Determining Widths of Pavements in Channelized Intersections

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IN general the widths of pavements in channelized intersections, or junctions, must be sufficient to provide for the movement of 3 types of vehicles: The 50-ft. semitrailer, the 35-ft. bus, and the passenger car. Larger or smaller vehicles may affect or control the width of some channels.

The design of a channelized intersection is greatly facilitated by the use of vehicle models.

A drawing of the intersection is made on a scale of 1 in. equals 10 ft. The wheels of models of the controlling vehicles, also to a scale of 1 in. equals 10 ft., are inked with a stamp pad and the widths and shapes of the wheel tracks traced on the drawing.

The width of pavement required at any point may now be determined directly from the wheel tracks.

The method is applicable to single-lane or multi-lane channels, and to all forms of curvature, simple, spiraled, compound or reversing.

Illustrations consist of drawings of controlling vehicles, photographs of principal models, and specimen applications of the method of design.

An appendix shows the dimensions of a variety of vehicles with sketches of their characteristic wheel tracks on curves, and tables listing the maximum track widths which can be reached by the vehicles on turns, with the minimum width of pavement required after the maximum track width has been reached for any given radius of curve.

● IN general, the width of pavements in channelized intersections, or junctions, must be sufficient to provide for the movement of three types of vehicles: (1) the 50-ft. semitrailer, (2) the 35-ft. bus, and (3) the passenger car.

Occasionally other vehicles must be considered, such as medium-sized trucks, logging trucks.

50-FT. SEMITRAILER

The track width of a 50-ft. semitrailer on a turn is greater than that of nearly all other vehicles normally using highways, including the 60-ft. full-trailer combination; pavements on turning lanes which will be used by 50-ft. semitrailers must, therefore, be made of sufficient width to accommodate this type of vehicle. The track width of a semitrailer on a tangent is assumed to be 8 ft. (see Fig. 1).

35-FT. BUS

The track width on a turn of the 35-ft. bus with 22-ft. wheelbase is considerably less than that of the 50-ft. semitrailer making the same turn and slightly more than that of a 30-ft. truck with 20-ft. wheelbase. However, the front overhang and rear overhang of the bus are considerable. The effect of the front overhang may influence the width of pavement required on sharp turns, while the effect of rear overhang may need to be considered at the beginning of a turn. The track width of a bus on a tangent is assumed to be 8 ft.

The bus will influence the width of pavement required on a turning lane: (1) when the turn will be used only by busses and smaller vehicles; (2) when the turn is designed for the 50-ft. semitrailer but it is desired to provide sufficient width to allow either vehicle to

pass the other in case of a breakdown; and (3) when the turn is designed for one-way, two-lane operation and it is assumed that no vehicle larger than a bus will pass a semitrailer moving in the other lane.

The dimensions of the bus are shown in Fig. 1(B).

PASSENGER CAR

The track width of the passenger car is less than that of any other vehicle used for design.

The passenger car will influence the width of pavement required on a turning lane under the same conditions listed for the 35-ft. bus if the passenger car is substituted for the bus. The track width of a passenger car on a tangent is assumed to be 6 feet.

The dimensions of the passenger car are shown in Figure 1 (C).

OTHER VEHICLES

Semitrailers

Some states permit semitrailers larger than the 50-ft. semitrailer. Such large semitrailers produce a greater track width on turns than the 50-ft. semitrailer, which must be considered in determining the width of pavement, particularly when a turning lane is bordered by curbs or islands. The increase is most noticeable when the radius of the turn is 100 ft. or less.

Single-unit Trucks

Designs based on the track width of a 35-ft. bus are adequate for single-unit, 30-ft. trucks with 20-ft. wheelbase. In some instances the largest vehicles which will use a turn are medium-sized single-unit trucks with a maximum wheelbase of 16 ft. In such cases a truck of this type may be used for design instead of a 35-ft. bus, subject to the same provisions, except that overhang will have very little influence.

Busses

Some busses are larger and have a longer wheelbase than the 35-ft. bus. Where such vehicles are operated they should be substituted for the 35-ft. bus, subject to the same provisions.

Logging Trucks

In the West logging trucks are common. The track width produced by these trucks on a turn varies with the wheelbase of the tractor, the length of logs, and the method of loading.

In general, pavements designed for the 50-ft. semitrailer are adequate for logging

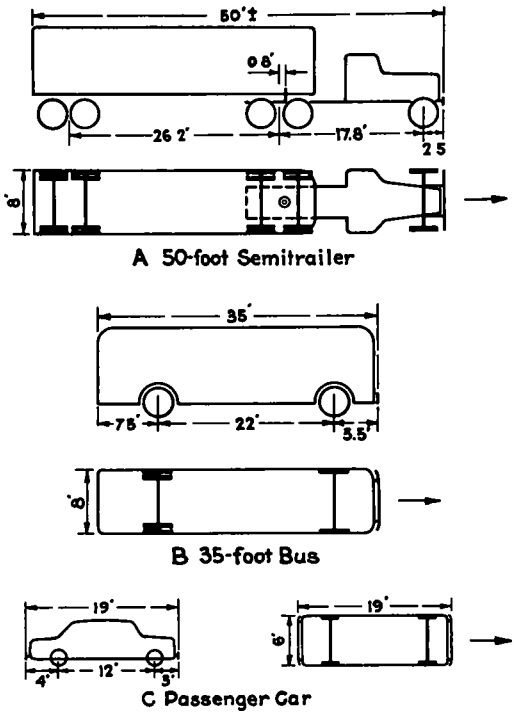

Figure 1. Dimensions of vehicles.

trucks carrying logs up to 60-ft. long when the radius of the turn is 80 ft. or more.

When the radius of the turn is less than 80 ft., the track width produced by a logging truck may be greater than that of a 50-ft. semitrailer.

The trucks are often loaded in such a manner that a portion of the load hangs over beyond the rear axle. In this case one corner of the rear overhang, of a load of 60-ft. logs, may sweep almost 4 ft. outside the path of the outside front

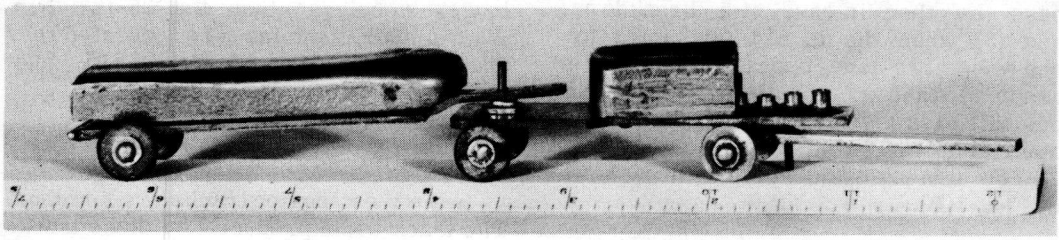

Figure 2. Model of 50-ft. semitrailer.

wheel on entering a very sharp turn (see appendix), and pavements must be designed to provide extra clearance between two lines of vehicles moving in adjacent lanes, where this occurs.

MODELS OF VEHICLES

It occurred to the writer, some years ago, that a drafting tool which could trace the path of the inside rear wheel of a vehicle (the rear wheel nearest to the center of a turn) would be useful for laying out the inside edge of the pavement on a turn. The tool which will accomplish this is an accurate scale model. Models were therefore made of the following vehicles: (1) the 50-ft. semitrailer (Fig. 2); (2) the 60-ft. full trailer combination (Fig. 3); (3) the 35-ft. bus (Fig. 4); (4) the passenger car; and (5) the logging truck (Fig. 5). All of these are to a scale of 1 in. = 10 ft.

Several of these vehicles have some tandem axles. In the models, equivalent single axles were substituted for the tandem axles. To simplify construction of the models, the front wheels are set at right angles to the front axle, which is pivoted at its center (a fifth-wheel arrangement). This does not affect the path of the inside rear wheel.

OPERATION OF MODELS

When a vehicle moves around a turn, it does so most conveniently by steering on a definite curved line. This curved line may be a simple circular curve or a spiraled curve. It may be called the "steering curve" and defined as the curve on which the center of the front axle of a vehicle would move if there were no variations due to fluctuating movements of the steering wheel. The "steering radius" (RS) may be defined as the radius of a circular steering curve or of the circular portion of a spiraled curve.

A sketch is made of the proposed channelized intersection or junction on which the steering lines, consisting of tangents and steering curves, with their radii, are indicated for the various channels and for connecting highway or speed change lanes.

Following this, a plan is drawn on a scale of 1 in. equals 10 ft., on which the steering lines are laid out.

The model of the largest vehicle for which the channels must be designed is now selected (this will, in most cases, be the 50-ft. semitrailer). The inside rear wheel of which the path is to be found is inked by rolling it over a stamp pad, and the model placed in position over

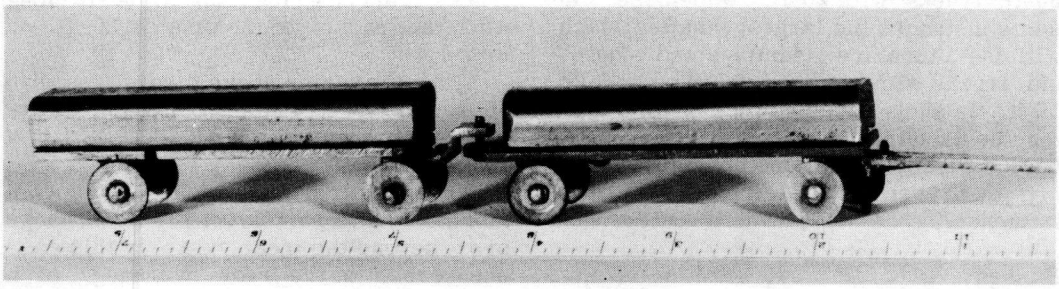

Figure 3. Model of 60-ft. full trailer.

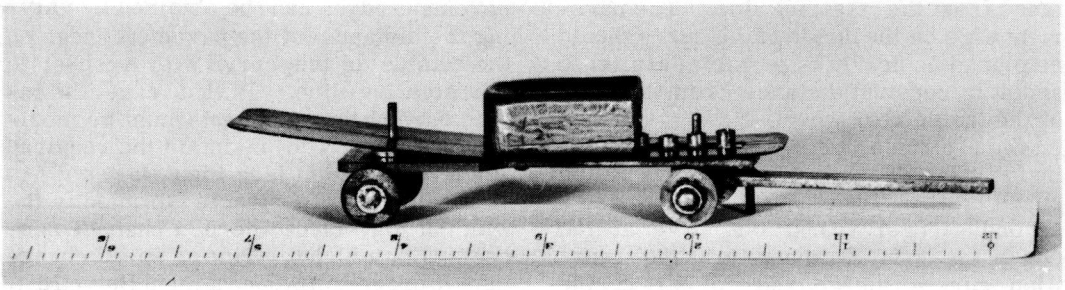

Figure 4. Model of 35-ft. bus.

one of the steering lines on the drawing. The model is provided with a pointer, which theoretically should be directly under the center of the front axle. However, in order to make the pointer visible, it is set just in advance of the front wheels, which has no appreciable effect on the trace of the rear wheel. The pointer is placed accurately over the steering line and the model drawn forward following the steering line carefully with the pointer. The ink trace produced on the drawing will accurately represent the track of the outer face of the inside rear wheel.

On long channels it will be necessary to re-ink the wheel when the trace becomes faint. If the model in use is that of a compound vehicle, the position of the wheels on one side of the model must be carefully spotted on the drawing with a sharp pencil, so the model can be reset in its exact position before the forward movement is resumed. The front and rear overhang can be observed and spotted on the drawing with a sharp pencil.

The forward movement of the model along the steering line in the channel must be continued along the lane to which the channel connects until the rear wheel has reached its normal distance from the centerline of that lane (for trucks and busses, 4 ft. on tangents; for passenger cars, 3 ft. on tangents).

The drawing now shows an accurate trace in ink of the path of the inside rear wheel.

In order to obtain the track width of the vehicle, it will also be necessary to show the path of the outside-front wheel. On many trucks the out-to-out width of the front wheels is less than that of the rear wheels, on some trucks and on busses the width is the same, front and rear. The distance of the outside-front wheel on trucks and busses is therefore assumed to be 4 ft. from the center of the front axle and on passenger cars 3 ft. This distance does not remain constant on a curve, it is least on any given curve when the wheels are fully turned to follow the curve. However, the decrease is small and the path of the outside front wheel may be drawn parallel to and 4 ft. distant from the steering line for trucks and busses and 3 ft. distant from the steering line for passenger cars.

The plan now shows the track width along the entire channel and the pavement edges may be laid out at any desired distance from the wheel tracks. The pavement edge on the outside of a curve will be parallel to and at a constant dis-

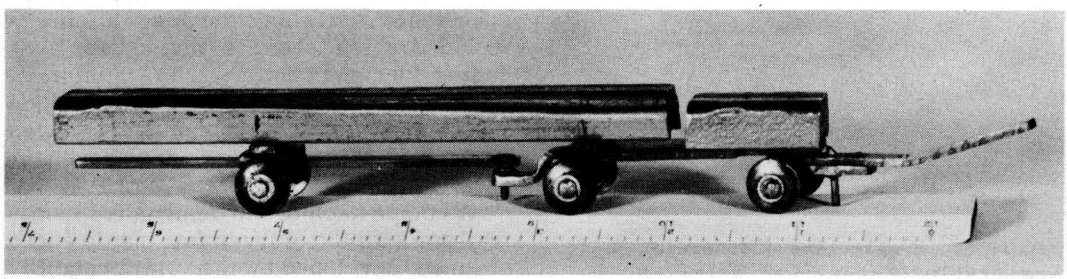

Figure 5. Model of logging truck.

tance from the steering line. The pavement edge on the inside of the curve should be placed as nearly as possible parallel to and at a constant distance from the path of the inside rear wheel.

On a circular or spiraled curve, the inside-rear wheel describes a transition curve at the beginning of a turn and a second, longer transition curve at the end of the turn. On many turns the transition curves merge and no part of the path of the inside-rear wheel is circular. (For a 50-ft. semitrailer this path is entirely transitional on turns with a steering radius less than about 80 ft. and a central angle of 90 deg. or less).

To design a pavement edge which follows the path of the inside-rear wheel as nearly as possible, a circular curve is selected which nearly fits the central portion of the wheel path. This curve is then connected with unsymmetrical or symmetrical compound curves or with unequal or equal spirals to the edges of the pavement on the approach lanes.

Sometimes a better alignment of the

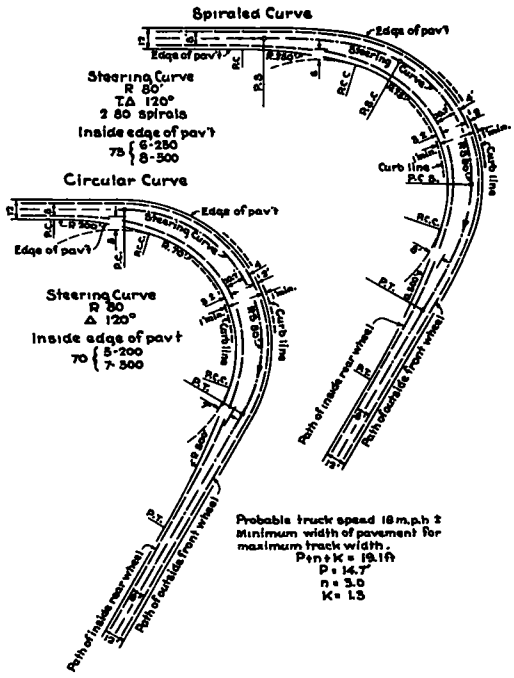

Figure 6. Single-lane channel for 50-ft. semitrailer, steering radius, 80 ft.; central angle, 120 deg.

pavement edges can be obtained by varying the distance of the pavement edge on the outside of the curve with respect to the steering line. In that case the inside edge of the pavement must be modified accordingly to maintain the required width of pavement (see Fig. 7).

It is often desirable to modify the width of pavement where a channel connects with a highway lane or speed change lane in order to produce a funneling effect.

DESIGNS FOR EDGE OF PAVEMENT, CALIFORNIA 1949

The California Division of Highways published a report entitled "Truck Paths on Short Radius Turns" in August 1949. This report describes a series of tests made to determine the track widths of trucks, including the 50-ft. semitrailer, on short radius turns. The wheel tracks of full size trucks were marked on a pavement, measured and platted. From these wheel tracks a table was prepared showing "Curve Data for Inside and Outside Edges of Lanes Which will Accommodate large Semitrailer Combinations."

DESIGNS FOR EDGE OF PAVEMENT, OREGON 1949

The writer prepared a paper for the Oregon State Highway Department in January 1949 entitled "Minimum Designs for Edge of Pavement and For Curve Radii for Intersections at Oblique Angles of Highways and Streets." This paper shows a series of minimum designs for edge of pavement on the inside of turns for intersection angles from 20 deg. to 160 deg. and of corresponding curb radii when parking is permitted on the intersecting roads but not on the turn. Since minimum designs should not be used unless such designs are unavoidable, a table is included which shows a method for producing designs better than minimum. The designs were developed from wheel tracks drawn by models, and cover turns for semitrailers, busses, and passenger cars.

A comparison of the designs for semitrailers with the curves for inside edges of lanes developed by the California Division of Highways shows close agreement.

MODELS USED FOR DESIGN OF CHANNEL PAVEMENTS UNDER ANY CONDITIONS

The channel pavements thus far mentioned are planned in each instance to follow a simple curve connecting two tangents. In practice however conditions are often not so simple. A channel pavement may be required to provide width sufficient for: (1) a single lane, (2) a single lane with added provision for emergency passing, (3) two lanes for traffic moving in one direction, (4) two lanes for traffic moving in opposite directions.

apart to allow the desired clearance between passing vehicles. When pavements are designed as one lane with extra width for emergency passing or for two-lane movements, the controlling vehicles occupying the lanes may be identical or of differing types. (Data on track width and amount of front overhang for a variety of vehicles and on the rear overhang of logging trucks may be found in the appendix. These data are useful for estimating the required distance between steering lines.)

A great advantage of the vehicle model as a design tool is that the width of chan-

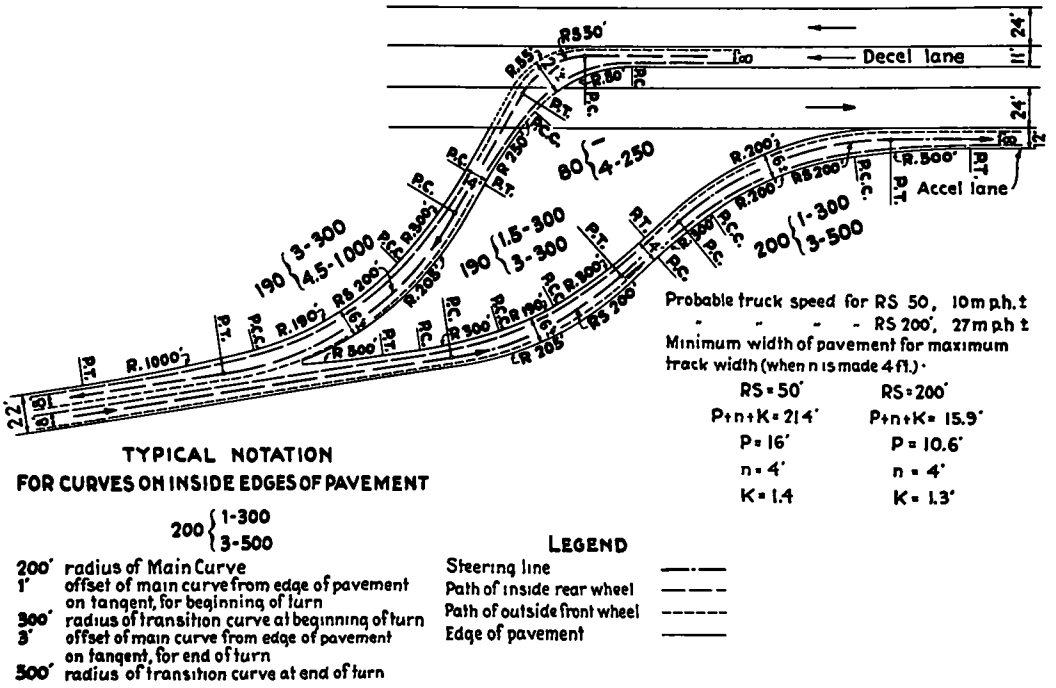

Figure 7. Single-lane channels for 50-ft. semitrailer; reversing curves separated by short tangents.

The steering line may consist of a simple curve, a spiraled curve, compound curves, reverse curves, curves separated by short tangents, and it may meet highway alignment on a tangent or on a curve.

If the channel consists of more than one lane, separate steering lines must be platted for each lane, and these lines will generally not be parallel throughout the length of the channel. These steering lines must be platted far enough

nel pavement required to meet all these conditions can be readily determined after tracing the wheel tracks of the controlling vehicles with the models (Fig. 6 and 7).

FORMULAS FOR DETERMINING WIDTH OF PAVEMENT FROM TRACK WIDTHS

1. Single-Lane Channels

Formula (1) $W = P + n + K$

W = Width of pavement in feet.
P = Track width at any point.
n is the excess of lane width over track width on a tangent.

When the lane width on a tangent is 11 ft:
n = 5 feet for passenger cars.
n = 3 feet for trucks and busses.

When the lane width on a tangent is 12 ft:
n = 6 feet for passenger cars.
n = 4 feet for trucks and busses.
K is a variable which increases the width of pavement to allow for the greater difficulty of maneuvering a vehicle on a curve.
$K = \frac{V}{2VRS}$ where RS is the steering radius of a curve and V is the speed in miles per hour.
K = 1.4 ft. when RS is 100 ft. or less.
K = 1.3 ft. when RS is 150 ft. to 250 ft.
K = 1.2 ft. when RS is 300 ft. to 450 ft.
K = 1.1 ft. when RS is 500 ft.

2. Single-Lane Channels With Extra Width for Emergency Passing

Formula (2) $W = P + P' + FO + 3$

W = Width of pavement in feet.
P = Track width of the controlling vehicle at any point.
FO = The encroachment of the larger front overhang.
3 = 3 ft., a constant used by the AASHO in "A Policy on Intersections at Grade" (page 21) to determine emergency passing widths.

3. Two-Lane Channels

Formula (3) $W = P + n + P' + n' + FO + K$

W = Width of pavement in feet.
P = Track width of the controlling vehicle at any point in one lane.
P' = Track width of a controlling vehicle at a corresponding point in the second lane.
n for the vehicle in the first lane has any of the values shown for formula (1).
n' for the vehicle in the second lane has any of the values shown for n, selected for that vehicle.
FO = The encroachment of the larger front overhang.
K has the values shown for formula (1), and is applied to the entire width of the pavement and not to each separate lane.

After scaling P, P', and FO from the platted paths (FO may be estimated from the tables in the appendix), the pavement width, at any point, determined from the formulas will provide a check on the width determined graphically on the plat.

Frequently it is found difficult to maintain a sufficient width between edge of pavement and nearest wheel track where the beginning or end of a turn connects with a highway lane or speed change lane when the edge of pavement is defined by an unsymmetrical or symmetrical three-centered compound curve. It may also be difficult to maintain the required clearance between vehicles moving in adjacent lanes of a two-lane channel at the beginning and end of a turn. These difficulties may be overcome or greatly reduced by flaring the lane to which the turn connects to more than its normal width.

The minimum lane widths on tangents considered suitable by the AASHO are: 11 ft. for passenger cars, 11 ft. for trucks at speeds up to 40 mph. and 12 ft. for trucks at speeds more than 40 mph. (Policy on Intersections at Grade, page 21).

APPENDIX

A paper prepared by the writer in 1951 for the Oregon State Highway Department entitled "Path of Vehicles on Curves and Minimum Width of Turning Lanes" follows as an appendix. This paper gives the dimensions of a variety of vehicles with sketches showing the characteristic wheel tracks of those vehicles on curves.

"Track width" is referred to as "width of wheelpath" in this paper.

The maximum track width which can

be reached by a vehicle turning on steering radii from 25 ft. for the passenger car, and 42 ft. for other vehicles, to 500 ft. was calculated and shown in the columns headed "P" in the tables.

The track widths which will be reached by the 50-ft. semitrailer on circular curves and on spiraled curves when the central angle of the curve is less than that required to produce the maximum possible track width for a given steering radius are also tabulated. These track widths have been scaled from wheel tracks made by a model.

The widths of pavement for turning lanes shown in the tables are the minimum widths required after the track width for a given steering radius has reached its maximum. They have been derived from the calculated width of wheel track by the methods used by the AASHO in a "Policy on Intersections at Grade."