REPORT OF DEPARTMENT OF DESIGN

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REPORT OF COMMITTEE ON SIGHT DISTANCES

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NEEDED RESEARCH FOR THE DETERMINATION OF SIGHT DISTANCES AT INTERSECTIONS

SYNOPSIS

Any intersection should be so designed that the operator of an approaching vehicle has an unobstructed view of both the whole intersection and a length of the intersecting highway sufficient to permit proper control of his vehicle This requires determination of sight distances that reflect the change in traffic behavior as vehicles approach an intersection, particularly to establish the highway lengths of the corner area that must remain unobstructed

This report briefly discusses the factors in determining sight distances at and near intersections It is a supplement to the committee report of last year which treated sight distances along the highway between intersections Chief among the several factors for which research is needed to determine values for geometrical design of intersections are perception time in discerning vehicles on roads intersecting at various angles, perception time at a stop or slow sign to determine a clear preference road and the time or distance required for all types of vehicles to start and accelerate to various speeds or to decelerate to safe speed from the highway speed All other factors that may affect or control sight distances also should be investigated and evaluated

The report of this committee last year[1] was concerned primarily with sight distance along the highway This paper confines itself to sight distances at intersections to complete the general report on the research needed for the determination of values to be used in this very important feature of highway design, a feature directly affecting the safety and utility of highways

Sight distances at intersections are the distances measured along the highways from the point of intersection between the extremities of which vehicles are just visible to one another and there are no obstructions inside the triangle formed by the highways and the line of sight There generally are innumerable combinations of sight distances along the intersecting roads but the problem is simplified by determining the minimum distances required for various assumptions for driver behavior, applying these distances to the roads considered and clearing the enclosed triangle of those obstructions which impair the sight across it If an intersection is designed in this manner all assumptions for driver behavior resulting in shorter sight distances naturally are provided for

Most simple right-angle intersections as regard sight distance fall within designs which are based on the following cases, three in number, each representing a set of assumptions for driver behavior

Case I—No traffic control, drivers see each other only soon enough to begin changing speed just before reaching the intersection

Case II—No traffic control, drivers see each other only soon enough to enable either or both to stop before reaching the intersection

[1] "Needed Research for the Determination of Sight Distance," Proceedings Highway Research Board, Vol 17, page 111.

Case III—Traffic on non-preference road controlled by STOP signs

Case I is more or less academic and develops absolute minimums It is highly hazardous and should be tolerated only at intersections where both highways carry very light traffic so that the probability of vehicles meeting at the intersection is very slight It implies that drivers see each other only soon enough to permit either or both to perceive the situation, remove his foot from the accelerator and apply his brakes Collision is avoided only if the drivers decide on different actions such as one proceeding through the intersection and the other applying his brakes The distances, obviously, should be considered absolute minimums and every effort made to secure longer distances no matter how unimportant the roads Where longer sight distances cannot be secured and traffic is greater than a bare minimum one road should be subordinated to the other and STOP signs provided as in Case III

The minimum sight distance along each road for Case I is that traveled at the design speed of the highway during perception and brake reaction time Perception time in this case is the minimum time, which is greater than the time required by almost all drivers from the instant a vehicle on the intersecting road can be seen to the instant a decision is reached regarding the action to be taken Research is needed to determine values for this form of perception time which may be different from the values for perception time involved in sight distance along the highway Research also is needed to determine factors which affect perception time

Brake reaction time, the time required from the instant the decision is made to the instant braking begins has been investigated extensively It was discussed in last year's report Variations do not affect sight distance appreciably and additional research does not appear to be necessary

Case II is the most common form of intersection at grade It generally is used where the traffic on either road does not justify any form of traffic control other than warning signs The intersecting road opens up to view at a distance from the intersection sufficiently long enough to enable the driver to stop his vehicle if the intersecting road is occupied Of course there is still some chance of confusion between drivers and of collision if neither driver slows down or stops or if both slow down in equal degree but the chance of collision is slight because of the time available to both drivers for maneuvering

The research needed to determine safe stopping distances at intersections is the same as that needed to make the same determination on the highway and reported last year. It may be of interest to report that a committee of State highway officials has agreed to use safe stopping distances of 200, 275, 350, 475 and 600 feet for design speeds of 30, 40, 50, 60 and 70 miles per hour respectively These distances are based on friction factors varying from 0 5 for 30 miles per hour to 0 4 for 70 miles per hour and on values for the sum of perception and brake reaction time varying from 3 seconds for 30 miles per hour to 2 seconds for 70 miles per hour The assumptions for perception time are not based on any extensive tests or factual data The need for research to determine perception time along the highway as described in last year's paper still exists The perception time at intersections, however, may be appreciably different due to the fact that the driver must look both to the right and to the left in addition to straight ahead and the decision to be made is slightly more intricate than along a highway where it is natural to decide to apply brakes when it is determined that an object is in your

path The driver approaching the intersection must decide whether to slow down and at what rate or whether to stop He must base his decision on the presence and behavior of traffic on the intersecting road within his vision and sometimes on the behavior of traffic on the road he is traveling Research to determine perception time of this character appears desirable

Case III also is a very common form of intersection at grade All traffic on the non-preference road is stopped at the intersection and proceeds to cross when the intersecting road within his vision is free of traffic or when traffic on the intersecting road proceeds at a pace which he thinks enables him to cross in safety during the inevitable break in traffic The driver of a stopped vehicle 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, therefore, 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 or the time it takes the driver to look up and down the intersecting road and arrive at a decision regarding his course of action, the time it takes to start the vehicle, and the rate of vehicle acceleration from a stopped position Some of these time factors probably overlap in the course of normal operation by most drivers Shifting into first gear while looking up and down the intersecting road is natural and proceeding at slow speed instead of stopping completely is not uncommon to say the least In a determination of minimum values to be used in design, however, the safest actions requiring the longest minimum sight distances should be assumed, provided they are used to some extent, and other actions which reduce these distances, no matter how natural and common, should be considered leeway for safety Some research on the acceleration of vehicles from a stopped position has been made and values are presented in succeeding papers These observations, unfortunately, are confined to passenger vehicles

Cases of possible driver behavior at intersections other than those presented may be considered Intersections in which traffic on one road is subordinated to that on the other but is not required to stop and intersections controlled by traffic lights are cases in point The researches needed to determine sight distances for these cases are in general the same as those needed for the cases presented and, therefore, are not discussed separately

All researches suggested thus far should be made for trucks and busses as well as for passenger vehicles, particularly since truck and bus requirements result in more critical values It generally is admitted, for example, that acceleration rates for medium and heavy trucks and busses are considerably less than the rates for passenger vehicles so that the time required to cross an intersection from a stopped position is much greater Likewise the braking deceleration rates for most trucks and some busses are less than for passenger vehicles but this may be counterbalanced by the fact that few heavy trucks travel at speeds assumed for passenger vehicles The effects of grade, road surface and atmospheric conditions should be determined, as well as the effects of night both on highways illuminated with fixed source lighting and those which are not

Sight distances at oblique-angle intersections are measured along the roads as at right-angle intersections but certain factors may be affected by sharp angles

Vehicles stopped at the intersection must cross greater distances and the time required to cross oblique-angle intersections, therefore, is greater than that required to cross a similar right-angle intersection Perception time may be affected when the intersection angle becomes appreciably different than a right angle due to the angular limit of vision of most drivers It appears to be desirable to study the effects of oblique angles on the various researches required

Signs are intimately associated with intersections in general While the ability to see and read signs is important in the proper operation of intersections they do not directly affect the determination of sight distances at intersections as defined. The subject of signs, their visibility and location particularly, is worthy of a separate paper A committee of the American Association of State Highway Officials and the National Conference on Street and Highway Safety is now engaged in revising the manual on Uniform Traffic Control Devices and it may be desirable to delay discussion of the research needed to determine the various factors in connection with signs until this work is completed It may be advisable to arrange for a separate committee for this important subject

DISCUSSION ON SIGHT DISTANCE AT INTERSECTIONS

Dr B D Greenshields, *The College of the City of New York*· Of special significance in Mr Barnett's paper is the statement that in

> "a determination of minimum values to be used in designs,—the safest actions requiring the longest minimum sight distances should be assumed"

If only the average driver is provided for, then the 50 per cent who are worse than average are likely to get into difficulty.

Perhaps it will not be out of place to review a few concepts to be considered in the research for sight distances "The visual field of the driver," according to James J Gibson, Smith College, and Laurence E Crooks, Society of Automotive Engineers (The American Journal of Psychology, July 1938, pp 453-471) "is a rather special sort of field in several respects It is selective in that the elements of the field which are pertinent to locomotion stand out, are attended to, while non-pertinent elements, such as 'Scenery,' normally recede into the background The most important part of the terrain included in this pertinent field is the road Within the boundaries of this road lies, according to our hypothesis, an indefinitely bounded field which we will name *the field of safe travel* It consists, at any given moment, of the field of possible paths which the car may take unimpeded "

It seems to me that it would be more correct to say perceptual field of safe travel rather than just field of safe travel.

The driver's factor of safety at any instant is the ratio of what he conceives to be his safe field of travel to the minimum stopping distance If the driver is overdriving his head lights he may be said to have a negative factor of safety in so far as sight distance is concerned.

It is this perception of the field of safe driving that brings a large number of incommensurable factors into the problem Not only the ability of the driver to see, but his inate cautiousness, his experience, and his attitude at the moment are all elements to be considered. These elements cannot be measured directly but, their effect, the behavior of the driver can be recorded and analyzed.

A varied pattern of behavior at an intersection would show uncertainty on the part of the drivers and indicate a

dangerous condition The importance of uniform behavior is recognized by penalties imposed for the violations of traffic lights At a dangerous intersection one could expect to find some drivers approaching at high speeds indicating that they were unaware of any danger Others might be approaching at a safe speed indicating that they were either naturally cautious and looking for hidden danger, or else were familiar with conditions from having traveled the road previously

Mr Barnett defines sight distances as

"the distances measured along the highways from the point of intersection between the extremities of which vehicles are just visible to one another and there are no obstructions inside the triangle formed by the highways and the line of sight"

This definition correctly bounds the visual field but it does not take account of the fact that the driver confines his attention to pertinent elements and excludes non-pertinent elements Study is needed to determine more accurately what elements are pertinent and what are not Highway signs are obviously among the pertinent elements, but signs that are habitually displayed where they are not needed or convey information what is too incomplete such as "curve" tend to become excluded from the driver's attention

As speed increases the driver's attention is concentrated farther and farther ahead and, as a consequence, his ability to judge the speed of moving objects becomes less In other words the perceived field of safe driving becomes less definitely bounded as it is extended, and it may be much narrower than the visual field. There is also the possibility that the visual field may be so obscured by what is in the background that a car approaching at high speed on a side road may be almost invisible