HUMAN FACTORS IN SKIDDING: CAUSATION AND PREVENTION

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This paper provides a state of the art overview of the human factor in skid accident causation and prevention. Available literature is summarized in two parts. First, the driver and skid potential are covered in terms of driver perception and responses in skid hazardous driving situations. Second, candidate traffic control techniques are reviewed as potential remediation techniques. The detection and appreciation of hazardous situations during wet weather conditions tends to come from knowledge of the fact that it is raining, the pavement appears wet or road alignment is changing (as on horizontal curves). Communicating potential hazards to motorists through static signing is generally ineffective; whereas flashing signals and dynamic displays and advisory speeds at such highway sites are effective in modifying control behavior and presumably in the reduction of loss of control. Specific road geometric conditions can lead to higher than acceptable frictional demands because their difficulty in negotiation is underestimated by motorists. Suggestions are made for readily implementable accident countermeasures and necessary research required for more effective countermeasure development is delineated.

There currently exists an urgent need for the integration of human engineering techniques into skid accident reduction programs. For more than two decades, the highway research community has directed its efforts almost exclusively to studying tire-pavement interactive phenomena. Concurrently, developments of the automotive industry have been primarily limited to radial tires and anti-skid braking devices. No systematic effort to examine broadly based causes of skidding accidents has ever been documented. Most sorely neglected is the cause of all skidding accidents - the driver.

This paper provides an overview of what limited documentation is available regarding the human factor in skid accident causation and prevention. An extensive literature review was conducted to, first, exploit the driver in a potentially skid hazardous environment and, secondly, to describe certain promising human factors remediation techniques. From this synthesis of knowledge, suggestions were formulated regarding direction of future research and development in the area of skid accident reduction as well as suggestions for currently implementable countermeasures.

Summary of Relevant Literature

Currently available documentation regarding the human factor in skid accident causation and prevention is summarized under two primary headings. The first section, the driver and skid potential, relates to accident causation by describing what is known in terms of driver perceptions and responses during driving conditions characterized by skid accident potential. The second section, countermeasures considerations, deals with prevention in terms of a review of candidate traffic control devices capable of reducing skid accidents.

The Driver and Skid Potential

There currently exists a dearth of empirical data regarding driver assessment of skid accident potential. Among hundreds of literature items searched on skidding, only three references were found relative to driver assessment of hazard. The area of greatest research need is field experimentation.

One published item (1) attempted a laboratory study of steering and the detection of skidding by the motorist, but the project was dropped after five years of effort. This study was originated in The Netherlands, and it was not possible to contact the researchers for further information. Another laboratory study (2) was augmented by a small sample of field observations of driver perceptual processes involved in curve negotiations. Visual search patterns and motor control movements were measured on the road, and curve psychophysics, information processing abilities and susceptitility to visual illusions were studied in the laboratory. The major results of the study were a) traditional measures of curve length and central degree were unrelated to accident statistics, drivers' perception of curvature, and drivers' tendencies to decelerate before the curve. b) Two driver-performance indexes of curvature were developed and were found to be significantly related to accidents on curves. Curves' perspective angle (as viewed by the driver) correlated highly with accidents ($r = .51$) but drivers are relatively insensitive to this information. Eye-movement patterns showed that drivers tend to successively fixate the edge-line of the curve before entering it, indicating that drivers perceptually negotiate the curve several seconds before entering it.

A field evaluation of signing to warn of skid hazards at three curve sites under wet and dry pavement conditions (3) peripherally dealt with motorists' cues of skid hazard. During the driver interview portion of the evaluation, drivers were asked if they thought the section of highway they had just driven through might be a skid hazard. Seventy percent of the 305 interviewed motorists assessed the sites as hazardous and cited the following cues:

1. Sharp roadway curvature.
2. Appearance of the pavement.
3. Pavement superelevation (banking).
4. Pavement wetness.
5. Known accident history of the site.
6. Driving behavior of other motorists.
7. Presence of the skid hazard warning sign.
8. Other reason.

The proportion of drivers citing each cue remained fairly constant over all ambient conditions with about one-third citing sharp curvature, about one-sixth citing driver behavior of other motorists, and almost one-third saying that the site was not a skid hazard. During wet pavement periods, some motorists' attention was diverted from sharp curvature to the fact that the pavement was wet or looked slippery. Only 4 out of 305 motorists interviewed cited the skid warning sign as a cue of potential hazard. Three of the four motorists citing the sign as their cue did so during wet pavement conditions. Specific sign conditions cited during wet pavement conditions were: the international symbolic "Slippery When Wet" shield used by itself; the shield with flashing lights; and with both the flashing lights and advisory speed limit. A "Slow When Wet" panel was cited during the dry condition.

Numerous other items of literature cited in the review that relate to elements in the driving environment which contribute to skidding accidents are now summarized as a basis for inferences relative to the effect of those elements upon motorist reaction to a potential skid hazard.

In a report presented during the First International Skid Prevention Conference (4), the driver was recognized as a dominant factor in skidding accidents. An analysis of the driver-vehicle-highway relationship in skidding accidents prompted a listing of matters which are misunderstood by the driver. The directly quoted list is as follows:

1. Friction between tires and road is often greatly reduced when the road surface is wet, increasing vehicle stopping distances very greatly. The effect of wetness on slipperiness varies greatly with different road surfaces, however.

2. Such friction for an emergency stop on most wet road surfaces is much lower in high speed stops. In a quite high-speed stop on a wet road, such friction is almost as low as that on ice.

3. Some road surfaces which are very non-skiddy when dry become treacherously slippery when wet.

4. When a road surface is wet, its slipperiness cannot be judged at all by a motorist looking at it.

5. A shower after a dry spell on a heavily traveled highway may cause the highway, due to oil drippings and road film, to suddenly become very slippery until the rain cleans off the surface - even on the best of road surfaces.

6. Even the slightest swerve, brake application, or speed-up can "trigger" a skid on wet or icy road surfaces. The higher the speed, the more true this is.

7. Unevenly or badly worn tires may result in skidding and loss of control on wet roads, the conditions of which are otherwise excellent.

8. Skidding is especially likely to occur at curves, near intersections, on steep hills, at traffic circles. One reason is greater pavement wear resulting in lowered friction coefficients. These are also places where drivers decelerate sharply, swerve, or otherwise change course rapidly.

9. Many drivers have not developed patterns for action in skids - and understanding of what not to do. These are things which cannot be learned by reading alone - they must be experienced.

Following the generation of that list, the subcommittee made a series of recommendations for remedial measures, one of which was that research agencies should study what motorists know about skidding. However, no such research was cited during the conduct of this literature search.

The role of the driver was included in an analytical systems approach aimed at identifying the interdependence of factors influencing the skidding accident (5). The resulting model was rather complex as can be seen in Figure 1. It was asserted by the authors that the driver's portion of the model is the most difficult to evaluate because of problems in determining the driver's psychological and physiological conditions. A primary factor affecting the driver is his experience, in addition to his psychological and physiological makeup. Components of all three factors are shown in Figure 2; it is the sum total of these interactions which affects the driver's perception of his overt actions which lead to accidents.

The importance of the physical environment as it communicates to the driver was also seen from the model. Figure 3 illustrates the formal and informal sources of communications to the motorist. Formal channels are traffic control devices (signs, signals, markings) specifically intended for the purpose of communication to the motorist. Informal communication is derived from geometrics, guardrails, delineators and roadway alignment. The combination of these elements influences the motorist and elecits a maneuvering response.

A study of driver sensory capability at the Ohio State University (6) has led to a driver's longitudinal control task model derived from the elementary stimulus - response concept of classical psychology. Figure 4 depicts the model in which the human controller is seen to receive vehicle dynamic stimuli and to determine the appropriate response as a function of both his perceptual characterisitics and operating criteria. The combination of models derived by Hankins and Rockwell seem to represent a conceptual description of the driver in a potentially skid hazardous environment.

In a recent study of vehicle and roadway interaction, the requirements placed on the motorist in a potential skid hazard can be seen in terms of the maneuvers which create a frictional demand (7). Applicable driving maneuvers are classified as acceleration, deceleration, and cornering. Deceleration demand has been defined as "numerical" equivalent to pavement frictional requirements. The importance of vehicular deceleration capabilities as they relate to pavement skid resistance is cited in numerous studies (8, and others). The high demand which deceleration places on roads in an emergency stop is illustrated in Figure 5.

Of the basic maneuvers, acceleration generally imposes the least frictional demand since few drivers try to achieve the maximum level of acceleration

Figure 1. Skidding accident systems model (Hankins, 1971).

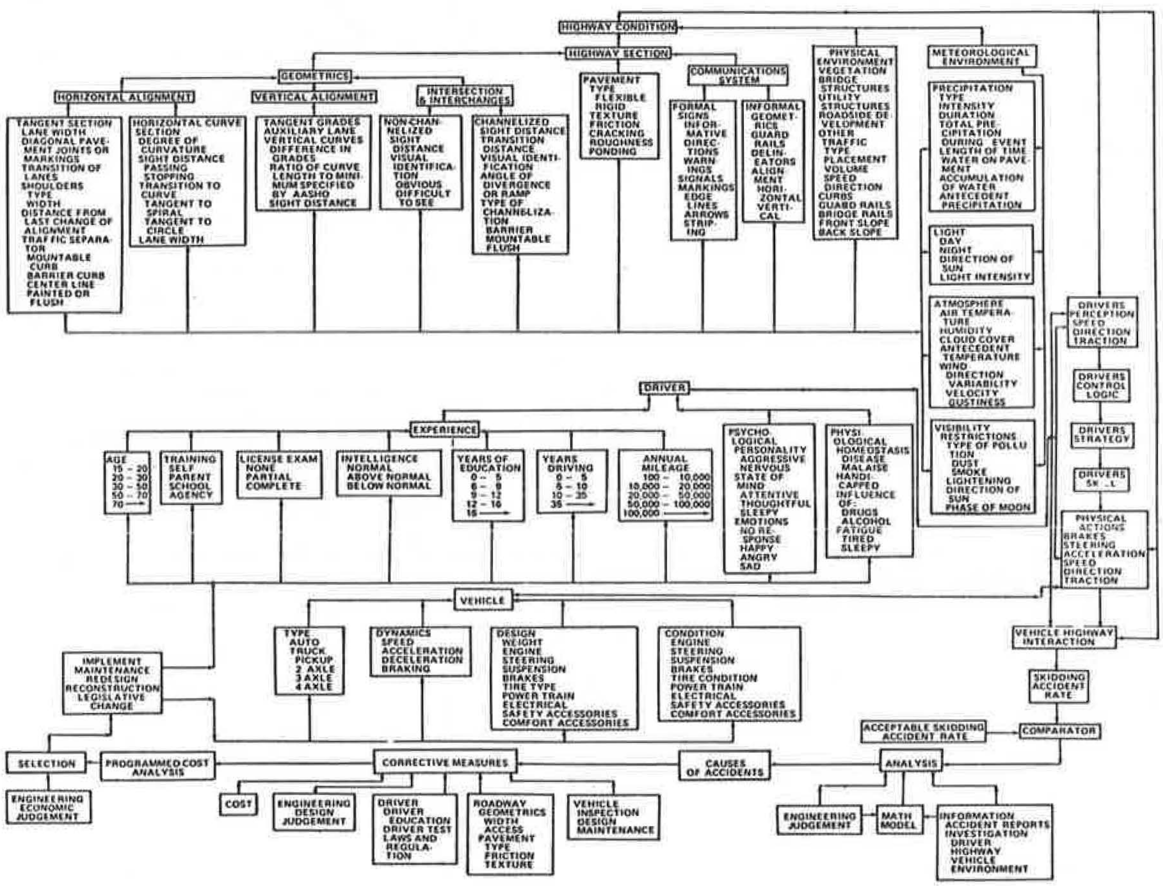
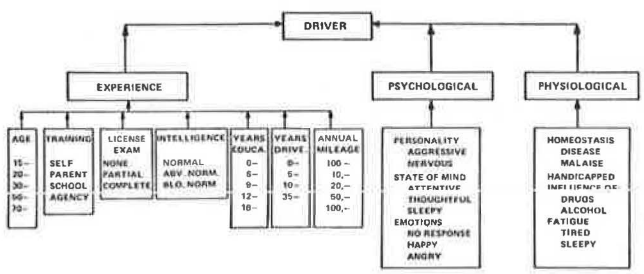


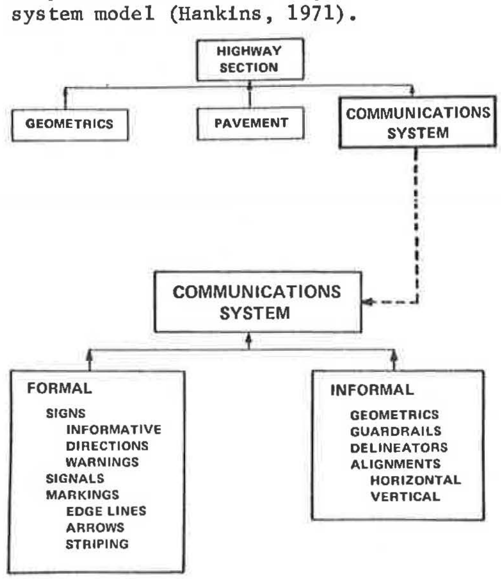
Figure 2. Driver components in the skidding accident systems model (Hankins, 1971).



of which their vehicle is capable. Further, the acceleration capabilities of vehicles are not as violent as deceleration capabilities. Cornering has been one of the principal concerns of skid studies ever since investigations of skidding commenced. Relationships developed for connering forces, by functions such as degree of curvature, have indicated that the maximum cornering force of the 95th percentile driver occurs at a curvature of 20 degrees (9). Recent work has demonstrated that drivers' choice of speed approaching a curve is related to perceived lateral g-forces (10). The driver demands resulting from combinations of cornering and decelerating or cornering and accelerating have not been a subject of published literature to date. Studies of these conditions have been confined generally to an examination of tire performance capabilities.

A recent study by the Texas Highway Department

Figure 3. Communications system components of the skidding accident system model (Hankins, 1971).



(11) regarding maneuvering along horizontal curves indicated that drivers develop much sharper curvature than the design curvature. In addition to providing information relating to skid hazard, the research is intended for use by highway agencies in developing allowable speed values in regulatory speed zoning during inclement weather.

Figure 4. Hypothesized function of driver in longitudinal control task (Rockwell & Snyder, 1968).

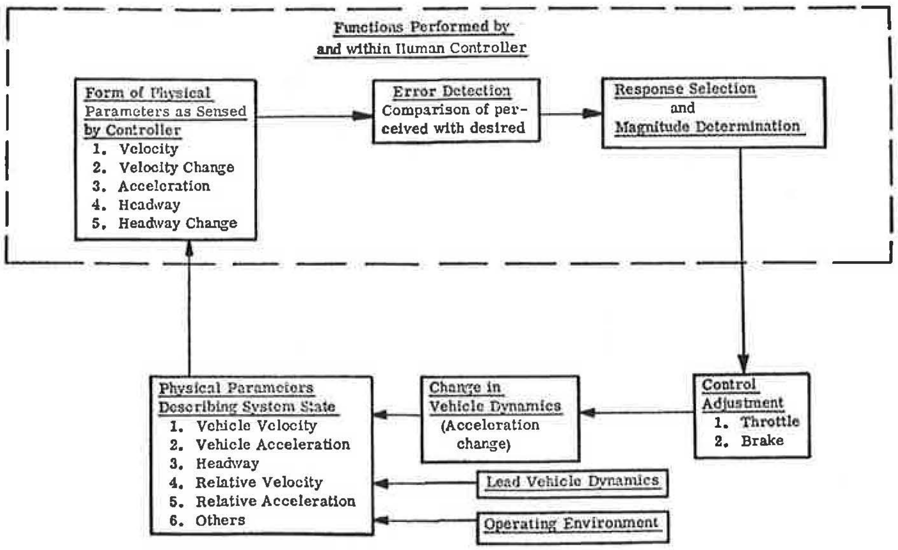
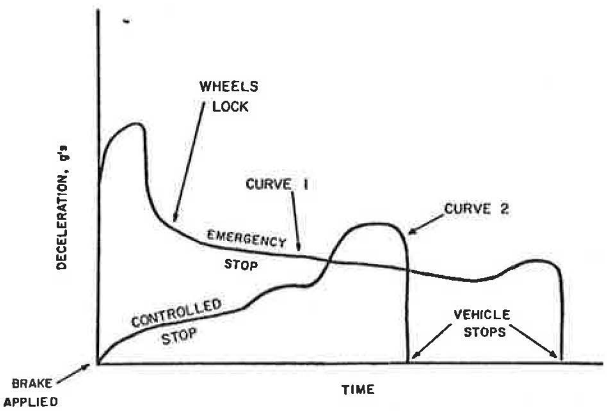


Figure 5. deceleration patterns for controlled and emergency stops (Ivey, 1971).



A later Texas study (7) addresses the issue of driver visibility during rainfall as one factor affecting wet weather accidents. The report presents a limited number of direct visibility observations and develops a framework useful in interpreting these data to determine the influence of reduced visibility on the operation of motor vehicles. Information from the literature shows the low probability of high intensity rainfalls. Conclusions concerning the hazard of passing maneuvers during rainfall of 1 in./hr. or more and the need to reduce speed under wet weather conditions are also presented.

Any overview of human factors in skid accident causation and prevention should note that driving schools comprise a valuable source of knowledge regarding driver behavior. Such schools are capable of generating considerable information relative to motorists' reactions in potential (or actual) skidding situations. A race-driving school records g-forces to which their students are subjected in each turn on the track (12). The purpose of the record is to show in which turns the driver could have achieved a higher speed and remained below his limiting or "break-away" g-force. There is a tendency for drivers to increase these safety margins as their speeds increase. Another school, the Liberty Mutual Insurance Company Skid Control School, has been innovative in developing a method for educating motorists. The program consists of two parts: a seminar on skid theory and a laboratory session on a practice skid pan. Objectives of the program are as follows:

1. To make a significant contribution to the present knowledge of skid causes so that control measures may be improved.
2. To demonstrate the practicality of skid instruction and encourage qualified traffic authorities and driving schools to undertake similar programs.
3. To make available to the driving public, through printed and visual means, a better understanding of the causes, prevention, and control of skids.
4. To provide a training ground for Liberty Mutual's highway safety engineers, for its fleet policy-holder driver trainers, and certain public agencies concerned with highway safety.

The Skid Control School is an educational technique consistent with a basic approach advocated at the First International Skid Prevention Conference. A human factors-oriented paper by Forbes (13) presented at the Conference stressed methodologies to assist the motorist in coping with skid hazards. In addition to the provision of favorable road conditions, highway engineers were encouraged to provide assistance to the driver by means of the following:

1. Driver understanding of basic factors relevant to skid accidents should be promoted by means of widespread advanced driver education.
2. Additional sensory cues should be provided to drivers to assist them in evaluating the situation. A device is needed to inform the motorist of hazardous geometry by means of a type of "feedback" which would enable him to sense vehicle instability through his controls or external vibrations.
3. Driver education can teach more advanced skills in evaluating highway conditions than it does at present. New techniques are needed to give the driver practice in evaluating a situation involving indications of slippery conditions or other skid hazards ahead.

The probabilities with which traffic signs are registered by drivers are rather low in ordinary road traffic conditions, and the differences in the registration probability are large. (Here, the term "registration" means that the driver sees the sign and is able to report it in the interview.) The registration percentages were found to be as follows: The "general warning" sign, 28 percent; the "general warning" sign with a supplemental sign "driving control", 62 percent; the 70 km/h speed limit sign, 78 percent; and the 50 km/h speed limit sign, 80 percent.

The speed at which the test sign was passed did not affect the registration probability. The change in action (deceleration) and the registration of the sign were closely interdependent. A large majority of the drivers who failed to obey the speed limit had not registered the speed limit sign.

The driver's familiarity with the road did not affect the registration of the sign per se. The groups differed significantly only as far as the registration of the supplementary sign was concerned. The drivers using the road frequently paid attention to the supplementary sign and recalled it more frequently than the other drivers. The distance travelled before the interview did not affect the registration of the test sign. The registration probability for a given driver was not affected by his annual mileage driven. Specific results of correct identification responses for each sign and as a function of driver familiarity are depicted in Figures 6 and 7.

Figure 6. Right answers, by road and experiment (Hakkinen, 1965).

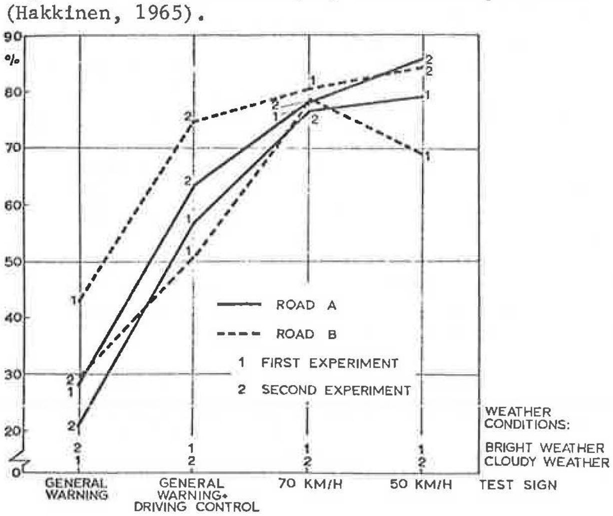
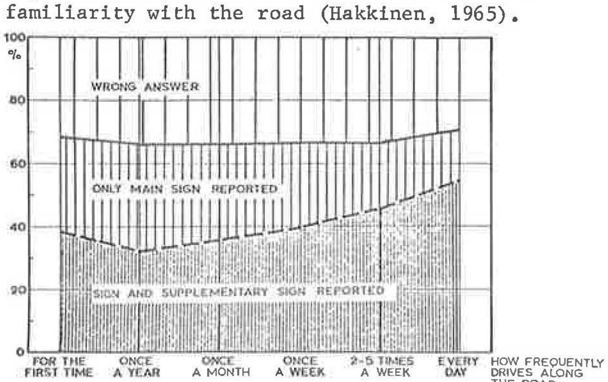


Figure 7. Dependence of answers on driver's familiarity with the road (Hakkinen, 1965).



Johannson (25), in analyzing 1,000 drivers' perception of five different warning signs, found that the percentage of drivers who noticed any one given sign was 47 percent. This fact is postulated as reflecting "urgency of information" based on past experience; that is, the more urgent the information, the more often it is perceived.

Howard (26) compared drivers' perception to a sign requiring driver action at a number of locations. Some of these locations were chosen so that the sign (sound horn) would make sense, others so that the sign would appear ridiculous. Data were recorded as to response, vehicle speeds and position, occupancy, and sex of driver. An advance warning sign was used in some cases and, as might have been expected, driver perception and response were greater with a replication (the probability of perceiving one sign is 13.9 percent; the probability of perceiving one of two signs is 25.9 percent). Howard concluded that perception of signs increases sharply the more "reasonably" the sign relates to roadway conditions.

Pages et al. (27) investigated the minimum brightness required for a traffic sign to be seen by the driver in different positions in relation to the sign. This experiment was conducted in a laboratory. In addition to reacting to a sign (slowing down or braking), the driver had to steer the simulated vehicle to keep two vertical bands in coincidence. Typical visual nighttime vehicular signals (white and yellow headlights, blinkers, etc.) were introduced. The findings indicated that the lighted sign is perceived if its brightness is at least equal to that of its surroundings.

A literature review (28) of motorists' perception of highway signing reminds us that there is a lack of knowledge in the area of warning sign design.

Sign Effectiveness as Hazard Warning. Numerous inferences can be drawn from the above cited studies regarding signing effectiveness to warn of skid accident potential. A number of studies which are more specifically applicable to the skid hazard situation are now discussed.

Marsh et al. (29), in discussing the specific problem of skidding hazard, indicated that drivers should be given clues as to what is ahead. Included among these should be: (1) realistic speed guide signs for sharp curves; (2) warning signs effective day and night for sharp curves, steep hills, dangerous intersections, and traffic circles (these being likely skid locations); (3) reflectorized curve delineators; (4) signs warning of pavement which is especially slippery when wet. Moreover, it is well documented that motorists are more likely to respond to a warning sign in the presence of a perceived hazard (13, 26, 30, 31, and others).

A recent field study (3) investigated the driver's general awareness and his response to warning signs for the hazard of wet pavements subjected to high driver frictional demands. Vehicle speeds were used as the primary indication of hazard awareness and sign response and driver interviewing was used to establish the motorist's cognizance of the hazard and his observation of the warning sign.

Three curved highway sections were treated using five experimental signing conditions. Comparisons between all signs and the "no sign" condition were made for wet and dry pavements. Normative driving behavior data were used to resolve time-of-day speed variations. Experimental signing

4. Training in actual emergency and recovery is needed.
5. Additional research is needed; too little data exists on how much drivers really know about basic factors involved in skidding.

Traffic Control Devices as Skid Accident Countermeasures

That no systematic human factors study of skid accident causation has been conducted to date has resulted in a knowledge gap regarding applicable accident prevention techniques. Thus, numerous attempts to increase driver awareness of potentially hazardous highway locations have relied on signing as an accident countermeasure. Yet, conflicting evidence has traditionally resulted regarding the effectiveness of signing in the regulation of driver behavior. In an attempt to exploit signing as a skid accident countermeasure, this review will address specific topics of signs to regulate vehicle speeds, to elicit driver perception, and to warn of hazardous locations.

Vehicle Speed Regulation. Several studies on the use of signing to affect driver speed behavior indicate less than optimum results. When signing violates driver expectancy, the driver apparently adheres to self-imposed safe speeds based on observed and expected conditions rather than on posted limits.

Bezkorovainy (14) examined the influence of horizontal curve advisory speed limits on the behavior of drivers of passenger vehicles on rural two-lane highways. Twelve horizontal curves (from 2 degrees to 12 degrees curvature) served as data collection sites, and statistical analyses (student t, analysis of variance) were used to compare the effects of an experimental standard sign versus no signing for nine testing conditions. During daylight hours and favorable weather conditions, drivers did not differentiate between the signs. Their speeds in negotiating the curves were not related to the posted advisory speed but rather to curve design geometric characteristics. Standard advisory signs (18" x 18") indicating "X" mph, experimental advisory signs (18" x 18") indicating SLOW to "X" mph, and combinations adding a standard curve sign (36" x 36") showed no significant differences in speed at the center of the curve. One item of interest was that, after passing the advisory sign, faster vehicles decelerated a greater rate than slower vehicles so that as they reached the center of the curve their speeds were the same.

A California study (15) evaluated the effectiveness of devices similar to those described in the Bezkorovainy study. The "Before-After" study used accidents as a criterion measure of effectiveness. Standard curve warning signs (designated in the MUTCD as W3R or W5R signing) were found to exhibit no significant accident reducing effect. However, when standard advisory speed signs (W46R) were added to the curve warnings, significant accident reductions resulted. The specific accident type impacted upon was the "nighttime single vehicle running off the road". Results were so impressive that the study recommended placing advisory speed limit signing at every location requiring curve signing. The study further recommended special oversize curve warning - advisory speed sign combinations in severe problem areas.

Brackett (16) indicated that signing had little influence on the motorist's choice of speed. He further noted that similar findings had been obtained by Rowan and Keese (17), the California Highway Department (18), Ottini (19), and Wiley (20). These studies were likely to conclude with such statements as:

> "Surveys show that motorists ignore speed limit signs."
> "Most drivers are careful and drive according to the existing conditions, not according to the signing."
> "Traffic ignores posted speed limits and generally runs at speeds which the drivers consider reasonable."

Driver Perception of Signs. Many studies have been performed relative to drivers' perception of signs. Among the variables considered were: sign observation, sign conspicuity, sign color and shape, sign brightness, vehicle speed and position, driver characteristics, and the "importance" or "urgency of information" of the sign message.

A Swedish study (21) examined the general motorists detection probability of highway traffic signs. Laboratory experiments simulating traffic conditions produced unrealistic sign awareness, so in-traffic experiments were conducted. Five persons driving along a 170 km stretch of road registered 91 percent of the signs. In an attempt to find out to what degree road signs are recalled, 6,000 drivers were questioned regarding the last road sign passed. This procedure took into account drivers' familiarity with the road, experience, exposure, whether or not they had been interviewed before. The signs were changed at various intervals and degree of road visibility was reported hourly.

Drivers familiar with the road and experiment gave the largest percentage of correct answers. Sign violators gave the lowest percentage of right answers. Sparse traffic tended to decrease driver awareness of signs.

A study conducted in Finland (22) dealt with factors affecting the conspicuity of traffic signing. Laboratory observations of driver recollections of numerous signs to develop the concept of conspicuity yielded the following conclusions:

1. The brighter a sign or the larger its brightness contrast, the better its conspicuity.
2. The simpler a sign is visually, the better its conspicuity.
3. The more a sign differs from other signs, the better its conspicuity.
4. The more frequently a sign appears on the road, the better its conspicuity.
5. The more obligatory a sign is, the better its conspicuity.

Ferguson, et al. (23) used questionnaires to evaluate driver awareness of sign colors and shapes. He found that there is a direct relationship between driver recognition and the uniformity of signing color and shape. There is a high carryover from traffic signal color since the signals require action and merit attention. Drivers do not pay much attention to or are not aware of particular sign colors. Red, yellow, and white in that order were the colors recognized most often. Shape and message were indicated as the most important sign variables.

Hakkinen (24) interviewed 2,768 drivers to determine the impact of some curve warning signs, some of which were augmented by advisory speed signs. Test signing was placed in advance of a curve in the roadway, and motorists were stopped ahead to report what they had recalled of the sign. Speed measurements were recorded for interviewed drivers.

Findings of the report are summarized as follows.

conditions were comprised of variations to the "Slippery When Wet" symbolic sign, ranging from its use by itself through increasing levels of specificity and conspicuity, to its use with flashing beacons and an advisory speed limit.

The primary measure of signing effectiveness was mean speeds at critical curve locations. The highest quartile speed group (fastest 25 percent) of vehicles arriving in advance of the curve was selected as the target sample. Significant speed reductions at critical curve locations were observed as the result of signing which employed flashing hazard beacons. Greatest slowing was observed during use of higher level signing with sign conspicuity having a greater impact than specificity. Higher speed reductions generally resulted from the supplementary use of advisory speed limits. These observations took into account normal hour-to-hour speed variation.

Questionnaire results were revealing in terms of motorists' responses to experimental signing. Vehicle speeds of interviewed motorists demonstrated that motorists who saw signing slowed down more than those who did not. Maximum speed decreases were observed at the most hazardous portions of curvature. The more familiar motorists were more likely to see the signs, and those with longer driving experience were more likely to read them. However, it was shown that the experimental skid hazard warning signs have a marginal effect on motorists' verbal assessment of the site as being a skid hazard.

Certain driver characteristics were linked to general perception of skid hazard. Younger drivers and those with prior skidding experience were seen to be more prone to assess test curves as potential skid hazards. Motorists who drive more miles per year exhibited higher speeds throughout the sites, but they were divided in their assessments of skidding potential. Female drivers were seen to be generally more sensitive to wet weather driving hazards because they gave lower estimates of safe wet pavement speeds, predominantly indicated that skid hazard warning signs were helpful, and indicated a tendency to panic in the event of an unexpected skid.

A recent British article (32) suggests a procedure for increasing the effectiveness of advisory speed limits in a way that would overcome motorist's known disregard for posted speeds. The article notes that a fixed speed limit is not necessarily suitable for all times of the day and night, nor is it suitable when the reduced speed is only required over a very short length of road such as on a bend or the approach to a road junction. This paper discusses the use of advisory speed signs, the effect of having a speedometer which can be seen while the driver is looking at the road ahead, and finally the use of pavement markings which give the driver the illusion that his speed is increasing causing him to slow down.

Suggestions for Accident Reduction Programs

The reviewed literature has demonstrated that, while there are vast gaps in human factors knowledge of skid accident causation, certain traffic control devices have been effective at deterring driver behavior known to contribute to skidding accidents. On the basis of this review, suggestions are made regarding both implementable remediation devices and direction for future research.

Implementable Countermeasures

Advisory speed signing at curve locations has been subjected to evaluation both through before-after accident study (15) and driver behavioral study (3) using rain-activated signs. Favorable results were obtained in each evaluation. Moreover, the use of advisory speed signs were shown to be legally feasible as a demonstration of prudent practice on the part of highway agencies (33); and a documented technique to determine applicable wet weather speeds is available (34).

The suggestion follows that activated warning signing be used as a skid accident reducing countermeasure. Specifically recommended signing is that designated in the 1971 Manual on Uniform Traffic Control Devices as the Slippery When Wet sign (W8-5) in conjunction with the Advisory Speed Plate (W13-1) and rainfall activated hazard identification beacons (similar to that called out in Section 4E of the MUTCD). The activation device should insure that beacon flashing will terminate as the pavement becomes dry. Sign location with respect to the curve should be in accordance with current practice.

Future Research Needs

A systematic human factors analysis of the driving task in a potentially skid hazard environment is necessary to examine broadly based causes of skidding accidents. Segmented progress toward such an endeavor already exists. Levels of driver performance have been defined (35); components of the driver's communication system relevant to skidding accidents have been identified (5); and search and scan patterns of drivers in a potential skidding situation have been studied (2). The integration of these and other human engineering findings in a system analysis can potentially lead to the development of additional skid accident reducing measures.

That more and better countermeasures are needed is evident from the facts that (1) skid resistive pavements are costly, and (2) signing has yet to be proven effective in a large-scale implementation effort. Moreover, signing was shown in one study to have a limited impact as the primary cue of potential skidding hazard. Other environmental components of roadway geometry, surface appearance, and prevailing ambient conditions are more apt to be sensed by the driver. Therefore, a more in-depth human factors study, incorporating sensitive measurement techniques such as driver eye movement photography, is needed to determine the appropriate sensory inputs used in certain skid prone driving situations. With such information, it is possible that more operationally effective, economic, and politically feasible countermeasures can be developed to alert the driver to skid accident potential.

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