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Reducing Runaway Truck Accidents Through Weight-Based Advisory Speeds

Research, Development, and Technology
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McLean, Virginia 22101-2296

FOREWORD

This report is part of a four-part series summarizing recent research findings in the area of selected truck geometric features. One of the critical large truck research areas is safety impacts of trucks--including geometric and operational issues, vehicle stability and handling, and accident rates. A number of research studies have been completed in the following areas: truck climbing lanes, grade severity rating systems for trucks, interchange ramp geometry design, and the operation of larger trucks on roads with restrictive geometry. This report summarizes the findings of the research in the area of grade severity rating systems for large trucks. For specific details on the research, the reader should consult the research reports referenced in the summary report.

Sufficient copies of this report are being distributed to provide one copy to each Regional office, Division office, and State highway agency. Direct distribution is being made to the Division offices. Additional copies are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Stanley Byington

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Director, Office of Implementation

NOTICE

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16. Abstract

Current developments in truck design may worsen the problem of runaway trucks. Trucks are becoming heavier, and the design of more aerodynamic cabs and the use of radial and smaller-diameter tires may increase the potential for brake failure on downgrades. This report gives State transportation officials an overview of the Grade Severity Rating System, a program to reduce runaway truck accidents through the use of weight-specific-speed signs (WSS). The report contains adequate information for State transportation officials to decide whether they want to implement GSRS-WSS and also tells potential users where to get the additional information needed for actual implementation.

The report summarizes the five steps required to implement WSS signing. The first step determines the magnitude of the runaway truck problem in a given State and identifies potential WSS sites. The second step analyzes the sites selected to determine percent and length of downgrade and truck braking length–the variables that determine brake temperature and hence safe speeds for different truck weight classes. In step three, analysts enter percent of grade and grade length or truck braking length into a computer program that yields advisory speeds for various truck weight classes. Step four converts the computer program output into the information that will actually be posted on WSS signs. Step five is actual installation of signs before and preferably along the downgrades selected for WSS.

The report is based on the following studies: Feasibility of a Grade Severity Rating System, FHWA/RD-79/116, The Development and Evaluation of a Prototype Grade Severity Rating System, FHWA/RD-81/185, Field Test of the Grade Severity Rating System (GSRS), FHWA/RD-86/011, and Grade Severity Rating System (GSRS)--Users Manual, FHWA-IP-88-015.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

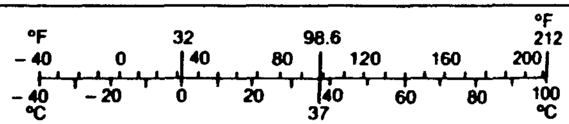
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F



* SI is the symbol for the International System of Measurement

These factors conform to the requirement of FHWA Order 5190.1A.

(Revised April 1989)

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CHAPTER 1
INTRODUCTION

Heavy truck involvement in accidents has steadily decreased over the past 50 years. However, accidents continue to occur, and some technological advances in highway and heavy truck design are making new safety measures necessary in order to maintain the favorable downward trend. Use of Weight-Specific Signing based on the Grade Severity Rating System (GSRS-WSS) could reduce the problem of runaway trucks on severe downgrades.

Simply stated, GSRS-WSS is:

- A procedure for identifying and rating steep grades that for some heavy trucks, especially those without retarders, can contribute to brake overheating, brake failure, and eventual runaway situations.

- A procedure for establishing the maximum speeds at which trucks of certain gross weights can traverse the grade without brake overheating.

- A road signing system that informs the truck driver of those safe speeds.

As such, it is a low-cost, low-liability method for attacking the problem of runaway trucks.

The Safety Problem

A series of interviews with truck drivers recently revealed that one in four drivers with mountain-driving experience had lost his brakes at least once during his career. One study of the number of annual runaways in the

United States produced an estimate of 2,450, with an associated cost of over $37 million. Some 73 percent of the trucks involved in those runaway events carried loads heavier than 60,000 lb (27,216 kg). Another study found that in one year, 16 percent of severe truck accidents nationwide involved runaways. For one mountainous State that figure reached 41 percent. This study cited the following factors as main contributors to downgrade accidents: failure to downshift, defective brakes, inadequate signing, and inadequate driver information. GSRS-WSS targets these factors for heavy trucks, especially those between 60,000 and 80,000 lb (27,216 and 36,287 kg).

New developments in truck design and operation can lead to greater braking distances and higher braking temperatures and may thus increase the potential for runaways. These developments include larger trucks, aerodynamic truck cabs, radial tires, smaller-diameter tires, and heavier loads. Natural frictional forces are substantial; indeed, for lighter trucks such forces can supply enough auxiliary braking power to prevent runaways. However, today trucks weighing up to 80,000 lb (36,287 kg) are present on the roadways. Aerodynamic truck cabs reduce the natural braking effect of the cab due to air friction. Radial tires and smaller-diameter tires allow heavier loads, and thus they too reduce braking effect due to friction between the tires and the road.

Efforts to Deal with the Hazard

Traditional methods for reducing the probability of runaway truck accidents include runoff ramps, also known as truck escape ramps, placed along the downgrade. More widespread has been the use of signs providing drivers with information about downgrade characteristics--mainly length and severity. The Manual on Uniform Traffic Control Devices (MUTCD) recommends placing the symbolic hill sign before downgrades and supplementing it with appropriate legends where special hill characteristics exist. For long grades, the MUTCD recommends that signs indicating length of grade remaining be placed at one-mile intervals along the grade (figure 1). Sometimes States provide additional information: for example, percent of downgrade, the need

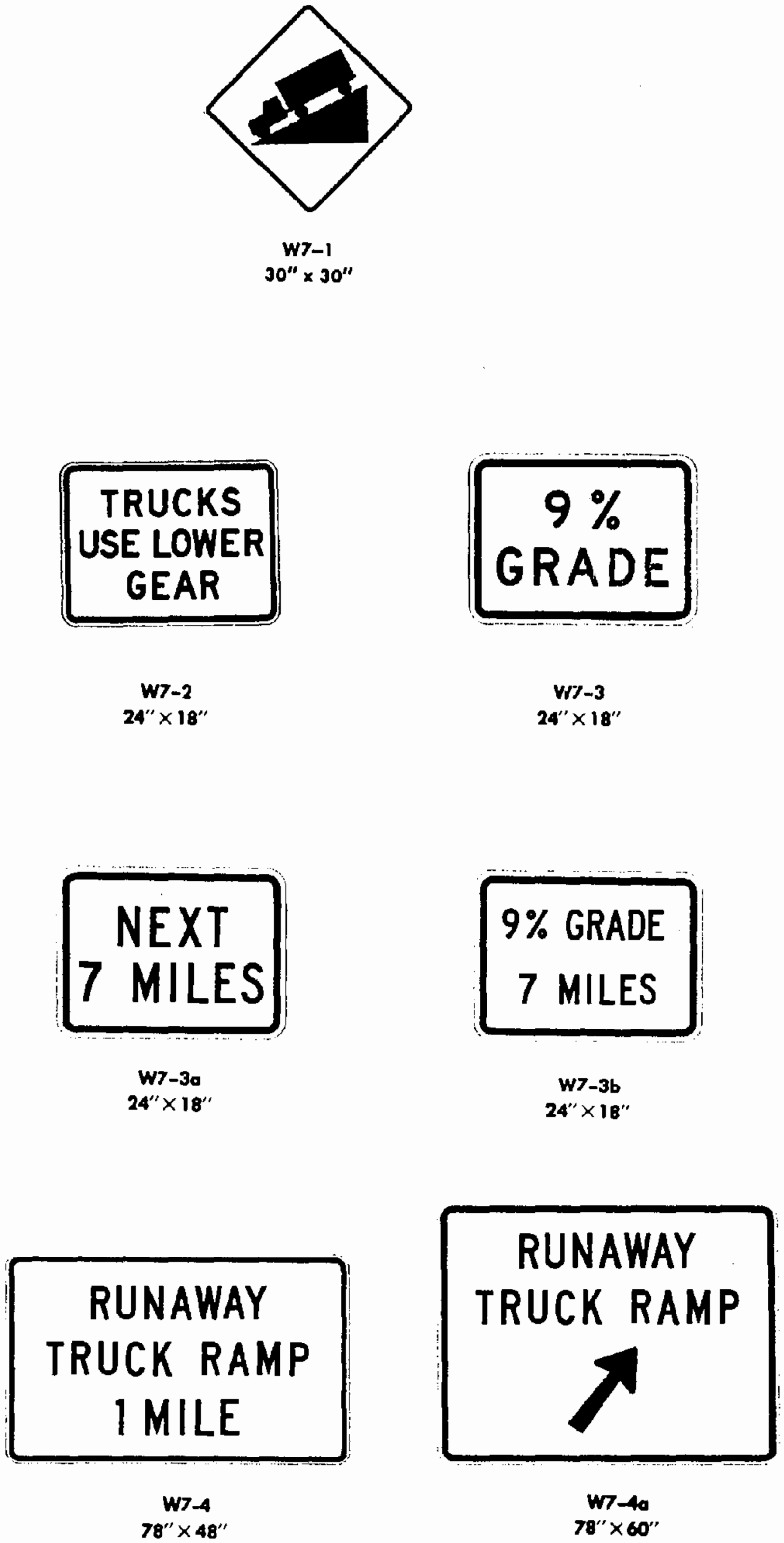

Figure 1. MUTCD hill signs.[1]

for the use of low gears, the physical features of the end of the downgrade, and the placement of truck turnouts and escape ramps. The use of such sign strategies varies widely by State.

Traditional signs do not provide drivers specific information about what to do and when to do it. Proper reactions to hill features are left to the subjective judgment of each driver. In contrast, the GSRS-WSS provides drivers with specific speed advice, and that advice is based on principles of brake heating (figure 2). GSRS-WSS can improve truck safety at relatively little cost. As a state-of-the-art measure, moreover, it can improve States' liability position in court.

This report is intended for State transportation officials who can influence decisions about highway signing. It is also intended for the trucking industry, whose managers and drivers can become aware of the system and make use of it. It is based on a series of studies, sponsored by the Federal Highway Administration (FHWA) and outlined in Chapter II, which developed and tested the GSRS-WSS approach.

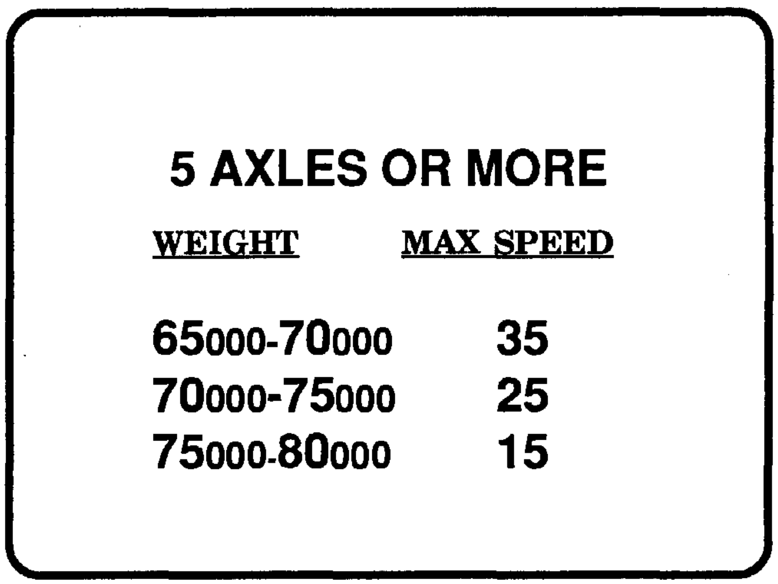

Figure 2. Example of Weight Specific Speed (WSS) sign.[2]

CHAPTER II
DEVELOPMENT OF THE GSRS-WSS

The GSRS-WSS attacks the problem of runaway trucks at the source: brake failure. The approach is descended from earlier programs to reduce accidents on downgrades, but it represents the first attempt to control runaway trucks by suggesting safe-speed limits based on measured parameters of truck operation and grade.

Attempts to Minimize Downgrade Accidents

- Prior to the 1960's, the U.S. Bureau of Public Roads developed a system for categorizing downgrade severity based on percent and length of grade. It placed all downgrades within three categories of severity. This scheme was expanded in the 1960's to form a system with 10 categories. Over 20 years later, work began on the development of the GSRS-WSS.

- In 1979, under the sponsorship of the FHWA, Myers, Ashkenas, and Johnson produced Feasibility of a Grade Severity Rating System.[2] This was the first analysis of brake failure that considered brake temperature. The researchers found that brake temperature at the bottom of a hill is mainly dependent on grade length and steepness, truck weight, and truck speed. They created a mathematical model that predicts brake temperature during descent.

- In 1982, with FHWA support, Johnson, DiMarco, and Allen prepared The Development and Evaluation of a Prototype Grade Severity Rating System.[3] The report included a study of truck problems and operational and geometric characteristics that contribute to downgrade accidents in the United States. The Johnson team found that the runaway truck accident rate could be expressed as a function of grade steepness and length, the average daily traffic on the grade, and the number of downhill lanes. The researchers employed the mathematical model for brake heating and developed a point system for finding the likelihood that a given accident was caused by a runaway. The research team also conducted a simulator-study of the effectiveness of the GSRS-WSS prototype. They concluded that the GSRS-WSS had greater potential for reducing heavy truck runaway incidents than any method in use at the time.

- A much more rigorous evaluation of the GSRS-WSS was sponsored by the FHWA in 1985. In Field Test of the Grade Severity Rating System,[4] Hanscom reported on a study of three test applications of the GSRS-WSS. After installing WSS signs at three severe grades, Hanscom measured substantial speed reductions in two of the cases.

- In 1989, FHWA published a report by Bowman entitled Grade Severity Rating System (GSRS)--Users Manual.[5] Bowman laid out the GSRS-WSS for the user, providing both a detailed description of the mathematical foundation of the program and step-by-step instructions for implementation. Bowman included, in printed form, the GSRS-WSS computer program for determining maximum safe speeds, written in BASIC language for use with IBM or IBM-compatible computers. He also included descriptions of two case studies, or sample applications, of the GSRS-WSS.

Factors in Brake Failure

Driver experience, truck design, truck mechanical conditions and other variables influence the occurrence of incidents. For this reason, there is no invariable formula for determining when brake failure will occur. However, the main contributors are the variables that affect brake temperature: grade severity, grade length, truck weight, and speed. Although drivers cannot influence many of these factors--grade severity, grade length, and perhaps truck weight--they can control speed and thus control brake temperature.

Johnson's team recognized that a truly safe descent speed should allow for emergency stops at the end of the downgrade, when brake temperatures are highest, without a significant loss in braking efficiency. They defined maximum safe speed as the speed from which an emergency stop at the bottom of a downgrade would not generate brake temperatures above a preselected limit. They redefined the original brake temperature model to include the sum of the temperature caused by steady descent speed and the incremental temperature increase resulting from an emergency stop from the safe downgrade speed. After observing the onset of brake fade for a number of brake linings with typical amounts of imbalance, they determined that 500 °F (260 °C) is an appropriate value for the maximum allowed brake temperature.

WSS Signs

The GSRS-WSS computer program calculates maximum safe speeds using the Myers mathematical formula and the maximum allowed brake temperature just described. The advisory speeds are given for 5,000 pound decrements until the posted speed limit is achieved. These recommended speeds are presented to truck drivers on the weight-specific speed (WSS) sign placed at appropriate locations in the vicinity of the downgrade. No more than five weight classes are specified on each WSS sign so that drivers will not be confused by too much information.

The speeds are advisory in nature because they are impossible to enforce: police cannot easily assess gross truck weights. WSS signs are rectangular with black lettering on a yellow, retroreflectorized background.

The GSRS-WSS computer program does not take into account retarders that supplement the brakes, such as drive-line, electric, or Jacobs systems. However, drivers with retarders can still benefit from reading WSS signs, because the signs emphasize the seriousness of upcoming downgrades and provide safety information.

CHAPTER III

IMPLEMENTING THE PROGRAM

This chapter summarizes the five steps needed to implement the GSRS-WSS. The recommended procedures can be abbreviated at several points to suit the purposes and needs of individual users.

Transportation officials who decide to adopt GSRS-WSS should consult the Users Manual, which provides detailed guidance on each step. The Users Manual also discusses the GSRS-WSS computer program used to determine safe downgrade speeds. This user-friendly program requires no computer expertise to run.

Implementation involves these steps:

- Step One: Identifying Sites (optional).
  - Identifying severe downgrades.
  - Collecting and analyzing accident data.
  - Assessing the magnitude of the runaway problem.

- Step Two: Performing a Field Inspection.
  - Verifying percent and length of downgrade.
  - Becoming familiar with the downgrade environment.
  - Determining truck braking length.

- Step Three: Determining Grade Severity and Weight Related Speeds.

- Step Four: Determining WSS-Signing Needs.

- Step Five: Installing WSS Signs.

Step One: Identifying Sites

Step One can be used to determine the magnitude of the truck-runaway problem and identify potential sites for WSS. It consists of three optional activities: identifying all severe downgrades, collecting and analyzing accident data, and assessing the magnitude of the runaway problem using a standard, quantifying scheme.

Some States may wish simply to implement GSRS-WSS on grades with a clear history of runaway accidents, while other States may want to develop a complete list of severe downgrades that includes potential danger spots as well. In either case, the most obvious candidates for GSRS-WSS are downgrades already equipped with escape ramps. Highway agencies usually have lists of escape ramps, sometimes including helpful information about related grade characteristics (e.g., plan and profile drawings). Records that reveal the frequency of ramp use, and even the dispositions of runaway trucks, may be available as well. Finally, highway departments may have plans for introducing new escape ramps.

Additional sources of information may help identify other potential sites for GSRS-WSS. Police departments may have records of problem downgrades. States may have maintenance records indicating grades that require excessive repair of guardrails or other shoulder fixtures--evidence of possible runaway problems. Many State agencies maintain records of driver complaints, some of which may relate to runaway trucks. Complaints about downgrade trucks traveling too fast, using more than one lane, or forcing other vehicles off the road may reflect runaway conditions. Other sources of information useful for identifying the location of severe downgrades include sign inventories, photo/video logs, files of roadway geometrics, and the knowledge of local engineering personnel.

After probable runaway downgrades are located, actual accident data can be used to determine which sites should receive WSS signs, to establish the magnitude of the runaway problem, and to create a base for evaluating program effectiveness.

To aid in determining whether an accident actually involved a runaway, a point system was developed in the study (figure 3). The system assigns

ACCIDENT TYPE	MANEUVER PRECEDING COLLISION	SPEED	DRIVER ACTION	VEHICLE CONDITION	1ST OBJECT STRUCK	2ND OBJECT STRUCK
Runaway truck = 100	Ran off road or Failure to negotiate curve = 40	Exceeding speed limit by 10 mph or more = 40 If the above "40" is used, then do not count "speeding" in next column (i.e., should not count speeding twice)	Failure to downshift properly or Speeding (Speed unsafe for conditions) = 40	Defective or lost brakes = 90	Escape ramp or arrester bed = 90	Escape ramp or arrester bed = 90
Truck accident = 10	Proceeding straight or Passing/changing lanes or Crossed into opposing lanes or Failure to make turn = 10	None of above = 0	Following too close or Failure to yield or Unfamiliar with roadway = 10	Transmission defect or Ran out of fuel or Engine defect or Other defect = 40	Other (e.g., overturned) = 10	Other (e.g., overturned) = 10
None of above = 0	None of above = 0		None of above = 0	None of above = 0	None of above = 0	None of above = 0

Note: Point scores (largest one from each column) are added to assess the probability that truck was a runaway. Total less than 50 is rated as an unlikely runaway; from 50 to 70 is rated a possible runaway; 80 and above is rated a probable runaway.

Figure 3. Runaway truck point system.[5]

numerical values to accident characteristics to quantify the likelihood that an accident resulted from a runaway condition. The study developed a point system that assigns numerical values to accident characteristics that quantify the likelihood that an accident resulted from a runaway condition. If the sum of the numbers is less than 50, the accident probably did not involve a runaway; if the sum is between 50 and 70, the accident may have involved a runaway; if the sum is greater than 80, the accident probably involved a runaway.

Step Two: Performing a Field Inspection

Step Two investigates individual downgrades to obtain information needed to determine appropriate weight-specific speeds. It consists of three activities: verifying the percent and length of downgrade, becoming familiar with the grade environment, and determining the truck braking length.

Percent grade can usually be obtained from construction plans or from conventional signs. The analyst, however, is encouraged to verify the percent grade, especially if the roadway geometry appears to differ from the original plans. In such cases, survey crews can determine percent grade as well as length of downgrade.

A good estimate of truck braking length is crucial to computing weight-specific speeds. In many cases, the length of the downgrade is equivalent to the braking length and can be used in the computer program. In other cases, where braking length is only slightly less than downgrade length, or where measurement of braking length is extremely difficult, downgrade length may also be used in the computer program.

However, if braking length is considerably shorter than the length of the grade, using length of grade in the computer program will produce unreasonably low maximum safe speeds. If the computer program suggests maximum safe speeds of less than 10 mi/h (16 km/h) for the highest-weight categories, then braking length should be obtained from field measurements. Such low speeds may be ignored by truck drivers and may encourage contempt for the program itself.

Step Three: Determining Grade Severity and Weight-Related Speeds

Step Three assesses grade severity and uses the GSRS-WSS computer program to calculate maximum safe speeds for weight classes. Multiple grades are a particular concern at this stage.

For GSRS-WSS, grade severity depends on both percent grade and truck braking length (or grade length). When values for these two factors are entered into the computer program, along with the maximum permissible truck weight and the speed limit, the computer program determines the maximum safe speed for the maximum load limit and for every 5,000-lb (2,268-kg) decrease in weight until the normal speed limit is reached (figure 4).

Most downgrades consist of stretches of roadway of varying slopes. If these stretches vary in slope only slightly, they can be considered a single slope. If the stretches vary greatly in slope, and if there are level stretches or even inclines, then the user can employ the program to calculate safe speeds for individual segments of the slope. In such cases, the number of grade segments and their associated percent and length of grade can be entered into the computer. The program is designed to accommodate these multiple grade segments in determining maximum safe speeds.

Step Four: Determining WSS-Signing Needs

Step Four converts the computer output into the information to be posted, to ensure that WSS signs will be effective.

WSS signs can present a maximum of five speeds, and the GSRS-WSS computer program may produce more than five speed categories. The speed categories

EASTBOUND SR30 AT COLEMAN PASS

INPUT DATA

PERCENT DOWNGRADE	BRAKING LENGTH (MILES)
6.6	1.9
3.3	.9
6.8	3.1
2.4	.9
5.4	2.7
6.1	1.1

OUTPUT

MAXIMUM TRUCK WEIGHT (POUNDS)	MAXIMUM SAFE SPEED (MPH)	BRAKE TEMP. FROM DECLINE (F)	BRAKE TEMP. FROM EMERGENCY STOP (F)	TOTAL BRAKE TEMP. (F)
80000	14	478	4	482
75000	16	484	5	489
70000	18	474	7	481
65000	22	482	9	491
60000	28	478	14	492
55000	32	479	17	496
50000	65	403	65	468

NOTE: INITIAL BRAKE TEMPERATURE = 150

Figure 4. Sample GSRS-WSS computer output.[5]

generated are for 5,000-lb (2,268-kg) weight increments, beginning with the maximum allowable weight and ending with the weight associated with the normal speed limit.

If the computer creates more than five weight categories, the user should combine adjacent categories, expanding some or all of the weight intervals to 10,000 lb (4,535.9 kg). Combining weight intervals is especially helpful for high severity grades, where 5,000-lb (2,268-kg) intervals on WSS signs will result in too many categories for very heavy trucks.

A second way in which State transportation officials can modify the computer output is by rounding off speeds to the nearest 0 or 5--for example, 20 or 25 mi/h (32 or 40 km/h). Rounded-off speeds may encourage drivers to adhere to the advisory limits, because the numbers would seem to represent reasonable estimations. Analog speedometers often do not indicate finer gradations of speed, and they are often not precisely accurate. On the other hand, exact speeds may suggest to drivers the scientific or legitimate basis of the speeds and may therefore encourage compliance. In this area, as in others, States are free to make their own choices based on what is convenient and reasonable for their circumstances.

The lowest-speed category (or highest-weight category) is placed at the bottom of the WSS sign; it represents the safe speed for the maximum load limit in the State. The highest-speed category, placed at the top of the sign, is for trucks whose weights are almost low enough to allow them to operate at the speed limit. For each weight category listed, the associated speed refers to the maximum safe speed for the heaviest truck in that category.

Step Five: Installing WSS Signs

Step Five concerns recommendations for installing the WSS signs prior to and along the downgrade. Sign placement must comply with criteria established by the MUTCD or local authorities, but it must also meet WSS requirements.

The first WSS sign in a series is placed about 1 mi (2 km) before the start of the downgrade. This alerts the driver that recommended safe speeds are in effect on the upcoming hill. If the approach to the decline is an incline, and heavy trucks will be proceeding slowly, then a second WSS sign should be placed about 750 ft (229 m) prior to the start of the downgrade. In any case, a WSS sign must be placed at the very beginning of the downgrade. If there is a truck turnout or brake inspection area at the beginning of the downgrade, a WSS sign should be placed in the parking lot. Users may also decide to place additional WSS signs every half mile (0.8 km) or so along the actual downgrade.

Supplementary signs informing drivers of percent grade and length of grade remaining should also be placed at the beginning of the downgrade and at 1-mi (2-km) intervals along the downgrade (See figure 1 in chapter 1). Supplementary signs of this nature should precede each WSS sign by about 200 feet (61 m). As a rule, WSS signs should not be placed closer than 200 feet (61 m) from any existing sign.

CHAPTER IV
CLOSING REMARKS

The GSRS-WSS system represents the most current approach to reducing the occurrence of truck runaway incidents on severe downgrades. Prior efforts have concentrated on classifying and categorizing downgrade severity based on the percent and length of grade. These attempts were effective in establishing downgrade severity, but they did not consider the downgrade's effect on the braking system of heavy trucks. The results were systems that did not provide information to truck drivers on what actions they could take to reduce the probability of runaway conditions.

The GSRS-WSS concept considers the combined effect of downgrade geometrics and truck weight on truck system brake temperature. The result is a series of recommended downgrade speeds for different categories of truck weights. If these speeds are not exceeded, the system brakes will have sufficient braking capacity to bring the truck to an emergency stop at any point along the decline. The GSRS-WSS, therefore, provides truck drivers with positive information for their gross weight on the maximum speed that they can use on the decline without experiencing brake fade or failure. This capability is unique to the GSRS-WSS system and has the potential for reducing the incidence of truck runaways.

The application of the GSRS-WSS system has been simplified by the development of a computer program. Developed for IBM/PC and compatible systems, this program adapts the GSRS-WSS system to applications in addition to determining the speeds for WSS signs. These applications include evaluating downgrade severity, determining the placement of escape ramps, determining brake temperature profile at 1/2 mile intervals, and assessing the brake temperature of accidents involving trucks. The computer program is user-friendly and requires no computer expertise to use.

REFERENCES

(1) Manual on Uniform Traffic Control Devices (MUTCD), Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1978.

(2) Thomas T. Myers, Irving L. Ashkenas, and Walter A. Johnson, Feasibility of a Grade Severity Rating System, FHWA/RD-79/116, Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1979.

(3) Walter A. Johnson, Richard J. DiMarco, and R. Wade Allen, The Development and Evaluation of a Prototype Grade Severity Rating System, FHWA/RD-81/185, Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1982.

(4) Fred R. Hanscom, Field Test of the Grade Severity Rating System (GSRS), FHWA/RD-86/011, Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1985.

(5) Brian L. Bowman, Grade Severity Rating System (GSRS)--Users Manual, FHWA-IP-88-015, Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1989.