Kansas
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A Ball-Bank Indicator is Helpful for Establishing Advisory Speed on a Horizontal Curve

By Hemin J. Mohammed

One of the most common crashes on horizontal curves in the United States is the run-off-road (ROR) crash, which often results from traveling too fast through those curves. About 42 percent of the ROR fatal crashes on all roads are on curves and this increases to 50 percent for two-lane rural roads [1]. As you might expect, the risk of ROR crashes on rural two-lane roads increases with the degree of curvature.

Providing drivers with a clear view of the curve prior to curve entry allows drivers to decrease their speed before entering the curve. Providing a clear view represents one of the most economical solutions to keep vehicles in the travelled lane [1].

Curve warning signs and advisory speed plaques are important tools to alert drivers of an upcoming change in geometry that may not be apparent or expected. Having uniform speeds and vehicle placement throughout horizontal curves negates the need for changing speed or excessive braking in the curve and change in speed within the curve [2]. It also guides drivers to perceive the road curvature correctly and minimize encroachments on the centerline and edge line [2].

However, the crash statistics mentioned above suggest that drivers often miscalculate the driving conditions on horizontal curves or often do not respond to or comply with warning signs. The evidence shows that one of the reasons for not complying with the advisory speed plaque was that the advisory speeds are inconsistent with driver expectation [3].

How to set curve advisory speeds

To improve consistency in horizontal curve signing and speed plaques, and to improve driver compliance with the advisory speed, the Federal Highway Administration identified the six most widely used (or newly proposed and promising) methods for establishing curve advisory speeds:

- Direct Method
- TTI Curve Speed Model - Compass Method
- TTI Curve Speed Model - Global Positioning System (GPS) Method
- TTI Curve Speed Model - Design Method
- Ball-Bank Indicator Method
- Accelerometer Method.

These methods are categorized into two general groups. The first group determines advisory speeds based on measured operating speeds or estimated operating speeds for a given curve geometry, which includes the Direct Method, the Compass Method,

When Was The Advisory Speed Determined? Before 2009?

Most curves and turns had advisory speeds established prior to 2009, and it is likely that there is little documentation concerning how the advisory speed was determined.

Section 2C.08 of the MUTCD, a new requirement in 2009, requires that advisory speed be established by an engineering study. An engineering study is a written report prepared by an engineer. An agency without an engineer on staff could use a ball-bank indicator to get a general idea if the existing advisory speed plaque is appropriate. If it is not, refer the matter to an engineer [8].

the GPS Method, and the Design Method. The second group determines advisory speeds based on lateral acceleration, which includes the Ball-Bank Indicator Method and the Accelerometer Method [4]. The methods in both groups follow the same procedures to determine advisory speeds. These procedures are: 1) collect field measurements, 2) compute the advisory speed, and 3) confirm the recommended advisory speed through a field trial run.

Of these, the two most common methods are the Ball-Bank Indicator Method and the GPS Method. The Ball-Bank Indicator Method is based on a set of field driving trials conducted to record readings for specific speeds using a ball-bank indicator and a speedometer [4]. The GPS Method is based on one field driving trial conducted to collect the data of horizontal curve geometry, which can be used with a speed prediction model to compute the average speed. This becomes the basis for establishing the advisory speed [4].

Therefore, advisory speeds determined by ball-bank values of 16, 14, and 12 degrees were used to address such driver behavior [5].

The simplicity of construction and operation of ball-bank indicators has led to its general acceptance as a guide to determine advisory speeds at horizontal curves. The Ball-Bank Indicator Method uses a vehicle equipped with a ball-bank indicator and an accurate speedometer to determine the advisory speeds in the field.

Two types of ball-bank indicators

A traditional ball-bank indicator consists of a curved glass tube filled with a liquid and contains a floated ball (see Figure 1). This indicator is mounted in the vehicle, and as the vehicle travels around a curve, the ball floats outward in the curved glass tube. The movement of the ball is measured in degrees of deflection, which is indicative of the combined effect of superelevation, lateral acceleration, and vehicle body roll [7].

Using a ball-bank indicator

The remainder of this article focuses on the lowest-cost method, using a ball-bank indicator. Various criteria were identified for establishing advisory speed on curves based on readings from ball-bank indicators. Two of the main references on the subject have somewhat different recommendations.

The Manual on Uniform Traffic Control Devices (MUTCD) 2009 edition, in section 2C.08, [5] determines the criteria for using a ball-bank indicator as following:

- 16 degrees of ball-bank for speeds of 20 mph or less
- 14 degrees of ball-bank for speeds of 25 to 30 mph
- 12 degrees of ball-bank for speeds of 35 mph and higher.

By comparison, AASHTO's "Green Book" [6] concluded that speeds on curves that do not cause driver discomfort are designated by ball-bank readings as shown below:

- 14 degrees for speeds of 20 mph or less
- 12 degrees for speeds of 25 and 30 mph
- 10 degrees for speeds of 35 to 50 mph.

The MUTCD bases its criteria on research findings that concluded drivers often exceed existing posted advisory curve speeds by 7 to 10 mph.

Figure 1. Ball-Bank Indicator [7]

Figure 2. Digital Ball-Banking Indicator (Rieker® Inc.)

A digital ball-bank indicator is an electronic measuring device used for determining advisory speed on curves. It contains a single line LCD display showing angle or superelevation in degrees as the vehicle travels around a curve (see Figure 2).

How to use a ball-bank indicator

A ball-bank indicator's test is normally conducted by two people, one person to drive and the other to record the ball-bank readings.

The curve advisory speed is fixed at the highest test speed that did not result in a ball-bank indicator reading greater than a recommended degree [4]. For example, if a series of test runs for a curve was started at 25 mph, it might provide a ball-bank indicator reading of about 7 degrees. This value is well below the suggested criteria of 14 degrees for a speed of 25 mph by the MUTCD. The speeds of the test runs would then be increased in five miles per hour increments until reaching readings of 10 degrees to 12 degrees. In this case, that was at 35 mph. (At 40 mph the readings were 13 degrees to 15 degrees). Therefore, the field measurement for this curve would result in posting an advisory speed of 35 mph [4].

Note: Because the amount of body roll varies for different types of vehicles and that affects the ball-bank reading by up to one degree, a typical passenger car is recommended to be used for the test. To ensure correct results from ball-bank indicators, three critical steps need to be taken before starting the test: 1) inflate all tires of the vehicle to uniform pressure as recommended by the manufacturer, 2) calibrate the test vehicle's speedometer, and 3) zero the ball-bank indicator.

Conclusion

Ball-bank indicators represent one of the recommended tools by the Federal Highway Administration and AASHTO to improve driver compliance with the advisory speed on horizontal curves.

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Kansas LTAP Loans Ball-Bank Indicators at No Cost

The current cost of a digital ball-bank indicator is more than $700 and a traditional style is about $80.

The Kansas LTAP has a digital ball-bank indicator for loan at no cost, as part of its Equipment Loan Program for local agencies.

Contact Kansas LTAP Road Safety Resource Coordinator, Hemin Mohammed, at *hemin@ku.edu* or (785) 864-4663, or go to *kutc.ku.edu/equipment-loan-program* for more information.

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