

# National Conference on Street and Highway Safety

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*Report of the*

## COMMITTEE ON CONSTRUCTION AND ENGINEERING

*Appointed by*

The Secretary of Commerce

This report is one of eight issued for consideration in advance of the National Conference on Street and Highway Safety. The reports are: I Statistics; II Traffic Control; III Construction and Engineering; IV City Planning and Zoning; V Insurance; VI Education; VII The Motor Vehicle; VIII Public Relations

Washington, D C

November 11 1924

## Conference on Street and Highway Safety

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# Conference on Street and Highway Safety

## Committee on Construction and Engineering

*Hon Herbert Hoover, Chairman,  
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Washington, D C*

SIR: Only a very small percentage of the street and highway accidents today can be attributed directly to construction and engineering defects. Nevertheless, so rapid has been the development of motor traffic and so rapid will its future growth unquestionably be, that the subject must be considered in anticipation of a much greater volume and density of traffic than now exists on most of the highways, of larger and heavier units, and possibly of higher allowable speeds.

Congestion multiplies the dangers of the road. Therefore, safety requires that these increasing currents of traffic be able to flow smoothly and continuously, by night as well as by day with a minimum of conflict between currents. It requires that individual operators of vehicles be able to proceed safely at a uniform rate of speed as far as possible, and that where for any reason they must slow down, stop or turn there must be unmistakable indications to that effect.

After consideration of the construction and engineering problems involved the following summarized conclusions are submitted:

### Summary of Conclusions

1 The roadway of every improved rural highway should be wide enough for at least two lines of traffic. Every pavement in a city street should be wide enough for at least three lanes of traffic without street cars or four lanes with street cars. Those for streets of heavy traffic should be wider. Street and highway pavement widths should be in multiples of widths of traffic lanes, i.e., 9 feet minimum for motor vehicles and 10 feet for street cars.

2 Right-of-way for parking space, for clear view at curves and intersections, and for future roadway widening should be provided before the cost of the land becomes prohibitive. Parkways and sidewalks should be so placed as to facilitate future widening.

3 In suburban streets carrying both street cars and heavy motor traffic the street cars should generally be given exclusive space in the center with a roadway on each side. In rural districts where car lines parallel the roadway, the tracks should remain continuously on one side.

4 To make it feasible to prohibit parking or stopping on the traveled roadway, improved rural highways should be provided either continuously or at intervals not exceeding 300 feet, with reasonably hard and level parking places entirely outside of the traveled way. It is generally not practicable to construct city streets and pavements of sufficient width to provide permanently for unrestricted parking.

5 Safety as well as economy requires that grades in excess of 6 per cent be avoided where feasible in laying out or improving thoroughfares of primary importance, whether in country, village or city.

6 Highways of primary importance should not have curves of less than 300 foot radius. Heavy grades and sharp curves should not be combined.

7 The cross-section of the pavement or roadway should be as flat as drainage conditions will permit. Curves should be widened and banked, and provided with transition curves to effect an easy transition between straight sections of the roadway and the curves.

8 Guard rails of substantial type should be erected on the shoulders of embankments.

9 A clear view of approaching vehicles for at least 300 feet should be provided at all points on highways of primary importance. This may necessitate removing trees, shrubs and sloping banks on or off the right-of-way at curves and intersections, and cutting down sharp hillcrests.

10 At street intersections the grades of each street should be maintained if possible, particularly those of main arteries of traffic. Curb radii should ordinarily be not less than 15 feet and 20 feet in special cases.

11 Grade crossing elimination through cooperation of municipalities, states and railroads must be the ultimate remedy for the railroad-highway grade-crossing peril. Where grades are separated, narrow or obstructed underpasses and sharp turns in the approaches thereto should be avoided.

12 The creation of new grade crossings should be avoided wherever possible. Before improving an important highway which has grade crossings or other serious disadvantages, consideration should be given to the possible substitution of some parallel route free from such difficulties, even if little traveled at present.

13 Crossings remaining at grade should be safeguarded in every reasonable way. Standard warning signs or pavement markings should be supplemented by automatic signals, crossing flagmen or gates depending on the volumes of highway and rail traffic. So far as possible

a clear view along the track in both directions from both sides thereof should be maintained. Sharp curves, abrupt changes of grade, roughness in the pavement or other conditions at or near the tracks, which tend to divert the attention of the motorist should be avoided.

14 Every bridge on an improved highway or street should be at least 22 feet wide, to enable two lines of traffic to pass without difficulty. Existing one-way bridges should be widened or rebuilt. On long bridges suitable provision should be made for the safety of pedestrians, either by sidewalks or by frequent safety zones built outward so as not to narrow the roadway.

15 Detours around highways, streets or bridges under construction or reconstruction should be carefully selected and maintained in safe condition, and clearly marked.

16 Safety requires that pavements and roadway shoulders be maintained in good condition. This will include prompt removal of snow from all streets and highways of heavy traffic.

17 Cautionary or stop signs and signals at danger points, direction and distance signs at important junctions and intersections, and signs and signals to indicate special traffic rules and regulations are all necessary for the safe operation of vehicles on the streets and highways, and should be provided as a part of the construction of the street or highway, unless provided in the cities by the traffic authorities. They should be simple and uniform for a given purpose throughout the United States.

18 For signs and signals, both luminous and nonluminous, the following color indications are recommended, and these colors should not be used for any other purpose: Red for "Stop"; green for "Proceed"; yellow for "Caution," as at curves; purple or some other color as a special cautionary indication at cross roads; white letters or symbols to be used on the red, green or purple background; black on the yellow. Distance and direction signs should be black and white.

19 Besides highway intersections, for which a special color is recommended, sharp curves, steep descending grades and narrow bridges or places in the roadway are danger points, and should be conspicuously marked with yellow cautionary signs. Red stop signs should be used at the entrances to through-traffic highways. Railroad grade crossings should be protected as indicated in Recommendation 13.

20 Many unimproved highways not part of the present or proposed Federal-aid or state highway system carry considerable motor traffic. Automobile clubs or other agencies can perform a useful service by placing standard signs at the chief danger points on such highways.

21. Two-lane rural highways should be marked with a white center line on curves, at and near hillcrests, at irregular intersections and at any other points where safety requires that motorists keep strictly to the right. White center lines should not be used on straight level sections of highway or street except at highway, street or railroad crossings. Black center lines on straight sections of highway are desirable.

22. Pedestrian lanes should be marked on the pavement at busy intersections.

23. City streets should be sufficiently illuminated so that bright headlights will be unnecessary and so that traffic signs will be clearly visible. Flood lighting of traffic officers is recommended. The desirability of lighting rural thoroughfares carrying heavy night traffic is recognized, but it is believed that at the present time this is in most cases not feasible.

24. Objects near the roadway, such as curbs, poles, fences and rock surfaces, should be painted white; also obstructions, such as columns and curbs, at the centers of underpasses.

By the Committee,

FRANK PAGE, *Chairman.*

Mr. Tuttle agrees, with respect to Conclusion 1 and the supporting text, that the width of roadway should be based on the number of lines of vehicles to be accommodated. He believes, however, that parking conditions and the prevailing type of vehicle expected to operate on the roadway must be taken into consideration in determining the proper width.

Mr. White does not approve Conclusions 18 and 19.

Mr. Halvorson does not approve of Conclusion 23 or of that section of the report dealing with the illumination of highways. He believes that inasmuch as the report recognizes that night traffic is of great importance there should be included some definite specification with regard to adequate illumination, which in his opinion is the only way in which the highways can be made safe at night. In his objection he states that the use of the automobile at night is greatly curtailed due to the headlight menace. He further objects to the suggestion contained in the report "that it is more important to provide the greatest mileage possible of improved roads than to light the principal thoroughfares now existing." He questions the right of the Committee to consider matters of expense in connection with safety measures.

*(The complete text of the Committee's report follows.)*



## Street and Highway Widths

The roadway of every rural highway worth improving should be wide enough so that two vehicles can pass without going off the pavement and without retarding speed. In open country well away from the large cities two lanes will probably in most cases carry all of the traffic safely, and where they will not it is preferable in the interests of both safety and capacity to build or improve a new two-lane highway parallel to and at no great distance from the first, rather than widen the first.

In suburban or metropolitan areas, for distances in some cases of 50 or 75 miles from the large cities, the travel on many of the highways will warrant wider roadways. If the traffic is balanced as well as heavy there should be four lanes, or two two-lane roadways side by side. Three-lane roadways are effective and economical, however, where there is a great preponderance of traffic in one direction at all times or in one direction part of the day and in the other at other times. In such cases the preponderating traffic will automatically determine the direction of flow in the middle lane. This applies primarily to highways leading into large cities and carrying a large number of persons daily to and from their places of business.

In city streets the minimum width of pavement should accommodate three lines of traffic, so that an occasional motor vehicle parked parallel to the curb will not narrow the roadway down to one line. Streets carrying a double-track car line should have a minimum paved width sufficient for a line of vehicles on each side of the tracks. Streets of heavy traffic will naturally require greater widths; generally an even number of lanes of traffic is preferable to avoid conflict of movement.

The roadway width in city streets should always be a multiple of the standard lane. A lesser width is unsafe; a greater width is uneconomical. Existing streets not so designated may sometimes be made to carry an additional line of traffic by slightly widening the roadway. The possibility of future development of a residence street into a street car or business street should be borne in mind and the trees and sidewalks placed accordingly, so as to facilitate future widening of the roadway.

No improved rural roadway should be narrower than 18 feet, to provide two traffic lanes as recommended. While the 18-foot roadway will permit ordinary automobiles and motor trucks to pass safely

without reducing speed, it is insufficient for the newly developed de luxe bus, which has a wide spread of the rear wheels. To enable such busses to pass other vehicles safely at high speed would require a 24-foot roadway. Whether this extra width should be provided at public expense to accommodate a relatively small number of vehicles operated for hire is an economic question outside of the province of this Committee. Safety requires, however, that the speed of such busses operating on highways less than 24 feet wide be severely restricted while passing other vehicles, and that they be prohibited entirely from operating on highways less than 18 feet wide.

Furthermore, the Committee is informed that plans are being developed for a new type of bus with six wheels and an overall length of some 75 feet. Such busses in addition to requiring a wide lane, will be unable to round the curves on some of our improved highways without crowding off vehicles they may meet. Therefore, no carrier for hire should be granted a permit to operate on any section of highway unless the vehicle it contemplates operating can pass over every section of the highway without encroaching upon the lane of traffic in the opposite direction.

The rapid growth of traffic that has followed the improvement of most highways points clearly to the necessity for anticipating future requirements and providing additional right-of-way before the cost becomes prohibitive for future widening as well as for providing parking spaces, protecting the view of the motorist and other purposes, the importance of which is pointed out in other sections of this report. For the same reasons additional right-of-way should be acquired at once along highways already improved where there is reason to believe that it will ultimately become a necessity.

As a police or zoning measure building upon land which will probably be needed for highway purposes should be prohibited, so that when the additional width is acquired it will not be necessary to pay for structures which have been built because of the improved highways. This is not acquiring property without compensation, it is only restricting its use to meet the public need.

### Street-Car Tracks

For wide principal streets and highways well outside of the congested or strictly business areas of the city accommodating both street-railway and vehicular traffic the public is best served by a physical separation of these two classes of traffic. A reservation in the center of the street should be provided for the exclusive use of

the street railway with a one-way driveway on each side for other vehicular traffic. This permits faster and safer operation of the street cars and gives opportunity for safe landing platforms for the passengers; and where such landing platforms are provided the motor vehicles are afforded safer and more rapid passage, inasmuch as they are relieved of the necessity of stopping behind street cars standing to discharge or receive passengers.

Street car lines running at the side of rural highways frequently cross and recross the roadway repeatedly. Aside from the danger to motorists arising from the sudden and unexpected turning of street cars into the roadway, these repeated crossings are dangerous because they may, particularly at night, mislead motorists into turning off the roadway into the ditch. The tracks or roadway in every case where possible should be relocated so that the tracks will remain continuously on one side of the roadway.

### **Parking Space**

The Committee on Traffic Control will recommend that vehicles be prohibited from parking or stopping on the traveled portion of any improved rural highway. A corollary to this recommendation is that there must be adequate space off the traveled way where motorists can park or stop safely. It is not necessary or desirable that these spaces be of the same material of which the road is constructed, but they should be sufficiently stable and level to support the vehicle at any time. They already exist naturally along many highways, but where they do not they should be provided as a part of the construction of the road, at intervals not to exceed 300 feet.

Parking space as such should not be regarded as an essential part of the design of city streets. The pavements are, however, usually designed to carry more than the traffic immediately anticipated, and this will afford opportunity for parking until the traffic authorities find it necessary to restrict or prohibit it to make room for the moving vehicles. The problem of providing parking space off of the streets in congested districts is one for the city planner, and will presumably be considered by the Committee on City Planning and Zoning.

### **Grades**

A general standard maximum grade of 6 per cent should be established for thoroughfares of primary importance, both in rural districts and in cities and towns, particularly for those thoroughfares in cities

and towns which form part of the general highway system. Topographic and economic conditions, however, often make it impracticable to hold to such a maximum grade. In highly developed country particularly in the East grades on existing highways greatly exceed this, and to keep to a rigid maximum of 6 per cent in the reconstruction of such a road or street would entail heavy property damage. In certain mountain country, also, a 6 per cent maximum is difficult to attain. However, a location can almost invariably be found with grades not higher than 9 per cent, and nothing steeper should be permitted on any highway or street of primary importance.

On rural highways of secondary importance, where it is necessary to hold the construction cost down in order to develop as much highway mileage as possible, 10 per cent grades may be permitted. In purely local residential developments in cities 12 per cent grades may be used to avoid unduly hampering property development. They should not be introduced where they are likely to carry any appreciable amount of through traffic. Grades as steep as 20 per cent exist in the built-up sections of some cities, and cannot well be eliminated. No new street, however, should be laid out with such grades.

### Curves

No curve on a highway of primary importance, or on an important park drive, should have a radius less than 300 feet. Even this radius should be permitted only when a clear view ahead of 300 feet is available from all points on the curve, including the inside traffic lane, and where this is not attainable the curve should be flattened or relocated.

The present day high-speed motor highway is comparable to the railroad, and railroad practices in the treatment of curves can well be followed in highway design at curves. The curves should be super-elevated on the outer rim and provided with transition curves at the ends, and heavy grades should be compensated for curvature. Exact calculation of such compensation is not necessary, but a combination of heavy grade and sharp curve should be avoided.

### Pavement or Roadway Cross Section

Excessive center elevation or crown in pavements and roadways is dangerous, especially in wet weather. Depending on the character of the pavement and also on the running grade of the street or highway, the cross section of the pavement should be as flat as drainage conditions will permit.

On some of the older highways the crown was carried around the curves as well as on the straight sections. Such curves are dangerous for high-speed operation and should be immediately reconstructed with the pavement sloping uniformly downward from the outer to the inner rim of the curve. Curves should also be widened to facilitate passing of other vehicles.

### Guard Rails

Highways on embankments should be protected by substantial guard rails. In the mountains and on steep grades the ordinary type of guard rail is not sufficient protection. Where space permits, the outside of all curves where the slope downward from the roadway is considerable should be protected by a substantial earth bank not less than 3 feet high. There usually will not be room for this where the highway is cut into the face of a rock cliff but in such cases there should be a substantial stone wall.

### Clear View of Approaching Vehicles

A motorist on a highway of primary importance should always be able to see an approaching vehicle for a distance of at least 300 feet. This applies on curves at and approaching hillcrests, and approaching highway intersections. Obscure highway intersections are particularly dangerous, and besides being conspicuously marked with cautionary signs should have the view so cleared if possible that a vehicle approaching the crossing from any direction may be seen in ample time to avoid a collision.

To provide a clear view at all points it will often be necessary to cut down hillcrests, remove trees, shrubs and other obstructions on the highway right-of-way and level down the slopes of cuts to the height of the eye of the motorist. To supplement these restrictions should be placed on the use of abutting property. The national associations of outdoor advertisers recognize the importance of a clear view and properly recommend that no advertising signs be placed where they will interfere with such view.

At intersections in streets it is equally important that a clear view be provided for as great a distance as possible. This is difficult when stores or other structures are built close up to the corners. Considerations of safety may ultimately require a setting back of buildings at such corners, a matter which comes within the province of the Committee on City Planning and Zoning.

### Street and Highway Intersections

Apart from the necessity in the interests of safety of providing as unobstructed a view as possible at all street and highway intersections, and of marking them conspicuously, many intersections call for careful study from the viewpoints of both the traffic and the topography to alleviate elements of danger.

At rural intersections where the preponderating traffic makes a turn it may be well to acquire right-of-way for a flat curve. Before doing this, however, consideration should be given to the possibility that it may introduce new junctions and cross currents of traffic more serious than previously existed. When there is heavy traffic on each of the roads coming to the intersection, with a considerable amount of turning the introduction of a circle may be an effective safety measure. At some of the busiest intersections separation of grades will appear to be the correct solution.

Intersections of streets on heavy grades call for careful study to make all possible movements as safe as practicable. The running grade of each intersecting street should be maintained if possible; the running grades of main arteries of traffic should always be maintained.

Curbs of too short radius force motor vehicles in turning corners out of their proper lane of traffic thus fouling other lanes. Safety requires that curbs be given sufficient radii to permit the average vehicle to stay in its proper lane while rounding the corner at a rate of speed reasonable for that intersection. This generally means a radius of not less than 15 feet. Larger radii up to 20 feet may be used in special cases while at acute angles there should generally be a minimum of 10 feet.

Curbs should not ordinarily, however, have greater radii than sufficient to permit the average vehicle to follow them at a reasonable speed for the reason that they increase the distance the pedestrian must travel to cross the street in line with the sidewalk or force him farthe back into the block to find the narrowest point.

Buttons or other fixed signals should not be placed in narrow intersections where they can be rounded only by interfering with other lanes of traffic, and traffic officers at narrow intersections should not require motor vehicles to pass around them.

### Railroad Grade Crossings

More than 10 per cent of our street and highway fatalities occur at railroad-highway grade crossings. A conference was called in Chicago on April 30 and May 1 of this year by the National Association of Railroad and Utility Commissioners and attended by about 175 representatives of railroads, public utility commissions, highway commissions and other agencies to consider the various phases of this problem. The conference passed a series of resolutions, and with most of those relating to construction and engineering this Committee is in substantial accord.

Elimination of the grade crossing is believed to be the only perfect solution of the problem. This does not mean that within the next generation every grade crossing of secondary highway and branch line railroad needs be eliminated, but it does mean that municipalities, states and railroads should join in an energetic campaign to carry elimination work forward as rapidly as funds obtainable will permit, with an equitable distribution of the expense. Each municipality, county and state should be at work on comprehensive programs for the elimination of its grade crossings, and should be taking steps to provide its share of the necessary funds. At the same time it should be realized that to eliminate even the grade crossings on improved highways and streets (and there are many dangerous crossings on unimproved highways which should be eliminated) would require a greater expenditure than is possible for many years to come, and that therefore the work should proceed on state-wide programs which begin with the highways where a given sum will accomplish the most in the interest of safety. In general the extra hazardous crossings—extra hazardous because of heavy motor travel, heavy rail travel, obscure view or other conditions—should be eliminated first, although there should be included certain other less hazardous crossings because they can be eliminated for very small sums of money.

Any method of safeguarding grade crossings other than elimination means delay for traffic and consequent inefficiency, whereas elimination means increased efficiency for both the railroad and the highway.

The Interstate Commerce Commission has for some time had under consideration requiring the railroads to install automatic train-control devices. Your Committee is thoroughly in accord with anything which tends to save human life but is convinced that the automatic train-control could not save as many lives as could an equal expenditure on grade crossing elimination. The Summary of Accidents issued by the

Interstate Commerce Commission indicates that there were 134 fatalities due to train collisions in 1923, while there were 2,268 fatalities at grade crossings. If the funds required for automatic train control are applied instead as the railroads' share of grade crossing elimination, and the public contributes an equal amount as it presumably will, the combined sum will go a long way toward removing the most dangerous grade crossings on our main highways.

Careful study will be required to determine the method of grade-crossing elimination, whether by separation of grades on the present or approximate location of the street or highway, by relocation of the highway where it crosses and recrosses the same railroad, or by consolidation of adjacent crossings. Even diversion of one highway into another remaining at grade may be very desirable to make it possible to give better protection at one crossing and also to divert traffic that would otherwise cross the railroad on one highway and back on the other.

Comparative costs, including property damage, will usually determine whether the street or highway shall be carried over or under the railroad. From the safety point of view, overcrossings are usually preferable to undercrossings, inasmuch as they are likely to afford motorists a better view and do not need to be obstructed by center columns or curbs.

Many grade separations, particularly underpasses, on what are now improved highways were made before the advent of the high-speed motor car, and are dangerous because of sharp blind curves at the approaches thereto, narrow side clearance, and low head room at the sides in the case of arches. These danger spots should be eliminated by whatever reconstruction is necessary to provide ample view and clearance.

Many more new grade crossings are being opened yearly than are at present being eliminated. New railroads or branch lines should, as far as possible, be required to avoid establishing additional grade crossings, and municipalities opening new streets across railroads should realize that even though the traffic expected in the near future would not warrant the expense of grade separation they are creating a new problem to require solution ultimately.

Before adopting plans for improvement of highways on which there are numerous railroad grade crossings or other sources of danger, the state and Federal highway authorities should give careful consideration to the possible substitution of some parallel route which is free from such difficulties, even if this parallel route is little traveled at present. This proposal naturally applies primarily to



highways that are expected to carry a heavy through traffic rather than to secondary highways needed to connect farms with markets

Crossings remaining at grade should be safeguarded in every reasonable way. A cautionary signal should be placed about 300 feet from the crossing and this is being supplemented effectively in a number of states by a series of transverse markings. These indications should be further supplemented by whatever protection the traffic and visibility conditions warrant. At crossings where the expense of flagmen or gates is not warranted, automatic wigwag signals are recommended, and to be effective at night such signals should carry a red light. They should be kept scrupulously in order. At crossings where there is frequent train movement as well as heavy motor traffic there should be a flagman or crossing gates. Gatemen and flagmen should be mentally competent and physically able to perform their duties properly. For the busiest intersections there should at all times be a watchman or gateman on duty, otherwise there should be adequate signs so that motorists will not depend on the flagman or gateman.

Transverse ridges in the road, zigzag turns and various other expedients designed to force the motorist to reduce speed at railroad crossings have proved ineffective and are not recommended. On the contrary, your Committee believes the operation of the motor vehicle, particularly on and in the immediate vicinity of the tracks, should be made as simple and easy as possible so that the operator can apply himself to watching for approaching trains. Very much can be done along these lines for a relatively small expenditure, and the dangers of many crossings can thereby be greatly reduced. Frequently where the railroad is on an embankment the highway is carried up to the level of the tracks by a short steep grade which breaks sharply at the track itself, causing danger of stalling. Such approaches should be extended and provided with easy vertical curves or level places so that the motorist can stop and hold his car easily within 10 feet of the railroad if he discovers a train coming. Short sharp descents to the tracks should likewise be cut away to easier grades to lessen the likelihood of motorists being unable to stop near the tracks, or of being rammed from behind and driven upon the tracks.

Where the crossings are planked, the planking should be maintained in good condition, firm and with a smooth surface. At many crossings driving across at anything other than a very low speed invites a broken spring, while at the low speed there is danger of stalling. Of the many motor cars struck at crossings because the

engine stalled, a considerable percentage might have escaped if the crossings had been smooth

Approaches to crossings should be relocated where necessary to eliminate sharp curves and junctions with other highways close to the tracks. Trees, shrubs, faces of cuts and all other obstructions to clear view along the tracks in both directions for as great a distance as possible should be removed from the highway and railroad rights-of-way. Railroad stations and other buildings should not be located close to highway grade crossings. Cais should not be spotted on side tracks where they will interfere with the view of motorists; if necessary to avoid this, team or industry tracks should be relocated. Effort should be made to persuade abutting property owners not to obstruct the view either with trees or buildings or with less permanent obstructions. Standing corn has contributed to many accidents.

### Bridges

Inasmuch as the Committee has already recommended that no highway be improved to a width insufficient for two lines of vehicles, it follows that all bridges on improved highways should also be wide enough for two vehicles to pass safely, without danger of striking the curbing or bridge superstructure. This calls for a minimum width of 22 feet, and de luxe buses operating on bridges of this minimum width should be subject to the same speed restrictions as on 18-foot roads.

One-way bridges are dangerous, particularly short culverts approached in each direction by steep curved descending grades, and they should be replaced by wider structures.

On long bridges suitable provision should be made for the safety of pedestrians. Where the expense of a continuous sidewalk is not warranted there should be frequent safety zones, built outward from the face of the bridge so as not to narrow the roadway.

### Detours

The problem of caring for traffic safety during the construction or reconstruction of streets, rural highways and bridges, particularly rural highways, is a serious one which requires study of the individual conditions. The public should realize that the road being reconstructed is usually the best and most used road in the community and is being reconstructed because it will no longer satisfactorily carry the traffic to which it is subjected, and that therefore it is virtually impossible to move the traffic by any other means or route without a considerable measure of inconvenience.

The highway authorities should use every care, however, to reduce that inconvenience to a minimum, and the highway contractors should be required to do the same. Where no safe and suitable detour can be found the traffic should, if possible, be permitted to move along part of the roadway under construction, but it should not be permitted to do so when this will impose serious danger or risk of undue damage to vehicles, even though warning to that effect is posted.

Where detours are used, they should be safe and reasonably satisfactory to operate on, even though this necessitates a certain amount of preliminary reconstruction and maintenance. In selecting them excessive grades and curves should be avoided as far as possible, and also roads likely to be very slippery in wet weather. Particular care should be exercised in the selection of detours from highways in the vicinity of large cities likely to carry continuous streams of heavy traffic.

Local residents must be accommodated while roads are under construction, and this calls for either the maintenance of a part of the road in passable condition or short detours around the immediate construction. To take care of the through traffic, however, the highway authorities should go back far enough in each direction, possibly to the nearest large town, to find a good alternate route, and should post this route conspicuously so that through traffic will follow it.

All detours, whether long or short, should be clearly marked. This applies to city streets as well as to rural communities. Streets and highways made impassable or unsafe by construction work should be carefully blockaded with signs and lights. Detour signs should be inspected daily to ascertain that they are in proper condition, and should be promptly removed when no longer required.

### **Maintenance and Snow Removal**

Safety requires that pavements be maintained in good condition, free from holes and depressions, which besides causing breakage are likely to interfere with drivers' control and with the free flow of traffic. This applies to both city streets and rural highways.

The shoulders of rural highways should also be maintained in suitable condition. Where the shoulder is broken off in an irregular form, particularly if the highway is narrower than desirable, there is danger in meeting other vehicles. This is true even where the pavement itself is in perfect condition, if the earth shoulder is not maintained level with the pavement. A case in point is the concrete highway with a vertical drop of four to eight inches at the edge.

The constant opening of pavements, particularly on busy thoroughfares constitutes an annoying situation which, notwithstanding all precautions which can be taken, seems to be unavoidable. When the city has a properly equipped maintenance force all openings should be repaved by the city forces. If this restoration work is left to the permittee it is difficult to control and bound to result in delay. Openings in the pavement are frequently left unpaved after refilling for a period of weeks to allow the ground to settle. Where there is any considerable vehicular traffic these openings should be covered at once by a temporary pavement, such as bituminous macadam, to be replaced by a permanent pavement when the settlement has ceased.

An important element of street and highway maintenance is snow removal. The motor vehicle has come to be an important agency of transportation the year around, and it must be safeguarded under all conditions and at all times. On rural highways, if the snow is not removed, even chains will not prevent skidding under certain conditions of snow and ice, and getting out of the ruts to pass other vehicles may be extremely hazardous, while in city streets of heavy travel the unequal packing and freezing of the snow creates depressions which have many of the dangerous elements of holes in the pavement itself, with the added dangers of poor traction, slipping and skidding.

Cities have in general found that to prevent the clogging of industry and commerce the important streets must be kept open at all times, and snow is usually removed fairly promptly from the principal thoroughfares. To accomplish this the forces should be in readiness and the snow should be attacked as soon as an inch or two has fallen. Scraping or flushing the snow into sewer catchbasins and manholes has been found effective in the early stages, although heavy accumulations have to be, to a large extent, carted away. Safety requires that the work of snow removal be extended as rapidly as possible to the streets of lesser importance.

Organizing for snow removal is more difficult in rural districts. Nevertheless both safety and the demands of commerce and industry require that the snow be removed from every main highway and every highway carrying more than 300 vehicles per day. While the cost may seem high, comparison with the cost of repairing the damage done by permitting the snow to remain on the road surface with the attendant running in ruts of heavy motor vehicles equipped with chains, will show that the net cost of snow removal is less.

## Signs, Signals and Pavement Markings

Proper signs and signals are essential to the safe movement of traffic on any street or highway. They should, therefore, be erected when the same is opened or improved and the cost should be included as an item of the construction cost. This applies to three general classes of signs:

- 1 Cautionary or stop signs and signals at danger points
- 2 Direction and distance signs at important junctions and intersections

- 3 Traffic control signs to indicate special traffic rules and regulations, such as speed limits, school zones, one-way streets and the like

Signs should be uniform for a given purpose throughout the United States. At present there is a wide variety of signs for the same purpose both those placed by the authorities of different states and those placed officially by motor clubs or advertisers. Standardization of signs cannot therefore be accomplished in a day. It can, however, be greatly facilitated if the U S Bureau of Public Roads, as the Committee is informed it contemplates doing, adopts the practice of placing signs on Federal-aid roads hereafter constructed as a part of the construction of the road, and at the same time as a separate Federal-aid project places the necessary signs on Federal-aid roads already built and such roads not yet built as it has been determined will be improved on their present locations. It can be assumed that the Federal-aid signs, if placed, will be uniform in every state and will point the way to state and county highway authorities to follow the same standards.

All signs should be simple, with the least amount of wording necessary to make them readily understood, depending mainly on distinctive shapes, symbols and colors. They should be entirely free from advertising, and advertising signs should not be permitted on the highway right of-way. Motor clubs and other responsible organizations should, however, be permitted to place standard signs, subject to the approval of the proper authorities, if not placed by the authorities themselves.

The American Engineering Standards Committee has for some time, through one of its sectional committees, been studying the adoption of a standard code of colors for signs and signals. Your Committee has had the benefit of conference with members of that committee and has found the views of the two committees substantially in harmony except that the preliminary report of the sectional standards committee advocated three colors only. Believing that a

special designation for crossroads is desirable, your Committee recommends the following code:

For luminous signs and signals the following color indications are recommended, and these colors should not be used for any other purpose

Red to indicate "Stop "

Green to indicate "Proceed "

Yellow to indicate "Caution," as at curves

Purple or some other color as a special cautionary indication at cross roads

Nonluminous signs and signals should follow the same color scheme, as follows:

Red background, white letters or symbols, to indicate "Stop "

Green background, white letters or symbols, to indicate "Proceed "

Yellow background, black letters or symbols, to indicate "Caution "

Purple background, white letters or symbols, to indicate "Cross Roads "

Distance and direction signs should be black and white

Cross roads, which more definitely affect other vehicles than do curves, grades and other points where caution is required, merit a distinctive color rather than yellow. The recommendation, however, does not conflict with the placing of a yellow sign at cross roads if individual state departments deem that preferable.

Besides highway intersections, the principal danger points on the highway calling for cautionary signs include sharp curves, steep descending grades and narrow bridges or places in the roadway. These should be conspicuously marked with yellow cautionary signs which warn not only of the danger but of the specific kind of danger. The through-traffic highway protected with boulevard stops calls for a red sign to indicate the requirement of a full stop before entering or crossing such a highway. Railroad crossings require special protection as indicated in Recommendation 13.

While the Federal-aid state and county systems of improved highways will perhaps ultimately embrace all highways carrying much traffic, there are at present many unimproved highways with good natural surfaces which carry a considerable amount of travel, and over large parts of which high speeds can safely be maintained.

Such highways may lead suddenly to dangerously steep descending grades, sharp curves or rough spots. Where these dangers are not marked by the public authorities, automobile clubs or other agencies can perform a useful service by placing signs at the chief danger points on such highways.

No road can be considered satisfactorily equipped with signs unless it has direction and distance signs containing sufficient information in legible form to permit a traveler to go anywhere he desires without the aid of maps or keys. To this end black and white signboards of adequate size should be placed at every cross road and junction, setting forth clearly the information as to direction and distance.

The Committee has considered carefully the extent to which white center lines should be marked on rural highways and streets. It believes that the white center line should be confined to those points where it is unsafe and in a number of states illegal to be on the left-hand side of the road, namely, on curves, at and near hillcrests, at irregular intersections, at railroad crossings and possibly at a few other points. If confined to those points the white line acts as a positive warning to motorists not to cross it or be on the wrong side of it. The warning effect is lost if the line is used on straight sections and therefore should not be so used. Black center lines, however, whether construction joints in the case of concrete highways built in two longitudinal sections, or lines painted on pavements of a character that will permit it, are effective as a guide in night driving and at all times in keeping each driver on his own side of the road when passing another car, and are recommended as not conflicting with the use of the white line.

Two-lane rural highways, therefore, should be marked with a white center line on curves at and near hillcrests and at irregular intersections, but not on straight level sections, except at highway or railroad crossings. The lanes or wider highways and of city streets should be similarly indicated by one or more longitudinal white lines at similar points.

Transverse pavement markings are desirable to supplement the work of signs. Pedestrian lanes should be marked across the pavement at busy intersections. The use of transverse markings in the vicinity of railroad crossings has already been indicated. They can also be used effectively to caution or instruct drivers approaching intersections or other hazards. Parallel lines to indicate individual parking spaces economize the total space where oblique parking is used.

### Illumination

Glaring headlights are a danger of the highway for which no complete remedy has as yet been found. The ideal remedy would be such illumination of streets and highways that bright headlights would be unnecessary. This is in general feasible in city streets, and the following amounts of illumination are stated by competent illuminating engineers to be the minimum desirable:

Class of street	Distance between lighting standards feet	Number of lamp lumens per foot of street
Business streets	50-75	100-150
Main thoroughfares	50-75	80-125
Residential streets	50-75	50- 75

Flood lighting of traffic officers is also recommended.

In rural districts the amount of money required to install and maintain illumination on even those thoroughfares carrying heavy night traffic would be enough to improve and maintain a large amount of additional highway. Taking into account the fact that even though the principal highways were illuminated, most motor vehicles would have to operate also on unlighted highways and would therefore have to be equipped with adequate headlights, the Committee believes that in general it is more important to provide the greatest mileage possible of improved roads than to light the principal thoroughfares now existing.

Certain highways connecting communities close together have become in effect city streets and should be illuminated. The problem here, however, is one of complete illumination and is distinguished from what is commonly called highway illumination, which is designed solely to serve the user of the roadway.

Anything adjacent to the street or highway which can be utilized to reflect light will be of assistance in night driving. Curves, tree trunks, telephone and trolley poles, sidewalks, fences and especially board fences erected at dangerous curves and at dead-end streets, if painted white or light in color, will be found effective.

Where parking is permitted at night—and it is frequently permitted at night in sections where it is not permitted in the daytime—the design of the illumination is important. This is especially true on narrow streets, where lamps mounted low may cause deep shadows of parked machines out into the center of the street, destroying the effectiveness of the illumination.