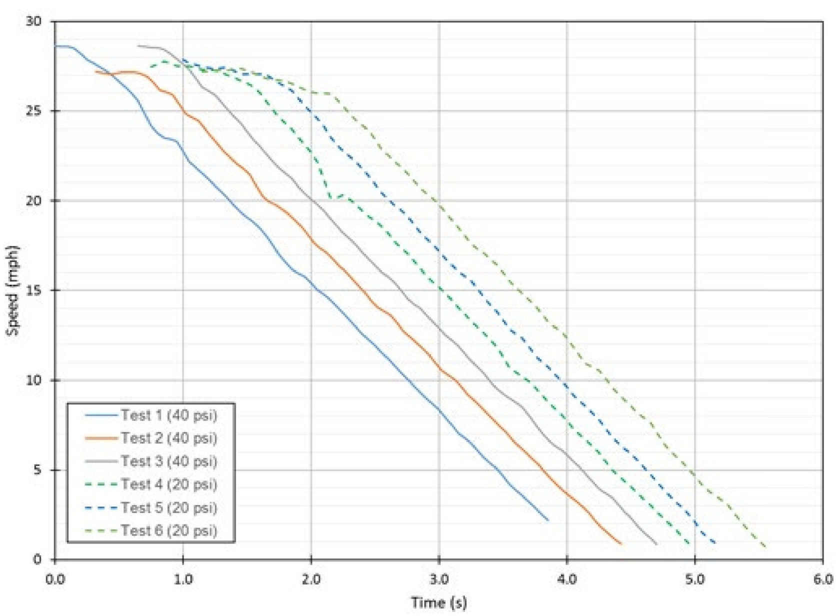


*Figure 9 – Speed versus Time Plot for All Six Tests*

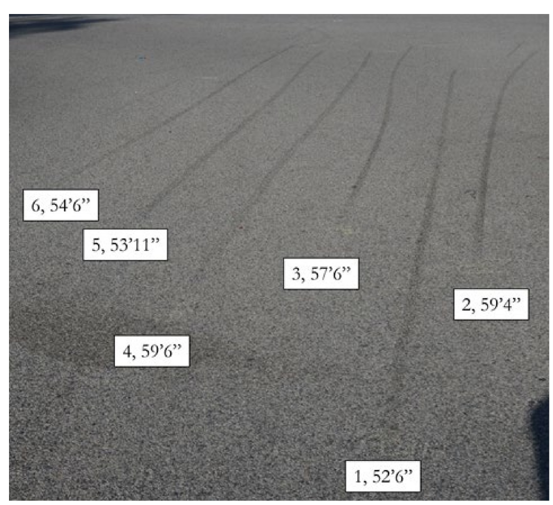


*Figure 10 – Skid Marks from the 6 Tests*