DO I BRAKE OR DO I SWERVE – MOTORCYCLIST CRASH AVOIDANCE MANEUVERING

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ABSTRACT

Motorcycle safety often depends on the ability of a rider to rapidly and reliably avoid obstacles. Motorcycles are highly maneuverable vehicles that can be steered around as well as rapidly slowed to avoid objects and obstacles in their path. Additionally, motorcycles are narrow which further enhances their ability to maneuver around an obstacle. When a rider chooses to either brake or steer around an object while performing an accident avoidance maneuver, several factors will affect the outcome of that maneuver. These factors include rider skill, rider training, motorcycle performance, environmental conditions and the nature of the event or obstacle that is to be avoided. While many of these factors cannot be controlled, rider skill can be positively influenced through education and effective training.

In the present research, a series of controlled swerve tests are performed with a sport type motorcycle to demonstrate the speed and execution of an obstacle avoidance maneuver. The swerve type maneuver is investigated using active, purposeful countersteering with minimal rider body lean. Comparisons are presented between stopping distance and swerve avoidance distance.

INTRODUCTION

A rider who is faced with an obstacle in the roadway must often make an immediate decision regarding the best method by which to avoid interaction. The rider's choices are either to swerve, to brake, do both, or to perform no action at all. The outcome of this choice will either be a successful avoidance maneuver or a collision. In order to perform this avoidance maneuver, it may be necessary for the rider to leave the usual 'comfort zone' and approach the performance limit of the motorcycle. In the case of a modern sport bike, the performance limit may be very high and may require a great deal of training and experience in order to exploit it in an emergency situation. In addition to the necessary training and experience in controlling the motorcycle, the rider must also have some understanding of the options available (turning or braking) and how much distance each of these options requires in order to avoid a collision. This paper attempts to give some insight into the relationships between speed and distance and how different maneuvers will affect the outcome of a given situation.

PERCEPTION-REACTION TIMES

The intent of the present research is to compare the distance required to perform an avoidance maneuver once the control inputs have been initiated. The time and distance covered during the perception and recognition of a hazard and the time and distance covered while the rider decides what maneuver to perform is not addressed in this present research. Rider experience and attentiveness has been previously demonstrated to have a great deal of influence on the total perception reaction time. Riding strategies such as covering the brake will allow a rider to achieve brake perception-reaction times of less than 1 second [Hurt, 1984; Ecker, 2001]. Since the rider's hands are positioned on the handlebars while riding, it is expected that for a highly alert, attentive rider, steering perception reaction times may be of similar magnitude.

STATISTICS

A considerable amount of reported collisions occur with fixed objects. Since motorcycles have a narrow frontal profile, opportunities may exist to mitigate these collisions through a greater understanding of a motorcycle's swerve capability. NHTSA reported [NHTSA, 2002] 28% of fatal motorcycle collisions were with fixed objects while another study, the Geo-demographic Analysis of Fatal Motorcycle Crashes [NHTSA, 2001] found 28% of fatal motorcycle crashes were with a fixed object.

When examining motorcycle evasive action, the *Hurt Report* [Hurt, 1981] indicated 31% of riders took no evasive action, 36% of riders executed evasive maneuvers that involved braking only while 17% of maneuvers involved swerving. Upon closer examination, it was found that 50% of the evasive maneuvers were not properly executed and 36% of the maneuvers were not proper for the situation. Twenty years later, the *Thai Report* [Kasantikul, 2001] reported that 37% took no action, 39% involved some form of braking, and 21% involved a swerve. Therefore, it would appear that a brake avoidance maneuver is chosen more often than a swerve.

ALTERNATIVE OBSTACLE AVOIDANCE STRATEGIES

Combining swerving and braking as suggested in MSF training materials may be an effective tactic for obstacle avoidance. However, this combination maneuver is not studied in this present research.

Another obstacle avoidance strategy, where the rider 'lays down' his motorcycle, is seen in real world motorcycle crashes. This is a poor crash avoidance strategy and can be understood by analyzing the relative performance of either a swerve or braking maneuver. This laying down maneuver usually starts with improper braking which leads to lock up of either the front or rear wheel. Lockup then results in a loss of stability at that end of the motorcycle and a large increase in roll and/or yaw. This results in the motorcycle falling over onto it's side. While falling, the motorcycle is undergoing little deceleration. Once the motorcycle has touched ground, it will continue a slide on plastic and metal components at a deceleration rate significantly lower than the braking capability of an upright motorcycle [Carter, 1996; Medwell, 1997]. Therefore, laying down the motorcycle will generally result in significantly longer stopping distances than what can be achieved with proper brake application. The longer stopping distance increases the potential for a collision.

SWERVE

To enhance rider performance in traffic situations, the Motorcycle Safety Foundation (MSF) has developed the SIPDE mnemonic (Scan, Identify, Predict, Decide, and Execute). The execute phase involves communication of movement, possible speed adjustment (braking) and possible roadway position adjustment (swerve). The decision to execute either a swerve maneuver, brake maneuver or a combination of the two may be critical in the ultimate outcome of the collision avoidance. The Advanced Rider Course Handbook demonstrates two situations where a swerve may assist the rider in avoiding a collision (Figure 1). When a hazardous situation is encountered, a more detailed understanding of swerving versus braking performance may improve the outcome for the rider.

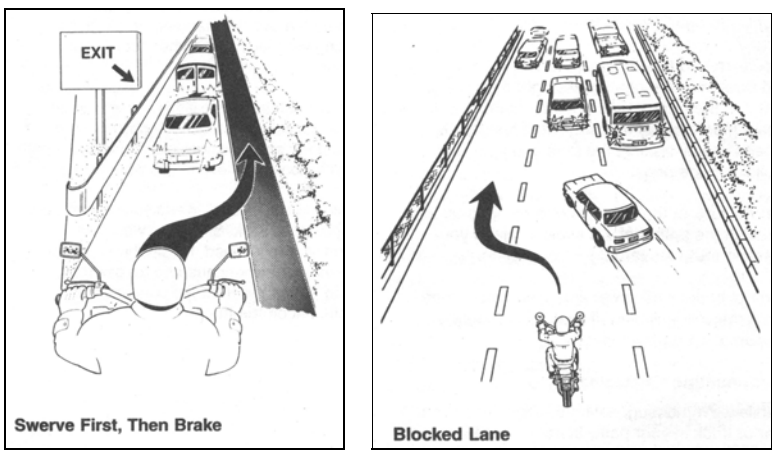

Figure 1. MSF Advanced Rider Course excerpts.

TEST PROCEDURE

Instrumented obstacle avoidance maneuvers were performed with a single rider operating a modern sport type motorcycle. Two lateral offset distances, 6.5 and 13.0 feet (2 and 4 meters), were tested. The test procedure called for the rider to approach the test area at constant speed of between 25 and 40 mph (40 and 64 kph) and then perform a rapid swerve maneuver.

The rider held a current State of California, Class M1 motorcycle license and possessed moderate street riding experience. He has received MSF training and was the owner of the test motorcycle (high familiarity with the motorcycle).

The motorcycle utilized in the testing is a 2004 Honda RC51 sport type motorcycle. It was in stock configuration and verified to be in good mechanical condition.

The motorcycle was fitted with a Racelogic VBOX III GPS based data acquisition system. Position and velocity data was collected at 100 Hz and processed using the Racelogic software. The testing was videotaped and photographed.

The test course was a well traveled, smooth, asphalt roadway with negligible grade and superelevation. Temporary pavement markers and orange cones were used to delineate the test course. The test course was one hundred and fifty feet long and consisted of two, parallel lanes (Figure 1) with sufficient approach to allow the motorcycle to be in a steady state as it entered the course. Three distinct zones defined the course: approach, transition and stabilization. In the test the rider approached along the baseline, made a left hand lane change in the transition area, entered the stabilization area and proceeded to the end of the course. The rider attempted to maintain a steady speed of between 25 and 40 mph (40 and 64 kph) throughout entire run.

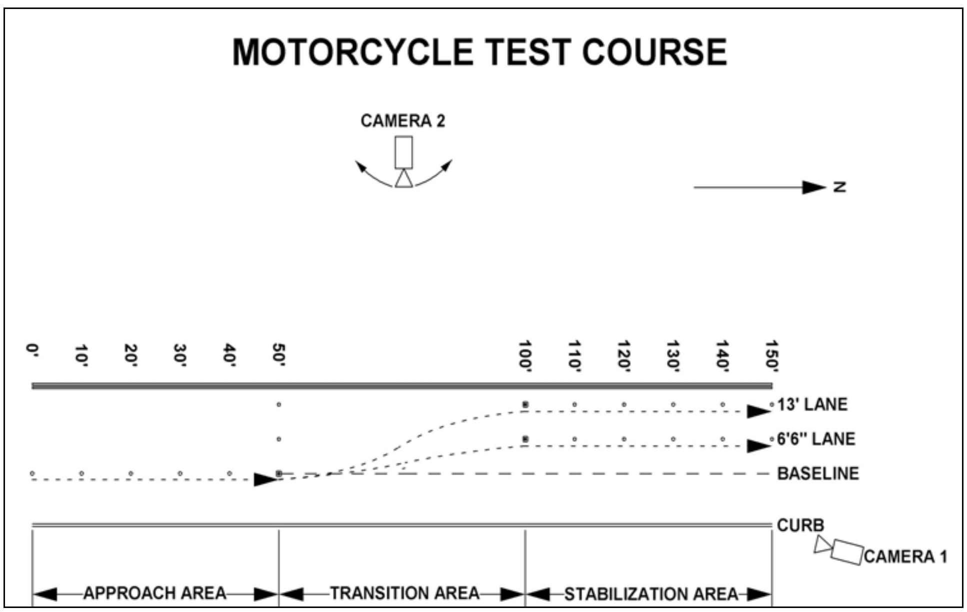

Figure 2. Test Course Configuration

TEST RESULTS

A series of 30 test runs were performed. The video tapes and the digital data were utilized to determine the lateral and longitudinal distances of the motorcycle at various positions through the swerve maneuver. The analysis of the electronic data as well as the videotape indicates that a swerve involves a sequence of cornering maneuvers from the initial countersteer to the final orientation of the motorcycle.

The beginning and end points of the swerve have the motorcycle upright and proceeding down the roadway at laterally offset roadway positions. The total swerve distance involves multiple steering inputs by the rider and a sequence of responses by the motorcycle. This total swerve distance is contrasted with the shorter distance whereby the front and rear tires have successfully moved laterally the desired distance. This wheel clearance distance may be sufficient to clear short roadway hazards even if the total swerve is not yet complete.

Since obstacle size varies in the real world, it is helpful to consider both the total distance for the swerve as well as the time for the wheels to clear the desired lateral offset. Figure 3 graphically compares these two concepts of swerve distance and Table 1 summarizes the results of the present testing. As seen in Table 1, it takes less time and distance to avoid an object near ground level than to avoid larger obstacles.

Figure 3. Swerve Maneuver

Table 1. Testing results.

SPEED		LATERAL MOVEMENT		WHEELS TO CLEAR		TOTAL SWERVE	
MPH	(KPH)	FEET	(METERS)	FEET	(METERS)	FEET	(METERS)
UP TO 30	(48)	6.5	(2)	47	(14.3)	69	(21.2)
UP TO 30	(48)	13	(4)	56	(17.0)	78	(23.9)
35	(56)	6.5	(2)	50	(15.2)	73	(22.2)
35	(56)	13	(4)	65	(19.8)	100	(30.3)
40	(64)	6.5	(2)	60	(18.3)	95	(28.9)
40	(64)	13	(4)	86	(26.2)	115	(35.0)

MOTORCYCLE BRAKING PERFORMANCE

Motorcycles have very high braking deceleration capability. Rider training, experience, and skill level will determine how much of this braking performance can be achieved under real world conditions. Since most riders can easily achieve 0.4 g's in deceleration levels, this level can be considered to be moderate braking. The level of 0.6 g's, achievable by many riders without extensive training, is considered to be hard braking in this discussion. The higher level 0.8 g's, a level that generally requires some advanced training and experience, is considered to be very hard braking in this discussion. Highly skilled riders are often capable of deceleration levels above 0.8 g's. Table 2 shows the times and distances associated with 0.4, 0.6 and 0.8 g stops.

Table 2. Time and distance for braking.

SPEED		BRAKE DISTANCE		BRAKING TIME	DECEL
MPH	(KPH)	FEET	(METERS)	SECONDS	g's
30	(48)	75	23	1.7	0.4
35	(56)	102	31	2.0	0.4
40	(64)	133	41	2.3	0.4
30	(48)	50	15	1.7	0.6
35	(56)	68	21	2.0	0.6
40	(64)	89	27	2.3	0.6
30	(48)	38	11	1.7	0.8
35	(56)	51	16	2.0	0.8
40	(64)	67	20	2.3	0.8

SWERVE VERSUS BRAKING

Table 3 compares the tabulated swerve distance results listed in Table 1 to the braking distance calculations listed in Table 2. For moderate (0.4 g) braking, the 6.5 foot (2 meter) and 13 foot (4 meter) total swerve maneuver is performed in an equal to or shorter distance than the moderate stop.

For hard (0.6 g) braking, the 6.5 foot (2 meter) swerve can achieve wheel clearance distances shorter than the required braking but the total swerve distance exceeds the braking requirements.

For hard (0.6 g) braking, the 13 foot (4 meter) swerve generally achieves wheel clearance distances shorter than the required braking except for 30 mph. At 30 mph, the braking distance is 6 feet shorter than the 13 foot (4 meter) swerve required for wheel clearance. However, the 13 foot (4 meter) total swerve distances exceed the braking distances.

For very hard (0.8 g) braking, the 6.5 foot (2 meter) swerve can achieve wheel clearance distances shorter than the required braking except for the 30 mph data. However, the 30 mph wheel clearance was only 9 feet longer than the braking distance. Examination of the total swerve distance indicated that the braking distances are shorter in all tested cases.

For very hard (0.8 g) braking, the 13 foot (4 meter) swerve always takes a greater distance than the required braking.

Table 3. Comparing braking and swerving.

SPEED		BRAKE DISTANCE		DECEL		SWERVE 6.5 feet		SWERVE 13 feet	
MPH	(KPH)	FEET	(METERS)	g's		wheels	total	wheels	total
30	(48)	75	23	0.4		47	70	56	78
35	(56)	102	31	0.4		50	73	65	100
40	(64)	133	41	0.4		60	95	86	115
30	(48)	50	15	0.6		47	70	56	78
35	(56)	68	21	0.6		50	73	65	100
40	(64)	89	27	0.6		60	95	86	115
30	(48)	38	11	0.8		47	70	56	78
35	(56)	51	16	0.8		50	73	65	100
40	(64)	67	20	0.8		60	95	86	115

DISCUSSION

This research presents results from testing a single rider on a single motorcycle. Distances covered during a swerve maneuver may be highly dependent on rider ability and motorcycle capability. It is recommended that further research explore these variables.

The test rider utilized a deliberate countersteer input to maneuver the motorcycle. It is recommended that further research be performed to study different countersteer input techniques and the resulting affect on swerve performance.

The presented data is limited in nature but gives an indication that the swerve maneuver has usefulness in the skill set of a competent motorcycle rider.

Braking and swerving both have advantages and disadvantages in the real world. Braking can significantly decrease the riders speed and subsequent impact severity if the maneuver is not successful. Swerving may prevent a rapidly slowing motorcycle from becoming a hazard to other road users.

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