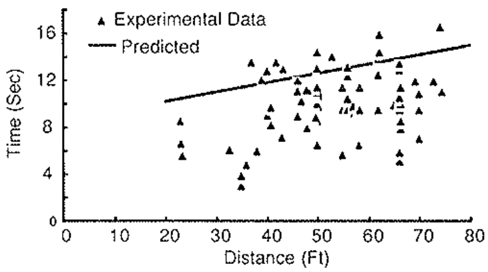

FIGURE 7 Comparison of experimental and predicted time-distance relationships on a level grade with tractor-semitrailers.

CONCLUSION

The agreement seen in Figure 7 indicates that nominal predictions of truck start-up performance can be made from the analysis presented. Because trucks and driver practices differ, the performance is variable. However, the predictions from the analysis capture approximately 90 percent of the vehicles and at that level provide a reasonable estimate of maximum clearance times required. Experimental data were only available for level grade crossings, so the accuracy of the predictions for steeper grades cannot be assessed.

REFERENCES

1. D.A. Klokkenga. Selecting Powertrain Components for Heavy Duty Trucks. SAE Paper 760830. Society of Automotive Engineers, Warrendale, Pa., 1976.
2. T.D. Gillespie. Field Data Collection Plan and Sampling Plan. Interim Report on FHWA Project on Truck Tractive Power. University of Michigan, Ann Arbor, Feb. 15, 1984.
3. B.L. Bowman and K.P. McCarthy. Consequences of Mandatory Stops at Railroad-Highway Crossings. Draft Final Report. Goodell-Grivas, Inc., New York, June 1985.

California Design Practice for Large Trucks

EARL ROGERS

ABSTRACT

Highway design engineers have long been concerned about the wide offtracking characteristics of large trucks. With the enactment of the Surface Transportation Assistance Act (STAA) of 1982, a truck longer and wider than ever before was allowed on the Interstate and qualifying primary system known as the designated system. Following the passage of the 1982 STAA, the California State Legislature changed state laws to comply with federal truck regulations on the designated system. The new state law prescribes access to the system. Service access and terminal access are separately defined. The former is handled by the State Department of Transportation. Local agencies are responsible for the latter. California has adopted an Interstate design vehicle based on dimensions spelled out in the 1982 STAA. A computer program is now available for generating offtracking plots. As a tool for highway design engineers a set of truck-turn templates has been prepared. Design practice is evolving. Current practice requires highway designers to use the Interstate truck-turn templates on all new or upgraded interchange projects. Some exceptions to the current practice are allowed. On 3R projects at designated service access points large trucks are accommodated if the work can be done at reasonable cost with no extra right-of-way. The answer to who bears the cost of retrofitting interchanges and upgrading local roads for terminal access is also evolving. The most likely arrangement will probably be shared cost with both public and private funding.

Highway design engineers have long been concerned about the offtracking characteristics of large trucks. With the enactment of the Surface Transportation Assistance Act (STAA) of 1982, a truck longer and wider than ever before was allowed on the Interstate and qualifying primary system known as the designated system.

California has traditionally controlled offtracking by limiting the maximum kingpin-to-rear axle dimension. Currently, California law places a 38-ft limit on the kingpin dimension except on the desig-

Geometric Design & Standards Branch, Office of Project Planning & Design, California Department of Transportation, 1120 N Street, Sacramento, Calif. 95814.

nated system where the combination of a 48-ft-long semitrailer and an unlimited vehicle length have disrupted the controls on offtracking. What does this mean for design engineers? At the very least it means that ramp intersections will have to be redesigned with wider flares; electroliers, signs, and signal poles will have to be moved; loop ramps will require widening; curbs and gutters will have to be replaced; and drainage inlets will need to be reset.

California has built about 6,000 freeway ramps on the Interstate system alone. If all of those ramp intersections were to be fixed and if all of the loop ramps were to be widened, the estimated cost would exceed $100 million.

The extra 6 in. of width allowed by the new law has also contributed to the severity of offtracking. Moreover, in the big cities California has restriped many miles of freeways using shoulders to provide an extra traffic lane and reducing the lane width to 11 ft. An 8.5-ft-wide truck must now operate with less maneuvering space in the narrow lanes.

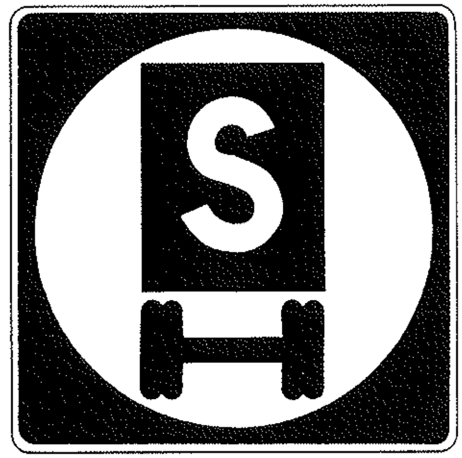

FIGURE 1 Interstate truck service access sign (blue on white).

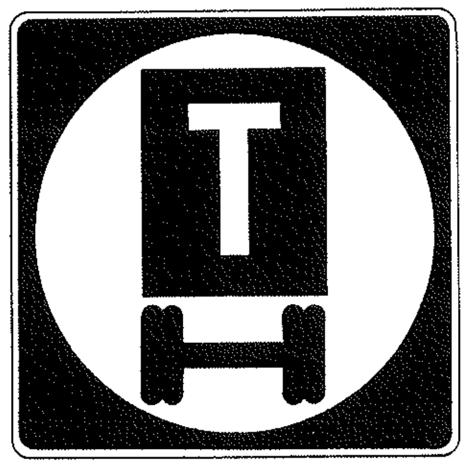

FIGURE 2 Interstate truck terminal access sign (blue on white).

ACCESS TO THE DESIGNATED SYSTEM

After enactment of the 1982 STAA, a bill was introduced in the California legislature to make state laws conform to federal laws for trucks using the designated system. This legislation was required of the states in order to avoid losing federal highway funds. The California bill that was signed into law by the governor in June 1983 also dealt with the question of access to the system, dividing access into two parts.

Service access is permitted for fuel, food, lodging, and repairs provided those services are within 1/2 mi of an interchange.

Terminal access, on the other hand, places no limits on the distance between terminal and interchange. "Terminal" is somewhat broadly defined as a facility at which freight is consolidated to be shipped; or where full-load consignments may be offloaded; or at which vehicle combinations are regularly maintained, stored, or manufactured.

Service access is handled by the California Department of Transportation (Caltrans) with the concurrence of local agencies. An interchange where service is currently available is reviewed for big truck accessibility. If fix-up work, such as minor paving or moving signs, can be done inexpensively, it may be handled by minor contract, or it may be incorporated into a 3R pavement rehabilitation project. Service access signs are placed on the freeway in advance of the interchange making it legal for a big truck to exit or enter the freeway without being cited. Figure 1 shows a service access sign.

Terminal access is treated differently. Local agencies bear the primary responsibility for terminal access routes. Instead of placing a limitation on the distance from the designated system to a terminal, California reviews each route for safe operation on a case-by-case basis. Terminal access routes originate as a request from the terminal operator to the local agency. Figure 2 shows a terminal access sign.

INTERSTATE DESIGN VEHICLE

Since enactment of the 1982 STAA, Caltrans designers have been using two different design vehicles. The Interstate design vehicle is for use on the designated system, which now includes 4,200 centerline miles of Interstate and non-Interstate freeway and some conventional highway.

The off-Interstate design vehicle shown in Figure 3 is the model used for the remainder of the state highways in California, about 11,000 centerline miles.

Figure 4 shows the dimensions of the Interstate design vehicle, a hypothetical tractor-semitrailer combination that is being used in California for the design of interchanges on the designated system. The 48-ft length and the 8.5-ft width of the semitrailer are the only dimensions spelled out in the 1982 act. All other dimensions are assumed.

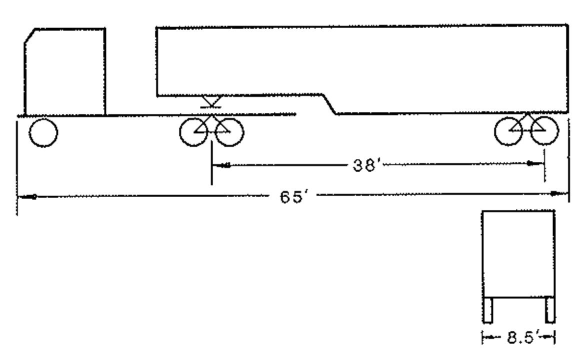

FIGURE 3 1983 California off-Interstate design vehicle.

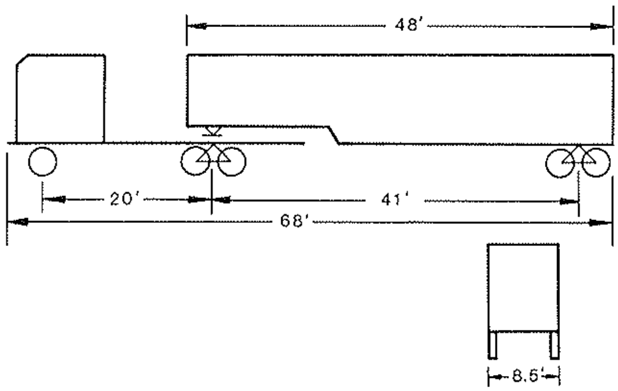

FIGURE 4 1983 Interstate design vehicle.

The Interstate design vehicle became the basis for truck-turn templates developed by Caltrans in early 1983 following passage of the 1982 STAA. The original work on the templates was done using a drafting tool (tractrix integrator) that draws an inked trace of the turning path of a tractor-semi-trailer combination on a sheet of vellum to a predetermined scale. The job took many months to complete because the initial graphic work had to be drawn to a large scale, digitized, run through a computer smoothing routine, and finally drawn at a reduced scale on an automated plotter.

In November 1983 Caltrans ran field tests using a tractor with a wheelbase of 15 ft 6 in. and a semi-trailer kingpin-to-rear axle dimension of 40 ft 6 in. These dimensions, somewhat less than those of the Interstate design vehicle, yielded swept widths that were about 5 percent less at maximum offtracking than the results of the graphic plots.

More recently Caltrans has been using a computer program that was originally developed by the University of Michigan Transportation Research Institute in cooperation with FHWA (see Vehicle Offtracking Models by M.W. Sayers in this Record). Caltrans added a number of enhancements and adapted the program to run on an IBM 360 driving a Calcomp or Xynetics automated plotter. The computer program will generate offtracking plots for virtually any vehicle combination in a fraction of the time previously required. The computer-generated plots show good results compared with those of field tests, hand-drafted graphic plots, and the SAE formula. The tractrix integrator and hand-drafted graphic solutions to offtracking problems have become history.

Figures 5 and 6 show the Interstate truck-turn templates for a 50- and a 60-ft turning radius. Figure 7 is a tabulation of loop ramp widening needed to accommodate the Interstate design vehicle.

DESIGN PRACTICE IN CALIFORNIA

The shortest horizontal curve radius necessary for the design vehicle to stay within a 12-ft traffic lane while turning through 180 degrees of central angle is about 300 ft. In other words, all offtracking will take place within the 12-ft lane provided the outside wheel of the steering axle is crowding the outside lane line. On the assumption that a large truck should not cross a lane line, especially a centerline, when traveling around a curve, and allowing for some margin of error, a 400-ft minimum curve radius was established for the designated system. Certain routes on conventional highways have been deleted from the designated system because of the 400-ft radius rule.

At freeway off-ramps the wide pavement area needed for truck turns at the crossroad intersection has raised some safety and operational questions. The wide pavement area makes sign placement difficult, increases the chance of wrong-way moves because the off-ramp looks more like an on-ramp, and requires longer pedestrian travel distance. Despite these concerns, current practice requires highway designers to apply the Interstate truck-turn templates on all new construction or major modifications to interchange and intersection projects. However, cost, right-of-way, environmental sensitivity, local agency desires, and the type of community be-

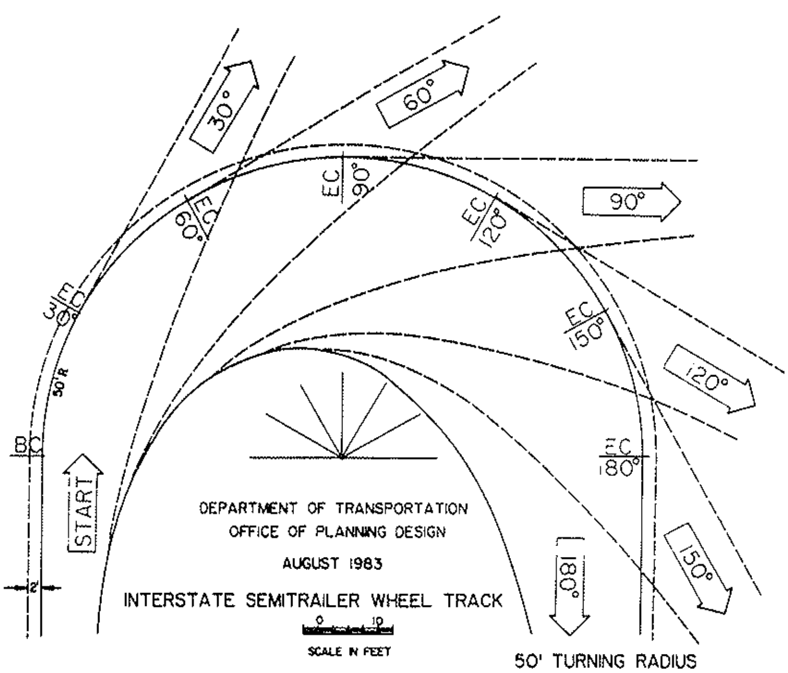

FIGURE 5 Interstate truck-turn template for 50-ft turning radius.

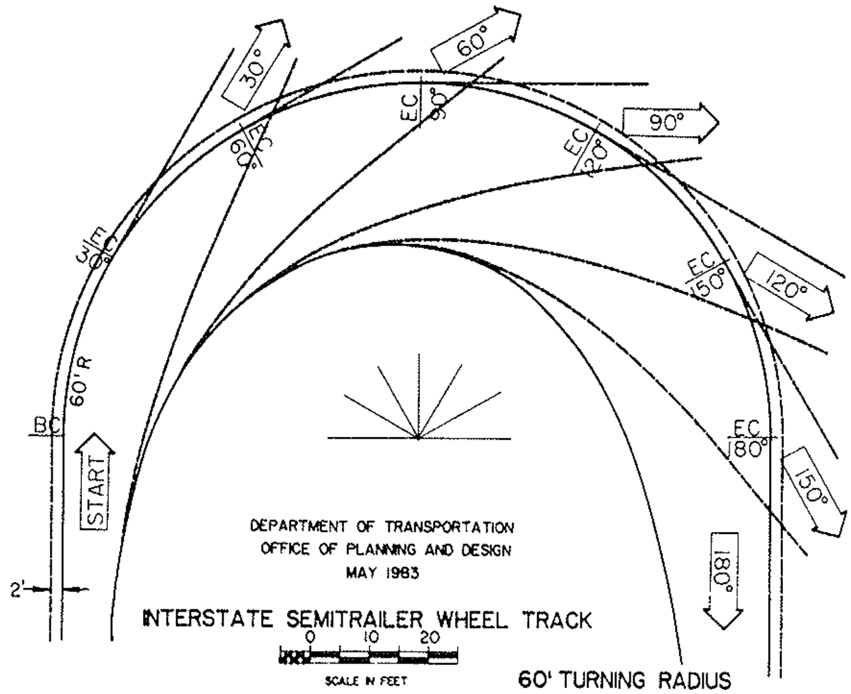

FIGURE 6 Interstate truck-turn template for 60-ft turning radius.

LOOP RAMP WIDENING			
Ramp Radius	Widening	Lane Width	Lane Plus Shoulder
120'	6'	18'	26'
150'	4'	16'	24'
180'	3'	15'	23'
210'	2'	14'	22'
250'	1'	13'	21'
300'	0'	12'	20'

FIGURE 7 Loop ramp widening needed to accommodate the Interstate design vehicle.

ing served are factors that will, on occasion, require exceptions to the current practice.

Who bears the cost of retrofitting interchanges and upgrading local roads for terminal access is unclear at this time. The most likely procedure will be a specific cost determination for each route with the state, the local agency, or the private sector paying all or a share of the cost.

On 3R-type projects at both service and terminal access points, modifications may be made to accommodate large trucks if the work can be done at reasonable cost with no taking of extra right-of-way.

To date only a handful of terminal access routes have been requested, and most of these are for military reservations like Fort Ord in the Monterey area and Vandenberg Air Force Base in Santa Barbara County. As more and more terminal access routes are proposed, it is expected that a good-faith effort will be made by the participants to reach an agreed-on sharing of costs.

CONCLUSIONS

California's design practice for large trucks is still evolving. Caltrans and the local agencies are reluctant to undertake expensive retrofitting of freeway interchanges and street intersections for the sole purpose of big truck access when other serious operational improvements are begging for money. All parties are still waiting to see just how the cost sharing for terminal access routes will shake out.

Except for signs and minor improvements for service access, no major construction work, such as widening, moving drainage inlets, extending pipes, or moving traffic signals, has yet been done. It is not entirely clear how such projects should be funded and whether they should compete with other operational improvement projects for federal and state dollars.