## Research Problem Statement

### Research Problem Title:

Applications for Advisory Speeds

### Statement of Problem

The 11th Edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) indicates in Section 2C.59 that an Advisory Speed (W13-1P) plaque may be used to supplement an advance warning sign to indicate the advisory speed for a roadway condition (FHWA, 2023).

Table 2C-6 of the MUTCD indicates whether the use of an Advisory Speed plaque for horizontal alignment changes is optional, recommended, or required depending on the speed differential, i.e., the difference between the advisory speed for the horizontal curve and the posted speed limit, statutory speed limit, or the 85th percentile speed on the approach to the curve. Section 2C.59 of the MUTCD also lists established engineering practices (e.g., accelerometer, ball-bank method) for determining the recommended advisory speed for horizontal curves and Section 6H.32 references AASHTO and ITE design documents containing engineering practices for determining advisory speeds for horizontal curves.

Although some other sections of the MUTCD (e.g., Section 2C.26 BUMP and DIP signs; Section 8B.16 Low Ground Clearance Grade Crossing Sign) include provisions for the optional or recommended use of Advisory Speed plaques with specific warning signs, the MUTCD does not provide specifications like those provided for horizontal curves for other potential applications of Advisory Speed plaques. Furthermore, the applicability and effectiveness of applying Advisory Speed plaques in other contexts – such as at roundabouts or areas with high pedestrian activity – is yet to be determined. The TCD PFS members expressed interest in considering other applications such as roundabouts, diverging diamond interchanges, intersection ahead, and pedestrian activity where there may not be a marked crosswalk.

Research is needed to inform decision making when transportation agencies are implementing Advisory Speed plaques across diverse roadway environments. The findings of such research could help inform updates to the MUTCD and other traffic control device guidance documents.

The objectives of this research are as follows.

1. Determine the applications in which advisory speeds are commonly applied or where it is of interest to apply advisory speeds and Advisory Speed plaques to advance warning signs.
2. Examine different methods for determining advisory speeds for applications where advisory speeds and Advisory Speed plaques are useful.
3. Determine the effectiveness of advisory speeds in a selected application or applications.

### Summary of Existing Literature

#### Applications for Advisory Speed Plaques (W13-1P)

As indicated in the Statement of the Problem, the MUTCD includes provisions for the use of Advisory Speed (W13-1P) plaques. The provisions in Section 2C.59 describe when the Advisory Speed (W13-1P) plaque may be used and how it should be used.

There are also several sections in the MUTCD that include provisions for the use of Advisory Speed plaques for specific types of warning signs including the Truck Rollover Sign (W1-13), Advisory Exit and Ramp Speed Signs (W13-2 and W13-3) and Combination Horizontal Alignment/Advisory Exit and Ramp Speed Signs (W13-6 through W13-13). HILL BLOCKS VIEW Sign (W7-6), ROAD NARROWS Sign (W5-1), BUMP and DIP Signs (W8-1 and W8-2), SPEED HUMP Sign (W17-1), PAVEMENT ENDS Sign (W8-3), Low Ground Clearance Grade Crossing Sign (W10-5), and ROUGH CROSSING Plaque (W10-15P); these provisions are summarized in Appendix A.

No further guidance is provided in the MUTCD for the use of advisory speeds for other applications.

#### Determining Advisory Speeds

Section 2C.59 of the MUTCD indicates the Advisory Speed plaque shall not be installed, except in emergencies or when the condition is temporary, until the advisory speed has been determined by an engineering study that follows established engineering practices. Section 2C.59, paragraph 12, of the MUTCD identifies five established engineering practices for determining advisory speeds for horizontal curves, but similar support information is not provided pertaining to setting advisory speeds in applications other than horizontal curves.

Furthermore, the Federal Highway Administration (FHWA) published a handbook, titled “Procedures for Setting Advisory Speeds on Curves”. This handbook describes “guidelines for determining when an advisory speed is needed, criteria for identifying the appropriate advisory speed, an engineering study method for determining the advisory speed, and guidelines for selecting other curve related traffic control devices.” 2.

The Texas DOT manual titled “Procedures for Establishing Speed Zones” discusses several applications of advisory speeds and suggests advisory speeds may be useful for curves and turns, intersections, narrow and one-lane bridges, descending grades of six percent or higher, dips, and exit ramps. Appendix A provides more detail on some of the key points discussed for each application.

There were limited standards of practice found for applying advisory speeds in various contexts outside of horizontal curves.

#### Relevant Research for Advisory Speed Applications

Although the MUTCD provides guidelines for setting advisory speeds on horizontal curves, some research suggests that “the inconsistent use of horizontal alignment signs, especially those with an advisory speed plaque, may have lessened the average motorist's respect for the message the signs convey” (TxDOT, n.d.). This consequence is a result of driver familiarity on roadways, which can lead to drivers believing they can navigate the road safely and ignore the posted advisory speeds. However, when drivers ignore these advisory limits on unfamiliar roads, they could drive too fast and be more likely to crash (Bonneson et al., 2009).

A study published in 1972 on the effectiveness of advisory speed and curve signs found that the average driving speed on horizontal curves exceeds the posted advisory speed when the advisory speed is set to less than 45 mph. It was found that the lower the advisory speed was, the more speeding occurred (within an average range of 2-10 miles per hour) (Ritchie, 1972).

The Texas A&M Transportation Institute led an effort to identify strategies for effective roundabout approach speed. The research included a review of existing guidance and previous research on speed reduction techniques, and provides recommended practices based on the findings. The study found warning and advisory speed signs to be a low-cost and low-effort solution to reduce driver speed before roundabouts. This study referenced a previous study that found signs to be ineffective and one study that found a “reduction of 2 to 3 mph at the point of curvature”, however no additional details on these studies were provided (Brewer et al., 2017).

Another study was conducted by Stonebrooke Engineering that strategized effective roundabout speed reduction. This report states that using advance signing (including advisory speed plaques) on roundabout approaches can reduce driver speed between 3 and 8 mph (Arvidson, 2022).

An alternative to advisory speed plaques is variable speed limit application, a dynamic sign that can reflect safe speed limits for current conditions. A major difference between advisory speed and variable speed limits is that variable speed limits are legally enforced, whereas advisory speed limits rely on driver compliance. However, in conditions where fast speeds could pose potential dangers to drivers and road users, it may be beneficial to have variable speed limits. A 2017 report discusses that the Missouri DOT installed a regulatory variable speed limit system on an interstate in St. Louis. They reported that law enforcement were reluctant to enforce the variable speed limit because they were uncertain of the current speed limits. Therefore, Missouri DOT changed the system to be advisory but the system was ultimately deactivated due to issues with driver compliance.

The FHWA published a study analyzing drivers’ interactions with simulated Diverging Diamond Interchanges (DDI). The FHWA Highway Driving Simulator was used to simulate a diamond interchange and two versions of a DDI. The conventional diamond interchange was used as a baseline for driver behavior. This was compared to the DDI, which included advisory speed signs and pavement markings, and the DDI-Minimal design, which eliminated some of the redundant signs and markings. Seventy-four licensed drivers were then recruited to “travel” through the simulated interchange environments and their driver behavior, including speed, was recorded. The posted speed limits were 35 mph on the arterial and 55 mph on the limited –access road. The advisory speeds were 30 mph on the freeway ramps and 25 mph on the approach to the DDI and DDI crossovers. Although the mean driver speed exceeded the advisory speed in each model, drivers did drive slower in the DDI and DDI-Minimal simulations. The average speed in the diamond interchange model, DDI, and DDI-Minimal was 34.4 mph, 23.2 mph, and 24.6 mph respectively. The report noted that “The difference in speed between DDI and DDI-M models was statistically reliable (p < 0.005) but relatively small.” Differing advisory speeds were not tested within each model, so an optimal advisory speed was not found (FHWA, n.d.).

FHWA published another study titled *Evaluation of Advisory Exit and Ramp Speed Signs*. In a laboratory study, participants were shown images of advisory exit and ramp speed signs with different advisory speeds (ranging from 15 mph to 45 mph) and provided subjective ratings of perceived severity of the upcoming curve and likelihood of compliance with the advisory speed. The results indicated that lower advisory speeds resulted in ratings of greater perceived severity and higher reported compliance. A field study evaluated driver behavior in response to variations in advisory speed signing approaches. The study included advisory speeds ranging from 20 mph to 50 mph, and posted speed differentials (i.e., the difference between the regulatory speed and the advisory speed) ranging from 15 mph to 45 mph. The data showed that drivers tended to drive at speeds higher than the advisory speed throughout the entire ramp. Furthermore, although the laboratory study showed that the earlier the advisory speed sign was placed on the deceleration lane, the earlier drivers generally thought they needed to slow down. However, the results from the field study suggested that drivers may not be reducing speed until they feel the need to do so. (FHWA, 2024).

Most of the existing literature pertaining to advisory speeds, including what is found in the MUTCD, is related to horizontal curves. Minimal research was identified on the effectiveness of advisory speeds in other complex applications such as intersections, areas with pedestrian activity without marked crosswalks, and locations with traffic-calming measures (e.g., speed humps).

### Potential Research Approach

#### Task 1 – Kick-off Meeting and Project Management

The research team will attend a kickoff meeting with FHWA and the TCD PFS panel. The research team will work with the Task Order Contracting Officer’s Representative to ensure a common understanding of the research objective, scope, and research questions. The kickoff meeting may also be used to obtain input on potential practitioner contacts for Tasks 3 and 4 from TCD PFS members and other stakeholders.

#### Task 2 – Literature and (Online) State of the Practice Review

The research team will review and synthesize literature regarding research that has been performed on the effectiveness of advisory speeds and methods for establishing advisory speeds in various types of contexts. Additionally, current practices (as identified through online resources) and MUTCD text will be summarized.

#### Task 3 – Review of Current Practices

The research team will conduct a review of current practices. The review will be focused on identifying the applications in which advisory speeds are used, the effectiveness (or perceived effectiveness) of advisory speeds in various applications, methods for establishing advisory speeds, and any other relevant information. The research team will reach out to the TCD PFS members and other practitioner contacts as identified in Tasks 1 and 2. This task will also be used to identify potential participants for the expert panel (Task 4).

#### Task 4 – Expert Panel Workshops to Identify Applications for Advisory Speeds and Methods for Establishing Advisory Speeds

The research team will assemble an expert panel of individuals identified using the findings of the previous tasks. Expert panel members may include TCD PFS members as well as other practitioners or stakeholders with relevant insight and experience. The research team will conduct two separate virtual workshops. It is likely that each of the panel members will participate in both workshops. However, there may be some participants who only attend one of the two workshops based on their experience or availability.

The first expert panel workshop will be focused on identifying applications in which advisory speeds are commonly applied or applications that are of interest to the expert panel. Potential applications to be considered and discussed include, but are not limited to, roundabouts, DDIs, areas with high truck activity, intersections, horizontal curves, areas of pedestrian activity without marked crosswalks, and locations with traffic calming measures (e.g., speed humps). This will also include discussion about whether advisory speeds should be used on an approach where road users may need to come to a stop. This workshop will also be used to identify potential measures of effectiveness for different applications and obtain any feedback (either empirical or anecdotal) on the effectiveness of advisory speeds in different applications that panel members have used. The research team will gather any other relevant information including decision-making considerations, challenges, etc.

The second workshop will be focused on identifying proposed methods for determining advisory speeds for applications other than horizontal curves. These methods may be specific to certain applications. For example, the proposed methods for determining advisory speeds for roundabouts will be different than those of pedestrian activity without marked crosswalks. Proposed methods may draw from speed limit setting methods from various sources depending on the context. Some existing speed limit setting methodologies incorporate pedestrian volumes so a similar approach may be desired for setting an advisory speed in a pedestrian-heavy area.

#### Task 5 – Research Plan Development

The research team will work with the TOCOR and TCD PFS members, to define the specific objectives of the field evaluation. This would involve selecting the specific applications (e.g., roundabouts) for providing advisory speeds, the methods for establishing the advisory speeds, and measure(s) of effectiveness for advisory speeds in different applications. The specific methodology, including independent and dependent variables, will be detailed in the research plan. It is expected that the primary dependent variable of interest will be vehicle speeds, but other potential measures will also be identified.

#### Task 6 – Field Site Selection and Preparation

Once the research plan is finalized, the research team will identify appropriate locations (or sites) that meet the criteria identified in the research plan. This task may include the identification of many similar sites and/or control sites. The research team will identify and consider other relevant factors such as local traffic conditions, existing enforcement practices, etc.

#### Task 7 – Data Collection and Analysis

The research team will collect and analyze data based on the final, approved, research plan. This will involve the collection of driving behavior in response to the presence of advisory speed limits. The field study will be focused on determining the context(s) in which advisory speeds are most effective.

#### Task 8 – Final Report and Presentation

The research team will develop a final report that describes the research approach and results and provides a discussion of the findings. The research team will also develop a concise 1-page summary of the project and findings. The team will present their findings to the TCD PFS members.

### Chance of Successful Evaluation

Medium

There is a high likelihood that the study can identify, via expert panel workshops, contexts and applications in which advisory speeds may be effective (at least anecdotally) and useful. There is also a high likelihood that the expert panel workshops can identify proposed methods for establishing advisory speeds in contexts other than horizontal curves.

The primary challenge of this proposed research will be in determining the effectiveness of advisory speeds in different contexts or applications. The TCD PFS has expressed interest in examining speeds, and potentially other measures of effectiveness (e.g., general awareness of the hazard/condition and of the advisory speed). However, vehicle speeds may not change, which would not necessarily indicate that the advisory speeds are ineffective. Furthermore, it may be difficult to determine whether the advisory speeds are effective based on speed alone. For example, if advisory speeds are applied in an area of high truck activity, the advisory speed plaque may lead to drivers being more aware and scanning the area more than they would have otherwise. That said, general awareness would be very difficult to measure in the field.

### References

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## Appendix A – Summary of Additional Literature Review Information

#### Summary of MUTCD Provisions Pertaining to Applications for Advisory Speed Plaques

The MUTCD includes provisions for the use of Advisory Speed (W13-1P) plaques. Specifically, Section 2C.59, paragraph 01, states “The Advisory Speed (W13-1P) plaque (see Figure 2C-1) may be used to supplement an advance warning sign to indicate the advisory speed for a condition.” Section 2C.59, paragraph 06, further indicates “The Advisory Speed plaque shall only be used to supplement an advance warning sign” and it “shall not be installed as a separate sign installation.” This section also indicates that the use of the Advisory Speed plaque shall be in accordance with Section 2C.06 and Table 2C-6. Table 2C-6, as shown in Figure 1, indicates whether the use of an Advisory Speed plaque for horizontal alignment changes is optional, recommended, or required depending on the speed differential.



Figure . MUTCD Table 2C-6. Use of Advisory Speed Plaque for Horizontal Alignment Changes.

Table 2C-3 also provides guidelines for the advance placement of warning signs based on the posted or 85th percentile speed of the roadway and the deceleration to the advisory speed of the roadway.

Section 2B.21, Speed Limit Sign (R2-1), reiterates that “an advisory speed plaque mounted below a warning sign should be used to warn road users of an advisory speed for a roadway condition” and states that “a Speed Limit sign should not be used for this purpose.”

There are several sections in the MUTCD that include provisions for the use of Advisory Speed plaques for specific types of warning signs; these provisions are summarized in Table 1.

Table . Provisions for the use of Advisory Speed plaques for specific warning signs in the MUTCD.

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| Section | Title | Provision(s) |
| 2C.11 | Truck Rollover Sign (W1-13) | Standard: If a Truck Rollover (W1-13) sign is used, it shall be accompanied by an Advisory Speed (W13-1P) plaque indicating the recommended speed for vehicles with a higher center of gravity. |
| 2C.12 | Advisory Exit and Ramp Speed Signs (W13-2 and W13-3) and Combination Horizontal Alignment/Advisory Exit and Ramp Speed Signs (W13-6 through W13-13) | Option:Where there is a need to remind road users of the recommended advisory speed, a horizontal alignment warning sign with an advisory speed plaque displaying the same advisory speed may be installed at a downstream location along the ramp. |
| 2C.16  | HILL BLOCKS VIEW Sign (W7-6) | Guidance:When a HILL BLOCKS VIEW sign is used, it should be supplemented by an Advisory Speed (W13-1P) plaque (see Figure 2C-1) indicating the recommended speed for traveling over the hillcrest based on available stopping sight distance. |
| 2C.17 | ROAD NARROWS Sign (W5-1) | Option:Additional emphasis may be provided by the use of object markers and delineators (see Sections 2C.70 through 2C.73 and Chapter 3G). The Advisory Speed (W13-1P) plaque (see Figure 2C-1 and Section 2C.59)may be used to indicate the recommended speed. |
| 2C.26 | BUMP and DIP Signs (W8-1 and W8-2) | Option:These signs may be supplemented with an Advisory Speed plaque (see Figure 2C-1 and Section 2C.59). |
| 2C.27 | SPEED HUMP Sign (W17-1) | Guidance:If used, the SPEED HUMP sign should be supplemented by an Advisory Speed plaque (see Figure 2C-1 and Section 2C.59).Option:If a series of speed humps exists in close proximity, an Advisory Speed plaque may be eliminated on all but the first SPEED HUMP sign in the series. |
| 2C.28 | PAVEMENT ENDS Sign (W8-3) | Option:An Advisory Speed plaque (see Figure 2C-1 and Section 2C.59) may be used when the change in roadway condition requires a reduced speed. |
| 8B.16 | Low Ground Clearance Grade Crossing Sign (W10-5) | Guidance:If engineering judgment of roadway geometric and operating conditions confirms that motor vehicle speeds across the tracks should be below the posted speed limit, a W13-1P advisory speed plaque should be posted. |
| 8B.25 | ROUGH CROSSING Plaque (W10-15P) | Option:If the grade crossing is rough, word message signs such as BUMP, DIP, or ROUGH CROSSING may be installed. A W13-1P advisory speed plaque may be installed below the word message sign in advance of rough crossings. |

Section 6H.32 of the MUTCD describes the use of Advisory Speed plaques for temporary traffic control (TTC) warning signs. Specifically, this section indicates that “In combination with a warning sign, an Advisory Speed (W13-1P) plaque (see Figure 6H-1) may be used to indicate a recommended speed through the TTC zone.” It provides supporting information that warning signs with Advisory Speed plaques inform drivers of the recommended operating speed based on temporary conditions within a TTC zone.

#### Summary of Key Points from Procedures for Establishing Speed Zones (Texas DOT, date)

The Texas DOT manual titled “Procedures for Establishing Speed Zones” discusses several applications of advisory speeds and suggests advisory speeds may be useful for curves and turns, intersections, narrow and one-lane bridges, descending grades of six percent or higher, dips, and exit ramps.

Table . Applications for Advisory Speeds from TXDOT “Procedures for Establishing Speed Zones”

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| --- | --- |
| Application for Advisory Speeds | Description |
| Curves and Turns | Horizontal curves having a safe operating speed of 5 miles per hour or more below the posted maximum speed limit should be signed with advisory speed limits. Vertical curves may also be signed with advisory speed limits. |
| Intersections | Advisory zones may be posted at intersections such as traffic circles designed for an operating speed less than the speed of the approaches, and intersections with restricted sight distances that require a reduction in speed for safe operation. |
| Narrow and One-lane Bridges | Advisory speeds should be applied when horizontal or vertical sight distance restrictions on the approaches require a reduction of approach speed for safe operation. The advisory speeds are intended to eliminate the element of surprise.  |
| Descending Grades of Six Percent or More | Where vehicles may attain a speed greater than required for a safe stopping distance or in excess of that required for safe travel around curves at the bottom or within limits of the grade, the posting of an advisory speed may be prudent. |
| Dips and Bumps | An advisory speed may be desirable where a depression or bump in the road profile is sufficiently abrupt to create a hazardous condition, cause discomfort to passengers, cause a shifting in cargo, or deflect a vehicle from its true course when crossed at speeds prevailing on the approaches. |

In some cases, the manual also provides information on how to determine the advisory speed. For example, page 5-13 states that “The speed to be posted for dips or bumps should be determined by trial runs. It should be the highest speed that will enable a vehicle to travel over the dip or bump without considerable discomfort to passengers, without causing a shifting of cargo, or without causing a deflection of a vehicle from its true course.”