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NEEDED RESEARCH FOR THE DETERMINATION OF SIGHT DISTANCES

SYNOPSIS

Two and three-lane highways should be designed with two minimum sight distances in mind, one to accommodate the passing of motor vehicles with safety and one to be considered a non-passing minimum It is desirable that the sight distance at every point on a highway should exceed the passing minimum This generally is not possible, but if drivers are to be encouraged to remain behind slower moving vehicles until it is safe to pass, safe passing sections must be encountered frequently

Sight distance adequate for passing with safety is the sum of three distances that traversed during perception time, that traversed while passing, and that traversed by an opposing vehicle Research is required to determine perception time, or the time elapsed from the instant the road opens up to the view of the driver to the time he begins the operation of passing, when the opposing lane is free of traffic, spacing of vehicles before and after passing, the acceleration of the vehicle, and the time of passing Research also is needed to determine many factors which influence most drivers in arriving at a decision regarding the passing of slower moving vehicles and to gauge the ability of most drivers to properly utilize long sight distances

At intersections research is required for many factors similar to those related to sight distances on the road, and for other factors such as acceleration of vehicles from a stopped position, which are related only to sight distances at intersections

All factors must be related to the assumed design speed of the highway and all research should be undertaken with this end in mind

The ability to see is of the utmost importance in the safe and efficient operation of a highway transportation system Rolling stock on a railroad is confined to a known path by fixed track, yet block signal systems and well trained locomotive drivers are necessary for safe operation The path and speed of motor vehicles on the other hand are subject to the control of drivers whose training is elementary If safety is to be built into our highways, it is vitally necessary that the road be opened up to view for a sufficient distance to enable the driver to pass overtaken vehicles without hazard and to control the speed of the vehicle to avoid encountering unexpected obstacles in its path

This paper lists and discusses briefly the factors which enter into the calculations for sight distances required for safe operation on the highway with the object in view of determining wherein research and investigation are required to arrive at proper valuation of the factors involved

ASSUMED DESIGN SPEED

The assumed design speed of a highway is considered to be the maximum approximately uniform speed which probably will be adopted by the faster group of drivers but not, necessarily, by the small percentage of reckless ones

If a highway is designed and constructed with reasonable margins of safety for operation at the speed thus defined, a safe highway will be provided for all users except a very few who may be termed reckless and whose unreasonable demands we are not justified in satisfying

The scope of this paper does not permit entering into a detailed discussion of assumed design speed It is mentioned because it is an important fundamental of highway design and factors for the determination of sight distance must be related to it

NON-PASSING SIGHT DISTANCE

The length of highway visible to a driver at every point on it should be in excess of the distance required to bring the vehicle to a stop before reaching a stationary object in the same lane when traveling at the assumed design speed of the highway This distance may be termed the safe stopping distance The values for the factors entering into its determination should be chosen conservatively in order that drivers who normally drive faster than the assumed design speed and drivers who do so occasionally also may avoid encountering obstacles in the road

The safe stopping distance of a vehicle may be considered as the sum of the following three distances

Distance traversed during perception time
Distance traversed during brake reaction time
Braking distance

Perception Time Perception time is considered to be the time elapsed from the instant a stationary object in the same lane is visible to the instant the driver comes to the realization that the object is stationary and the brakes must be applied

Perception time probably varies considerably and is dependent upon the speed of the vehicle, the optical ability and natural reaction of the driver, the distance to the stationary object the instant it is visible, the character and visibility of the stationary object, the portion of the stationary object which first comes into view, the relative position and visibility of roadside objects, the condition of the atmosphere, the time of day, the interference and distraction of other vehicles, and the effects of opposing headlights

Perception time generally is discriminative in character, that is the realization that the object is stationary comes to the senses of the driver only by association with other objects For example it may take a few seconds for most drivers to come to the realization that another motor vehicle in the same lane is stationary It is only by subconscious association with fences, trees, or other stationary objects along the road that one realizes that the vehicle is stationary An apparent increase in the size of the vehicle tells the driver that he is approaching it but does not tell him that it is stationary Increase in size of vehicle is apparent only when a large portion of it is visible, by which time the observer will have advanced a considerable distance beyond the point where the vehicle first was visible Sometimes perception time is very short Persons alongside a stationary motor vehicle convey to the driver almost instantly that the vehicle is stationary, but the top of a vehicle is visible some time before a person changing a tire, for example, comes into view Perception time for objects other than motor vehicles may be appreciably different than that for a motor vehicle

Perception time may be different for the two general cases of an object becoming visible around a bend or over a crest

Perception time, which may be a few seconds, has an appreciable effect on non-passing sight distance, each second requiring a distance in feet equal to nearly one and one-half times the assumed design speed in miles per hour Research on which to base values for use in design is needed

Sometimes objects moving slowly in the same direction as the vehicle present considerable hazard If the vehicle can be stopped before reaching a stationary object it can be stopped more easily before reaching a moving object, but the moving object may deceive the driver into a false sense of security so that he does not apply his brakes as quickly Perception time for moving objects may be different than that for stationary objects

Brake Reaction Time Brake reaction time is considered to be the time elapsed from the instant the driver realizes that an object in the same lane is stationary and the brakes must be applied, to the instant the brakes are effectively applied

Considerable research has been done on brake reaction time The average generally is found to be between ½ and ¾ of a second Many drivers react in less than half a second, many require more than a second, and many whose average brake reaction time is ½ sec occasionally require a full second or more

The variation in values found is too small to affect non-passing minimum sight distance appreciably The difference between ¾ of a sec, which is greater than most drivers require, and 1 sec, which will cover nearly all drivers, is but 22 ft for an assumed speed of 60 miles per hour No additional research appears to be justified

Braking Distance Braking distance is considered to be the distance traversed by a motor vehicle from the point where the brakes are effectively applied to the point where it is brought to a stop

There has been considerable research on braking distance The results indicate that the conditions under which the tests are made have an important bearing on the braking distance Important factors affecting braking distance are effectiveness of brakes, condition of tires, and character and condition of road surface Climatic conditions and the presence of moisture, mud, and ice also affect the results appreciably

The braking distance of a vehicle on a level highway may be determined by the use of the formula

$$d = \frac{v^2}{2fg}$$

in which d is the braking distance in feet, v the velocity of the vehicle in feet per second when the brakes are applied, f the coefficient of friction between tires and roadway, and g the acceleration of gravity The friction force is assumed uniform throughout the period of deceleration The friction force may not be uniform but the adoption of a uniform coefficient of friction leads to little error in view of the fact that most tests are made by measuring the distance required to brake a vehicle and then using the formula assuming uniform friction to determine the coefficient of friction

Tests on clean wet pavements result in friction coefficients at impending skid varying between 0 4 and 0 8 The National Bureau of Standards made some tests to determine the comfortable rate of deceleration and arrived at 16 1 ft per sec per sec, which is equivalent to a coefficient of 0 5 The Motor Vehicle Department of the State of New Jersey assumes a comfortable rate of deceleration of 17 4 ft per sec per sec equivalent to a coefficient of 0 54

For the purpose of determining non-passing minimum sight distance a value for the coefficient of friction which is some fraction of the average friction at impending skid and which is lower than that likely to be used by most vehicle operators should be chosen For an assumed speed of 60 miles per hour a variation in the value of f between 0 4 and 0 5 means 60 ft and between 0 5 and 0 6 means 40 ft in required sight distance There appears to be sufficient data on which to base a value for the coefficient of friction precise enough for all practical purposes Additional research therefore does not appear to be justified unless a change in highway and motor vehicle construction practice appears to have a radical effect on braking distance

When a highway is on a grade the braking distance may be determined by the use of the formula

$$d = \frac{V^2}{2g(F \pm \text{grade})}$$

in which "grade" is the percent of grade divided by 100 Light grades affect the result very little For an assumed design speed of 60 miles per hour and an assumed coefficient of friction of 0 4 a 3 percent grade, for example, affects the braking distance about 20 ft There is little justification therefore for extensive research for stopping distances on grades except that the determination of the effect, if any, of grade on the coefficient of friction may be desirable

SECTIONS SAFE FOR PASSING

Passing on highways in which two or more lanes are provided for traffic in each direction presents no unusual problem Crossing the centerline of a highway of this type, except to avoid impending collision, is highly reckless driving resorted to by so small a percentage of drivers that no provision need be made for passing with safety by utilizing opposing lanes It may be assumed therefore that passing will be done in a lane in which other vehicles will be traveling in the same direction and sight distance in excess of the non-passing minimum is sufficient for safe operation

Passing on two- and three-lane highways which constitute the bulk of our highway system must be accomplished on a lane which may be occupied by opposing traffic If passing is to be accomplished with safety the driver of the passing vehicle must see enough of the highway clear of opposing traffic so that if opposing traffic appears after he has started to pass he will have sufficient time to pass and return to the right lane without cutting off the passed vehicle and before meeting opposing traffic

The ideal two- or three-lane highway from the standpoint of sight distance is one in which the sight distance at every point is in excess of the minimum sight distance required for passing with safety Passing slower-moving vehicles on a highway of this character is retarded only by the presence of traffic on the passing lane, that is the opposing lane on a two-lane highway or the middle lane of a three-lane highway, within a distance required for safe passing

It is rarely possible or economically advisable, however, to construct two- and three-lane highways with sight distance at every point in excess of the minimum required for passing with safety, nor is it necessary to do so Drivers for the most part are careful and remain behind slower-moving vehicles at sections where sight distance is insufficient for passing with safety, provided their patience is not overtaxed Sections with sight distance sufficient for passing must be provided at frequent intervals if safe driving is to be encouraged

On the basis of the foregoing it is evident that two- and three-lane highways should be designed with two minimum sight distances in mind, one to accommodate the passing of motor vehicles with safety and one to be considered a non-passing minimum Where highways are designed with one minimum sight distance in mind sections with sight distances considerably greater than the minimum generally are constructed These sections, however, are the accidental result of topographic conditions They may or may not be long enough to permit passing with safety and the distance between them may or may not be short enough to encourage drivers to confine attempts to pass to these sections

Sight distance in excess of the non-passing minimum should be found at all points on a highway The research required for an accurate determination of non-passing minimum sight distance has been discussed

Sight distance required for passing is considered to be the sum of the following three distances

Distance traversed during perception time
Distance traversed while passing
Distance traversed by opposing vehicle

Perception Time Perception time in connection with sight distance required for passing is considered to be the time elapsed from the instant the road opens up to the view of the driver of the overtaking vehicle to the time he begins the operation of passing when the opposing lane is free of traffic Research is needed for an accurate determination of the perception time which will be sufficient for most drivers Each second represents in feet about 1½ times the assumed design speed in miles per hour

The Operation of Passing: Passing generally is accomplished by one of two methods, though combinations of both methods often are used

In one method the driver of the overtaking vehicle remains some distance behind the slow moving vehicle and when the road opens up to view he edges over towards the passing lane and accelerates at the same time When he reaches a point close to the slow moving vehicle he decides to pass if the road is clear By this time he is traveling at a higher speed at which speed he continues (or he may continue to accelerate) until he passes the slower moving vehicle and returns to the right lane If opposing traffic appears when he is about to pass he can brake and return to the right lane behind the slow moving vehicle

In the second method the driver of the overtaking vehicle slows down and remains behind the slow moving vehicle until the road opens up to view when he sizes up the situation (perception time) and if the opposing lane is clear of traffic decides to pass He passes the slower moving vehicle and returns to the right lane by accelerating

For purposes of design, minimum sight distance should be based upon conditions which require the longest sight distance for safe operation provided such conditions are encountered on the road frequently The method of passing therefore which results in the longer required sight distance should be assumed if it is used frequently Many drivers naturally use the second method of passing and the necessity for waiting until opposing traffic clears the passing lane often makes the second the only possible method of passing

Research is required for accurate determination of the spacing of vehicles immediately preceding and after completing the operation of passing and of the maximum acceleration, which will be less than that used by most vehicle operators These data may be supplemented or replaced by research leading to an accurate determination of the total time of passing

The time of passing may be developed as follows

t—time of passing in seconds
v—speed of passed vehicle in ft per sec.
a—acceleration of passing vehicle in ft per sec per sec
S—average spacing of vehicles immediately preceding and after completing the operation of passing

Distance traversed by passing vehicle $= vt + 2S$

Average speed of passing vehicle $= \frac{1}{2}(v + v + at)$

Distance traversed by passing vehicle $= \frac{1}{2}(v + v + at)t$

Equating

$$vt + 2S = vt + \tfrac{1}{2}at^2$$

from which

$$t = 2\sqrt{\frac{S}{a}}$$

It may be noted that for constant vehicle spacing and acceleration the time of passing is independent of the speed

In 1934 Dr H C Dickinson[1] made some tests in which the method of passing employed was the same as the second method described herein The time of passing was found to be very nearly six seconds and independent of the speed, which varied from 5 to 45 miles per hour The rear car, traveling at the same speed as the car ahead, started to accelerate from a position about 1½ sec in time behind the car ahead If this period of time was the time it took the rear vehicle to overhaul the slower vehicle, the spacing of vehicles was constant and explains the constant time of passing

The spacing of vehicles may not be the same for different speeds In 1933 Dr Bruce D Greenshields[2] used a photographic method for studying behavior of traffic from which he developed the following formula for the spacing of vehicles in a train when the speed is controlled by the first vehicle

$$S = 21 + 1.1V$$

in which S is the spacing in feet and V the speed of traffic in miles per hour The spacing of vehicles immediately preceding and upon completing the operation of passing may be found to be different from the above and different from each other but there is reason to suspect that they will vary with the speed

Dr Greenshields[3] later used the photographic data in an attempt to determine the time of passing and found it to be 10 or 11 sec for most drivers The large variation in results found by these and other investigators indicates the need for further research on this important factor in minimum sight distance for passing

Distance Traversed by Opposing Vehicle The distance traversed by an opposing vehicle which comes into view at the beginning of the operation of passing is the product of the total time of passing and the speed of the opposing vehicle This distance must be included in the minimum sight distance required for passing with safety The speed of opposing traffic must be assumed and generally is considered to be equal to the assumed design speed of the highway No research in connection with this factor appears to be necessary

ADDITIONAL FACTORS

The factors which enter into the determination of the minimum sight distance required to pass a single slower moving vehicle with safety are not the only ones which enter into the design of sections with sight distance adequate for passing on two- and three-lane highways of various assumed design speeds

A driver traveling at the assumed design speed of a highway naturally desires to pass slower moving vehicles This desire is reasonable and should be satisfied To what extent, however, should design be adjusted to satisfy this desire? If conditions are such that an appreciable percentage of drivers are tempted to

[1] H C Dickinson, "Distance Required to Overtake and Pass Cars," *Highway Research Abstracts* No 14—October 1934

[2] The Photographic Method of Studying Traffic Behavior, by Bruce D Greenshields, *Proceedings*, Highway Research Board Vol 13 (1933)

[3] Bruce D Greenshields, "Distance and Time Required to Overtake and Pass Vehicles," *Proceedings*, Highway Research Board, Vol 15 (1935)

pass, good design, from the standpoint of safety, calls for recognizing these conditions and providing adequate facilities for passing Research is needed for accurate determination of these conditions which may be described by the following questions

What is the maximum distance between the end of a safe passing section and the beginning of the next one which will not cause impatience and not tempt an appreciable percentage of drivers to pass at points unsafe for passing? This must be related to the probable speed of overtaken vehicles because the time of traversing this distance varies inversely as the speed at which the vehicles will be required to travel It also should be related to traffic density because of the possibility of the passing lane being occupied by opposing traffic when a safe passing section is reached

What is the minimum difference in speed which will tempt an appreciable percentage of drivers to pass? The greater the difference in speed the shorter is the sight distance required for safe passing

What minimum number of vehicles in a train will discourage passing? The sight distance required for passing with safety increases appreciably with each increase in the number of vehicles in the train This factor should be related to assumed design speed and to the probable speed of the train of vehicles

What is the probable spacing of vehicles in a train? This factor also should be related to the probable speed of the train of vehicles

SIGHT DISTANCE AT INTERSECTIONS

Some of the factors used in the determination of sight distance at intersections are not appreciably different from those used for sight distance along highways Others apply only to sight distance at intersections Research is needed for accurate determination of some of these factors The development of the theory of sight distance at intersections is worthy of a separate paper, but some of the factors which appear to require research are listed

Perception time at intersections is different in some respects from perception time along a highway The driver approaching an intersection must glance diagonally across two triangular areas, one to the left and the other to the right, to observe traffic in both directions on the intersecting highway and arrive at a decision regarding his own actions If he is on a non-preference road signed for stopping no problem presents itself until after he has stopped If it is not desirable to subordinate traffic on one road to that on the other the driver approaching an intersection must decide whether to slow down and at what rate or whether to come to a stop His decision must be based on the traffic he observes on the intersecting highway Research on the period of time required by most drivers to reach this decision is needed Angles of intersection other than right angles may affect the results

When a driver is stopped at an intersection he should see enough of the intersecting highway to be able to cross without being endangered by a vehicle that appears after he has started The visible length of intersecting road in each direction should exceed the product of the assumed design speed of the intersecting road and the time it takes the stopped vehicle to cross To determine the time which should be assumed for a vehicle to cross a road research is needed on perception time of the driver stopped at an intersection, the time it takes to start the vehicle, and the rate of vehicle acceleration from a stopped position, due recognition being given to the fact that gears must be shifted These factors probably would have to be evaluated separately for passenger vehicles and for trucks

OPTICAL ABILITY OF THE DRIVER

The research listed thus far is needed to evaluate factors which enter into the determination of sight distances required for safe and efficient highway operation In some cases the resulting sight distances are of little practical value because of the inability of many drivers to take advantage of them If, for example, it is found that on a two-lane highway on which the assumed design speed is very high the sight distance required for passing is very great it may be inadvisable to expend extra sums for providing such sections Some drivers may not be able to see that far and many may not be capable of correct judgment where such distances are involved It may indicate that the assumed design speed for a two-lane highway is limited

Research is needed to determine the maximum distances which most drivers can see and react for various purposes and under varying conditions both day and night Research of this character may not be needed as urgently as that which may be used as a basis for determining minimum sight distances There is no danger in providing unnecessarily long sections of highway open to the view of the driver

IMMEDIATE APPLICATION

The adoption of correct principles regarding sight distance in the design of highways need not be delayed because of the lack of data outlined herein Values for the various factors considered reasonable or on the safe side may be assumed and used until such time as research develops more accurate values.

For non-passing minimum sight distance two seconds for perception time, one second for brake reaction time, and 0 4 for the uniform coefficient of friction may be considered reasonable values They result in non-passing minimum sight distances equal in feet to about ten times the assumed design speed in miles per hour The variation is not uniform being greater at higher speeds and less at lower speeds For four-lane and divided highways a greater margin of safety may be advisable This may be secured by assuming a speed 10 miles per hour greater than the assumed design speed of the highway for sight distance purposes

In the design of two- and three-lane highways, sections safe for passing should be given conscious thought and not come about only as accidental results of fitting the highway to the topography A distance of one to two miles between the end of one and the beginning of another safe passing section may be assumed as a desirable maximum for two-lane highways, shorter distances should be assumed for three-lane highways, and advantage should be taken of every favorable location to effect the construction of frequent safe passing sections

For passing minimum sight distance it may be assumed that vehicles traveling at an assumed number of miles per hour less than the assumed design speed will be passed in the face of opposing traffic traveling at the assumed design speed If this speed difference is assumed to be 10 miles per hour, perception time is assumed to be 3 sec, and time of passing is assumed to be 9 sec the required sight distance for an assumed speed of 40 miles per hour is about 1,000 ft and for 60 miles per hour about 1,700 ft

DISCUSSION ON SIGHT DISTANCE

DR B D GREENSHIELDS, *College of the City of New York*· Mr Barnett pointed out that the safe distance required for passing was made up of three items, the distance traveled during the perception time, that traveled while passing, and that traveled by the opposing vehicle I think that there should be an added distance for a safety factor

Perception time and reaction time might be combined Usually in taking brake reaction time we flash a light and then note the lapse of time from the flashing of the light until the operator puts his foot on the brake This I believe is the common conception of reaction time and includes the time of perception This combining would not change the character of the formula

In regard to the spacings between vehicles on the opposite lane, I think it has been found that the distribution of the time intervals between the appearances of vehicles on an unobstructed highway, follows the normal probability curve These intervals, varying from a few seconds to a maximum depending upon the density of traffic, are the opportunities one has for passing As Mr Barnett stated, if one assumes an average difference of speed the time for passing becomes a constant Passing is possible only when this much time is available from traffic on the opposing lane The average or minimum spacing has little significance in the study It is rather the variation from the average which offers sufficient time for passing

I agree with the finding that about 1,000 ft is the distance required for passing for average speeds This is the same result which I obtained from observations made in Ohio and reported at a previous meeting of the Highway Research Board The assumption was made in the analysis that all slower cars were passed by the faster traveling ones and that the passings were made only as sufficient time became available on the opposite lane. It was assumed that the drivers selected their own safety factors The results would be safe passing distances rather than minimum

DR A R LAUER, *Iowa State College* I agree with the general presentation by Mr Barnett and also the comments made by Dr. Greenshields However, for the sake of clearness, I would like to point out the difference between *"sense"* and *"judgment"* Ordinarily in thinking of the term "sense", we mean in the case of vision, "Do you see a thing or not?" Perception or interpretation of markings, etc , on the roadway is somewhat another area It is merely an interpretation and does not take three seconds for realization There is the third category of which we still have to take account and which is most important of all That is judgment When you see an object in a store window, or on the road and after you decide what it is, then, "Do you want it or don't you want it? "Can you pass it or can you not pass it?" These decisions are matters of judgment It is a process more complex than "sensation" or "perception " The amount of time required for accurate judgment may run into minutes instead of seconds

The lack of good judgment partly accounts for the fact that younger drivers have more than their share of accidents It accounts for the fact that one of low intelligence is likely to have more accidents in passing It partly accounts for the fact that alcohol seems to cause many accidents It is often not a question of, "Do they see it?" but a question of, "Do they see it and know what to do?" I fully believe the time has come when high speed on roadways, such as the proposed Pennsylvania super-highway or the high-speed roadways in Germany, should be limited Who can perform safely at those high rates of speed? The fact seems obvious that we need to keep the public out of the air so far as piloting is concerned We don't allow any one to fly a plane until he is well qualified I think the application of scientific principles to the situation at hand should be, first, define our terms carefully, and second, determine the safety factor required to satisfy the needs of any emergency and, as Dr Greenshields said, make it *sufficiently adequate* I do not see any reason for limited non-passing areas The minimum passing distance, as Dr Greenshields has suggested, should be established and maintained Otherwise someone may try to pass at any point and there are short places where you cannot see far enough ahead on existing highways, which is the reason for many accidents Why not plan the highways so the poorest driver will have no excuse for his accident on grounds of inadequate sight distance? Give them enough room to stage a self-debate on the advisability of passing and have plenty of time to actually do it The maximum passing distance will be short enough at high speeds

MR BARNETT It appears to be desirable to separate perception time and brake reaction time As Dr Greenshields pointed out, brake reaction time is direct On the road considerable time may elapse from the instant certain conditions develop to the beginning of brake reaction time

The report of the Massachusetts Highway Accident Survey, made in 1934 under the direction of the Massachusetts Institute of Technology, records the results of testing some drivers under varying conditions with both laboratory and road tests Among the latter were tests in which the stop light was covered and the rear driver was instructed to brake as soon as he noticed the forward vehicle slowing down I believe the contact between cars was made by radio The conclusion drawn was that "a driver who showed a reaction time of 0 2 to 0 3 sec under laboratory conditions might require 1 5 sec to apply his brakes under normal road conditions, if the stop light of the car ahead was out of order, after the driver ahead had actually applied his brakes" In other words their reaction time on the road, despite the fact that distraction was eliminated from the tests, was about seven times what it was in the laboratory

Reference has been made to a factor of safety A factor of safety may be applied in many ways It can be applied by assuming critical values for all factors and increasing the resulting sight distances It may be applied by assuming values below the critical for all factors such as a friction factor of 0 4 when tests on clean wet pavements indicate impending skid factors of 0 7 or 0 8

The concept of two minimum sight distances for an assumed design speed should be given consideration particularly when improving conditions on existing roads There seems to be little advantage in the practice of increasing minimum sight distances on existing two- or three-lane highways or increasing standards for minimum sight distances for new highways unless such increases provide the minimum sight distances sufficient for passing with safety This is particularly true on high speed highways on which minimum safe passing sight distances are much greater than the non-passing minimum sight distances Increasing sight distances by small amounts in excess of the non-passing minimums generally does not provide sight distances adequate for passing with safety and may make the highways more hazardous by encouraging vehicle operators to attempt to pass Few vehicle operators know or sense the distance required to pass a vehicle It seems to be more advisable to concentrate expenditures on limited sections of the highway where topographic conditions make such changes feasible and improve these sections to secure sight distances adequate for passing with safety