



## Speeds on Houston Freeway Connector Ramps Show Variations by Vehicle Type

Interchanges on freeways have proven to be particularly dangerous for large trucks, especially those traveling at high speeds on freeway-to-freeway connector ramps (see Table 1). The development of this project was based largely on experience in the Houston urban area, where truck rollover crashes have occurred on several freeway-to-freeway connector ramps in the past decade.

This project focused on examining the relationship between vehicle operations and current advisory speed signing practices and whether there should be a distinction between passenger cars and trucks with respect to advisory speed signing on freeway-to-freeway connectors.

### What We Did . . .

This project examined comfort levels for drivers of various types of vehicles: passenger cars, sport-utility vehicles, heavy-duty

dump trucks, and 18-wheelers. Each of these vehicles was driven through seven freeway-to-freeway connectors at speeds ranging from 30 mph to 55 mph, depending on the particular freeway connector curve. Ball-bank indicator readings (taken manually) and electronic lateral acceleration readings were recorded during each drive through the curve.

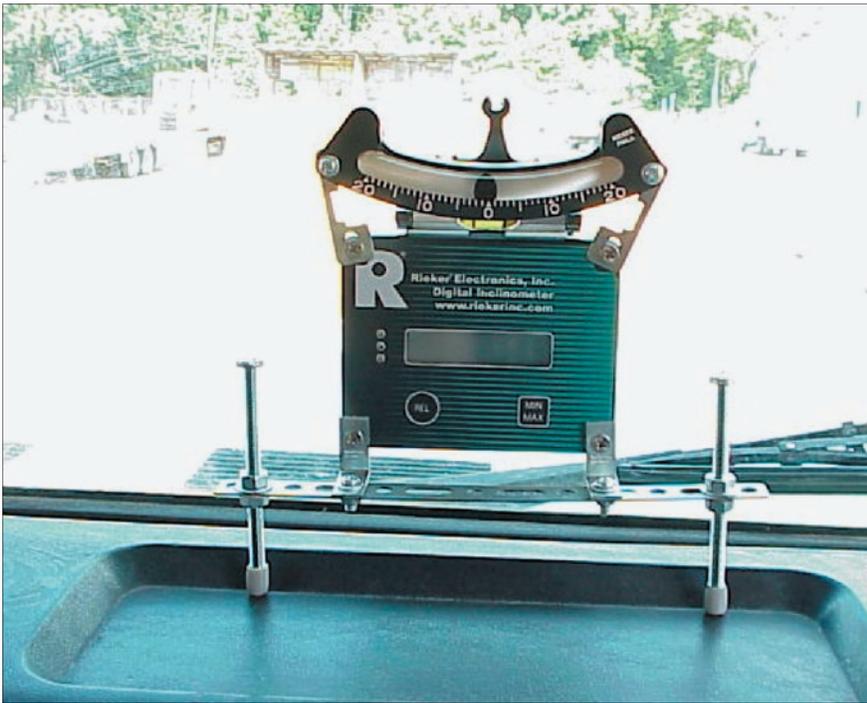
These measurements determined if the comfort levels experienced by drivers of the different vehicle types were similar and how each corresponded to existing advisory speed-setting criteria. If the levels of comfort were similar for drivers of all vehicle types, then the current procedures of setting speed advisory levels for all vehicles would be appropriate

**Table 1.** Crashes at Selected Houston Urban Interchanges (1997–1999)

Freeway Interchange	Number of Crashes		
	Total	Connectors Only	Involved Truck on Connector
I-610 NL @ US 290	288	28 (10%)	16 (54%)
I-610 NL @ I-45N	653	192 (29%)	110 (57%)
I-610 NL @ US 59N	265	63 (24%)	37 (59%)
I-610 SL @ I-45S	466	97 (27%)	44 (45%)
I-610 EL @ I-10E	146	63 (43%)	36 (57%)
I-610 SL @ SH 288	203	57 (28%)	25 (44%)
I-610 WL @ US 59S	1179	248 (21%)	97 (39%)
I-610 WL @ I-10W	329	70 (21%)	44 (63%)
Average		23%	50%

Notes: Excludes crashes on frontage roads and transit facilities.  
Source: TxDOT/DPS crash records.





Data collection apparatus

for all curves, without modification. However, if the comfort levels of the drivers for different vehicle types differed, then the possibility of a dual advisory speed would need further investigation.

### ***What We Found. . .***

Results indicated some generalized findings about the current practice of speed advisory setting and existing traffic operations on freeway-to-freeway connectors:

- Drivers of passenger cars, light trucks, and sport-utility vehicles generally exceed the posted advisory speed limit on freeway-to-freeway connectors, often by more than 10 mph. Drivers of trucks generally exceed the posted advisory limit by about 5 mph or less.
- There is no discernable difference in the lateral accelerations

experienced by drivers in different types of vehicles for a given speed over the course of a freeway-to-freeway connector curve.

- On most freeway-to-freeway connectors, maximum comfort levels for drivers of passenger cars and sport-utility vehicles appear 5 to 10 mph higher than for drivers of larger vehicles.

Since the lateral accelerations experienced by different vehicles are essentially the same for a given curve, but the maximum comfortable speeds differ (5-10 mph), it is logical to assume that drivers of larger vehicles may be more aware of the dangers and consequences of excessive speed on freeway-to-freeway connectors. Discussions with truck drivers confirmed this finding. The truck drivers stated that their peers are aware of the pitfalls of excessive speeds, especially on curves with a

combination of horizontal and vertical grades, typical of curves at freeway interchanges.

It was also observed that the 85th percentile speed on a particular curve typically corresponds very well to the maximum “comfortable” speed of the test drivers. This result infers that an observed maximum ball-bank reading for passenger cars of 13 to 14 degrees would represent a lateral acceleration threshold more realistic of today’s driver comfort levels than the 10 degrees traditionally used for setting advisory speeds. However, the project found that the threshold for tractor-trailers (10 degrees) was decidedly lower than that for passenger cars. This observation may be used to infer that the ball-bank reading of approximately 10 is an acceptable measure to set realistic advisory speeds for large trucks.

These results seem to confirm the expectation that the comfort threshold for car drivers has changed since setting assumptions used in current advisory speed-setting practice. It also infers that there may be a need to develop a two-tiered system for setting advisory speeds on curves for cars and heavy trucks.

### ***The Researchers Recommend. . .***

The project results indicate that there may be differences in the maximum comfortable speeds that drivers of heavy vehicles and passenger vehicles will accept for a freeway-to-freeway curve. The following findings confirmed by this



project are applicable to freeway-to-freeway connectors and should be considered in their design and especially in their re-design:

- Provide adequate deceleration and acceleration distances for tractor-trailers and other heavy vehicles. Designers should not use the minimum lengths specified by the American Association of State Highway and Transportation Officials (AASHTO) guidelines but should consider lengthening these distances by 30 to 50 percent.
- Where possible, reduce the side friction demand. Consider developing superelevation more on the tangent, allowing the trailer of a tractor-trailer combination to adjust the distribution of its load before entering the curve. Consider the negative effect of placing restrictive, low-speed horizontal curves on downgrades.
- Limit the use of sharp, short curves near the gore points of freeway-to-freeway connector ramps, especially where the point of curvature for the ramp curve is close to the ramp divergence point. This situation presents itself as a short reverse curve and can cause load instability from the rocking motion resulting from traversing the reverse curve.
- Place curve advisory speed signing with regard to the deceleration needs of trucks. In some cases, the curve warning signs are placed too close to, or even past, the point of curvature. Guidelines presented



*Appropriate speeds on freeway-to-freeway connectors may be different for trucks than smaller vehicles*

in the 2000 Manual on Uniform Traffic Control Devices (MUTCD) may be used to determine sign placement, considering both approach speed and curve speed. It is also recommended to use the new W13-5 sign (2000 MUTCD) to supplement the W13-2 (EXIT + speed advisory sign) and W13-3 (RAMP + speed advisory sign). The W13-5 provides the term “CURVE” instead of “RAMP” or “EXIT” with an advisory speed.

- Non-standard or differential signing should be considered where a demonstrated history of truck crashes merits giving trucks more advisory information than would be considered “normal” or “standard.” One such procedure would be to use a ball-bank indicator test (in a passenger car or light truck) to determine at what

speed the 10-degree level would be achieved. This 10-degree level would be used to set a truck advisory speed. The test would also determine the speed at which the 13-degree level would be achieved and used for setting a more realistic passenger car speed that would approximately represent the 85th percentile speed on the curve. Again, this procedure is based on limited field-testing of vehicles and on correlating these limited results to many thousands of speed readings at each study curve, so there may be some basis to implement a dual system in the field at yet-to-be-determined test sites.



## *For More Details . . .*

This research is documented in Report 4318-1: *Evaluation of Vehicle Speeds on Freeway-To-Freeway Connector Ramps in Houston*

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## *TxDOT Implementation Status July 2003*

This research project examined the speed characteristics of passenger cars and vehicles with high centers of gravity on freeway-to-freeway ramp connectors to determine any differences between the two vehicle types. The technologies included in this study were a manual ball-bank indicator and a digital inclinometer to measure lateral acceleration. One product was required for this project: guidelines and procedures for determining safe speeds of vehicles on freeway-to-freeway ramp connectors. The guidelines and procedures are being submitted in Research Report 4318-1, which can be used immediately in the design of freeway-to-freeway ramp connectors to:

1. provide adequate deceleration and acceleration distances for tractor-trailers and other heavy vehicles,
2. reduce the side friction demand on trucks in a curve by developing superelevation more on the tangent, and
3. place curve advisory speed signing with more regard to the deceleration needs of trucks.

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