ARE CURRENT TRAFFIC SIGNAL HEAD PLACEMENT DESIGN STANDARDS ADEQUATE?

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ABSTRACT OF

ARE CURRENT TRAFFIC SIGNAL HEAD PLACEMENT DESIGN STANDARDS ADEQUATE?

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The purpose of this research is to determine if current design standards for traffic signals, specifically the minimum distance from the stop bar at which mast arm mounted signals can be used exclusively, provide adequate signal head visibility for all possible driver-vehicle combinations.

A total of 55 mast arm signal locations in Bartlesville, Oklahoma, were evaluated using different driver-vehicle combination. Five different eye heights, 42, 45, 46 50, and 66 inches, were evaluated, and for each eye height, signal head visibility was observed with the visor in use and not in use.

The results showed that for most driver-vehicle combinations, many mast arm signal heads could not be seen from the stop bar. When the sun visor is in use, most signal heads could not be seen from the stop bar.

While eye height does affect signal head visibility, it is not the best predictor of signal head visibility, yielding an inconclusive relationship. Instead, the zenith angle, that is the driver's angle of visibility above the horizon, yields the most consistent relationship with signal head visibility, with lower zenith angles generally having fewer visible signal heads.

Using a combination of the zenith angle and driver eye height, a mathematical model was created that corrected predicted whether a not a signal head would be visible from the stop bar for approximately 90 percent of the observed data points.

INTRODUCTION

One reason frequently given by motorists who have traffic accidents at signalized intersections is the inability to see the signal head. Is this a legitimate complaint, or just an excuse to justify bad driving? The purpose of this research, then, is to determine if there are legitimate signal head visibility issues at locations built in compliance with the current engineering standards.

LITERATURE REVIEW

A review of the Institute of Transportation Engineers (ITE) and Transportation Research Board databases and existing standards reveals a dearth of information on the topic. The only standard found for signal head placement, both vertically and horizontally, is the standard established in the *Manual on Uniform Traffic Control Devices* (MUTCD). According to Section 4D.15 of the *2003 MUTCD*, the minimum distance of a signal face from a stop line is 40 feet, with a maximum mounting height of the top of the signal housing above the pavement of 21 feet at that distance. In other words, a signal face mounted at least 40 feet from the stop bar and whose housing top is no more than 21 feet above the pavement is in conformance with the standards.

The only other standard found that may be applicable is that of driver eye height. The *AASHTO Green Book* references a driver eye height of 42 inches with respect to geometric design. Although this particular driver eye height is not mentioned in connection to signal head placement and visibility, since it is such a ubiquitous standard, it is reasonable to conclude that this value was incorporated, directly or indirectly, in the *MUTCD* signal head placement standard.

PURPOSE OF THIS STUDY

The primary hypothesis for this study is that existing signal head placement standards are not adequate for all driver-vehicle combinations; in other words, at some locations, drivers will not be able to see the signal heads even when they comply with existing standards.

Because the primary hypothesis assumes that existing standards are not adequate, the data were collected in a manner to determine how different physical characteristics of the driver and vehicle affect signal head visibility. For example, what is the effect of driver eye height on signal visibility, and if visibility is impacted by driver height, is there a clear relationship? How does visor use affect signal head visibility, and can the relationship between visor use and signal head visibility be defined?

SCOPE OF THE STUDY

A total of 55 locations in Bartlesville, Oklahoma, were evaluated. Each location met or exceeded the minimum 40 feet longitudinal distance from the stop bar; in addition, the heads were mounted at a height of 20 feet, which exceeds the minimum standards. Thus, all locations tested complied with the standards prescribed in the *MUTCD*.

Three different subjects and three different vehicles were used in this study. The combinations of subjects and vehicles yielded five different driver eye heights: 42, 45, 46, 50, and 66 inches. Observations were taken in the various vehicles with the sun visor in the unused, or up position, and the used, or down, position. Data were collected and tabulated for a total of ten different visor position and driver eye height combinations, yielding a total of 550 data points.

At each location, each test subject noted whether or not the signal head was obstructed or unobstructed for both the visor up and visor down condition. A signal head was considered to be obstructed if any part of the signal head was not visible by the subject at the stop bar. For example, if the subject found it necessary to slouch or bend or crunch out of the normal sitting position to see all of the signal head, then that signal was considered to be obstructed. In more technical terms, if any part of the signal head was outside of the zenith angle, the angle of visibility above the plane of the subject's eye, then the signal head was considered to be obstructed. (**Figure 1**)

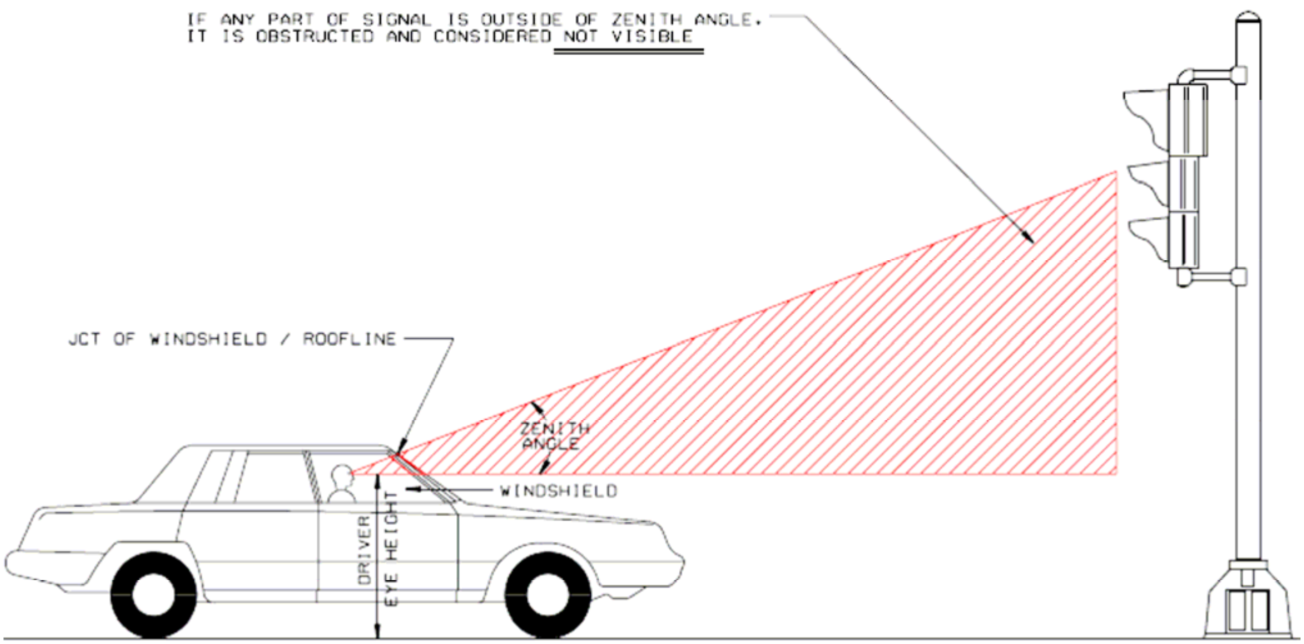

FIGURE 1. Signal head visibility and the zenith angle.

RESULTS

The observations for the five driver–vehicle combinations with the visor not being used, or in the up position, are displayed in **Figure 2**. (Unshaded areas represent heads that are unobstructed; shaded areas represent heads that are obstructed.) At a driver eye height of 42 inches, the standard driver eye height for geometric design as specified in the *AASHTO Green Book*, all signal heads were visible at all longitudinal distances; interestingly, the same is also true for the observations taken at a driver eye height of 66 inches. However, for the remaining three driver eye heights, numerous signal heads were obstructed, despite the fact that at all locations the signal head placement exceeded the standards. For the 45 inch driver eye height dataset, a signal head 72 feet from the stop bar was obstructed; in other words, a signal placed at a distance almost twice the standard could not be seen. For the 46 inch and 50 inch datasets,

ID	DIST FROM STOP BAR (FT)	DRIVER EYE HEIGHT (IN) 42	45	46	50	66
7d	41	U	o	o	o	U
4a	48	U	o	o	o	U
7c	60	U	o	o	o	U
4b	61	U	o	o	o	U
3a	64	U	o	o	o	U
6d	70	U	U	U	o	U
4d	72	U	o	U	o	U
3b	74	U	U	U	o	U
4c	74	U	U	U	o	U
2b	77	U	U	U	o	U
6b	77	U	U	U	o	U
Ab	79	U	U	U	o	U
6a	80	U	U	U	o	U
6c	80	U	U	U	o	U
2a	82	U	U	U	U	U
Ad	82	U	U	o	o	U
Dc	84	U	U	U	o	U
Aa	86	U	U	U	U	U
Bb	86	U	U	U	U	U
1c	87	U	U	U	o	U
Ac	87	U	U	U	o	U
1a	88	U	U	U	o	U
1b	88	U	U	U	U	U
7b	90	U	U	U	o	U
3c	93	U	U	U	o	U
2d	96	U	U	U	U	U
9c	96	U	U	U	U	U
2c	97	U	U	U	U	U
3d	97	U	U	U	U	U
Db	99	U	U	U	o	U
Ed	99	U	U	U	U	U
1d	104	U	U	U	U	U
Eb	105	U	U	U	U	U
Ec	105	U	U	U	U	U
Ba	106	U	U	U	U	U
9d	108	U	U	U	U	U
Cc	113	U	U	U	U	U
Da	113	U	U	U	U	U
Ea	114	U	U	U	U	U
8b	116	U	U	U	U	U
Dd	116	U	U	U	U	U
8d	124	U	U	U	U	U
8c	127	U	U	U	U	U
Cd	127	U	U	U	U	U
5a	133	U	U	U	U	U
5d	134	U	U	U	U	U
Ca	137	U	U	U	U	U
9a	139	U	U	U	U	U
Cb	141	U	U	U	U	U
5c	142	U	U	U	U	U
9b	147	U	U	U	U	U
8a	151	U	U	U	U	U
Bd	152	U	U	U	U	U
5b	154	U	U	U	U	U
Bc	155	U	U	U	U	U

Shaded = obstructed Unshaded = Unobstructed

FIGURE 2. Visibility of signal heads with visors not used.

signals were obstructed at distances of 82 feet and 99 feet, more than twice and almost two-and-one-half times the minimum longitudinal distance, respectively.

The observations for the five driver–vehicle combinations with the visor being used, or in the down position, are displayed in **Figure 3**. Again, unshaded areas represent heads that are unobstructed; shaded areas represent heads that are obstructed. Unlike the observations with the visor in the unused position, when the visor is being used signal heads are obstructed for both the 42 inch and 66 inch driver eye heights. At 42 inches, signal heads at a distance of 80 feet, or twice the minimum standard, are obstructed; at 66 inches, the obstructed distance is 127 feet, more than three times the minimum standard. At the 45 inch, 46 inch, 50 inch, and 66 inch driver eye heights, most of the signals observed could not be seen when the visor was in use. For example, at the 45 inch eye height, signal heads were visible and unobstructed at only 19 of the 55, or 35 percent, of the locations, and then only at longitudinal distances greater than 113 feet from the stop bar. The observed data for a driver eye height of 46 inches reveals only 13 of the 55 locations, or 24 percent, were unobstructed, with a signal head 137 feet from the stop bar being obstructed from the driver's view. The 50 inch dataset is the nadir of signal head visibility, with only 8 of 55 locations, or 15 percent unobstructed, with a signal head as far away from the stop bar as 154 feet observed as obstructed. There was a slight improvement at 66 inches, as 13 of the 55 locations were unobstructed, and the farthest that a signal head was obstructed was 133 feet. From this data, is it clear that the minimum standards are not adequate for all vehicle-driver combinations, and are woefully inadequate when visors are in use.

ANAYLSIS

Since the existing standards are not adequate for all driver-vehicle combination or driving conditions (i.e. the need for a visor), can the obstructed conditions be modeled mathematically? Is there a mathematical model that can be used to predict when a signal head will be obstructed?

Effect of Driver Eye Height on Visibility

Initially, a mathematical model was created based on the driver eye height. As can be seen from both **Figure 2** and **Figure 3**, for the first four datasets, 42 inches, 45 inches, 46 inches, and 50 inches, there is a direct relationship between driver eye height and the number of obstructed signals. For every inch increase in driver eye height beyond the design height of 42 inches, the longitudinal distance at which a signal head is visible and unobstructed increases by approximately ten feet. For a driver eye height of 45 inches, which is three inches greater than the design value, the minimum distances at which a signal head is unobstructed are 70 feet and 113 feet for visor not used and visor used conditions, respectively; for 42 inches, those distances are 40 feet and 80 feet. Thus, for both the visor used and visor not used conditions, three inches additional driver eye height results in an increase of thirty feet of the longitudinal distance at which a signal head is visible and unobstructed. In other words, an increase in three inches of driver eye height increased the longitudinal distance at which the signal heads were visible by thirty feet; thus, the one inch of additional driver eye height yields ten feet of additional longitudinal distance to see the signal head unobstructed.

For both the visor up and down datasets, this simple relationship between driver eye height and the longitudinal distance at which the signal heads were unobstructed was a good approximation of the empirical observations, until the 66 inch dataset was included, at which

ID	DIST FROM STOP BAR (FT)	DRIVER EYE HEIGHT (IN) 42	45	46	50	66
7d	41	o	o	o	o	o
4a	48	o	o	o	o	o
7c	60	o	o	o	o	o
4b	61	o	o	o	o	o
3a	64	o	o	o	o	o
6d	70	o	o	o	o	o
4d	72	U	o	o	o	o
3b	74	U	o	o	o	o
4c	74	U	o	o	o	o
2b	77	U	o	o	o	o
6b	77	o	o	o	o	o
Ab	79	U	o	o	o	o
6a	80	o	o	o	o	o
6c	80	o	o	o	o	o
2a	82	U	o	o	o	o
Ad	82	U	o	o	o	o
Dc	84	U	o	o	o	o
Aa	86	U	o	o	o	o
Bb	86	U	o	o	o	o
1c	87	U	o	o	o	o
Ac	87	U	o	o	o	o
1a	88	U	o	o	o	o
1b	88	U	o	o	o	o
7b	90	U	o	o	o	o
3c	93	U	o	o	o	o
2d	96	U	o	o	o	o
9c	96	U	o	o	o	o
2c	97	U	o	o	o	o
3d	97	U	o	o	o	o
Db	99	U	o	o	o	o
Ed	99	U	o	o	o	o
1d	104	U	o	o	o	o
Eb	105	U	o	U	o	U
Ec	105	U	o	o	o	o
Ba	106	U	o	o	o	o
9d	108	U	o	o	o	o
Cc	113	U	U	o	o	U
Da	113	U	U	o	o	o
Ea	114	U	U	o	o	o
8b	116	U	U	U	U	o
Dd	116	U	U	o	o	o
8d	124	U	U	U	U	o
8c	127	U	U	U	U	o
Cd	127	U	U	o	o	U
5a	133	U	U	o	o	o
5d	134	U	U	U	o	U
Ca	137	U	U	o	o	U
9a	139	U	U	U	U	U
Cb	141	U	U	U	o	U
5c	142	U	U	U	U	U
9b	147	U	U	U	o	U
8a	151	U	U	U	U	U
Bd	152	U	U	U	U	U
5b	154	U	U	U	o	U
Bc	155	U	U	U	U	U

shaded = obstructed Unshaded = Unobstructed

FIGURE 3. Visibility of signal heads when visors are used.

point this relationship breaks down. Due to the lack of datasets between the 50 and 66 inch eye heights, it cannot be determined whether or not the 66 inch dataset was a singular anomaly or part of a trend that can be mathematically modeled.

Effect of Visor Use on Visibility

A comparison of **Figures 2** and **3** indicates a strong correlation between visor use and signal head visibility, specifically that signal heads are less visible when visors are used (down). Unlike the relationship between driver eye height and signal visibility, this relationship is consistent for all datasets, and does not break down with the 66 inch dataset. A close comparison of the two figures reveals that the use of the visor results in an increase of the longitudinal distance required to see the signal heads of 40 feet, and that this differential is consistent for all five driver eye heights. In other words, where a signal head can be seen at a distance of 40 feet with the visor up and not in use, a signal head cannot be seen at a distance of 80 feet when the visor is down and in use. In Oklahoma, where many major roads follow latitudinal section lines and run due east-west, this is highly problematic as a visor is a necessity in the morning and evening hours when the sun is rising and setting.

Effect of Zenith Angle on Visibility

Because of the possible relationships between driver eye height and signal head visibility, and visor use and signal head visibility, the datasets were combined and segregated by the zenith angle, the angle of visibility above the horizon as shown in **Figure 1**, as the zenith angle is a derivative of both the driver eye height and visor use. Due to a measurement oversight, the measurements necessary to calculate the zenith angle were not available for one of the datasets, resulting in nine datasets segregated by zenith angle, as shown in **Figure 4**. As can been seen from **Figure 4**, the unshaded areas, i.e. the unobstructed signal observations, generally decrease as the zenith angle increases, indicating a relationship between the zenith angle and signal head visibility. It should be noted that there are more obstructed data points for a zenith angle of 8.43 degrees when compared to the lesser zenith angle of 7.77 degrees, but it can be logically concluded that this is an anomaly since the relationship holds for all the other datasets.

Predicting Signal Head Visibility

Because there exists a direct relationship between the zenith angle and signal head visibility, then it is possible to mathematically predict if a signal head will be visible from a particular longitudinal distance for a given zenith angle. One such mathematical model is as follows:

$$(I/12) + (D \times \tan \angle Z) \geq H$$

Where:

I = driver eye height (in)
D = longitudinal distance from stop bar to signal head (ft)
$\angle Z$ = Zenith Angle (degrees)
H = Height to top of signal housing (ft)

ID	DIST FROM STOP BAR (FT)	ZENITH ANGLE (Degrees) 22.38	20.85	16.39	13.24	12.80	11.31	8.43	7.77	5.19
7d	41	U	U	o	o	o	o	o	o	o
4a	48	U	U	o	o	o	o	o	o	o
7c	60	U	U	o	o	o	o	o	o	o
4b	61	U	U	o	o	o	o	o	o	o
3a	64	U	U	o	o	o	o	o	o	o
6d	70	U	U	U	U	o	o	o	o	o
4d	72	U	U	o	U	U	o	o	o	o
3b	74	U	U	U	U	U	o	o	o	o
4c	74	U	U	U	U	U	o	o	o	o
2b	77	U	U	U	U	U	o	o	o	o
6b	77	U	U	U	U	o	o	o	o	o
Ab	79	U	U	U	U	U	o	o	o	o
6a	80	U	U	U	U	o	o	o	o	o
6c	80	U	U	U	U	o	o	o	o	o
2a	82	U	U	U	U	U	U	o	o	o
Ad	82	U	U	U	o	U	o	o	o	o
Dc	84	U	U	U	U	U	o	o	o	o
Aa	86	U	U	U	U	U	U	o	o	o
Bb	86	U	U	U	U	U	U	o	o	o
1c	87	U	U	U	U	U	o	o	o	o
Ac	87	U	U	U	U	U	o	o	o	o
1a	88	U	U	U	U	U	o	o	o	o
1b	88	U	U	U	U	U	U	o	o	o
7b	90	U	U	U	U	U	o	o	o	o
3c	93	U	U	U	U	U	o	o	o	o
2d	96	U	U	U	U	U	U	o	o	o
9c	96	U	U	U	U	U	U	o	o	o
2c	97	U	U	U	U	U	U	o	o	o
3d	97	U	U	U	U	U	U	o	o	o
Db	99	U	U	U	U	U	o	o	o	o
Ed	99	U	U	U	U	U	U	o	o	o
1d	104	U	U	U	U	U	U	o	o	o
Eb	105	U	U	U	U	U	U	U	o	x
Ec	105	U	U	U	U	U	U	o	o	o
Ba	106	U	U	U	U	U	U	o	o	o
9d	108	U	U	U	U	U	U	o	o	o
Cc	113	U	U	U	U	U	U	U	U	o
Da	113	U	U	U	U	U	U	o	U	o
Ea	114	U	U	U	U	U	U	o	U	o
8b	116	U	U	U	U	U	U	o	U	U
Dd	116	U	U	U	U	U	U	o	U	o
8d	124	U	U	U	U	U	U	o	U	U
8c	127	U	U	U	U	U	U	o	U	U
Cd	127	U	U	U	U	U	U	U	U	o
5a	133	U	U	U	U	U	U	o	U	o
5d	134	U	U	U	U	U	U	U	U	U
Ca	137	U	U	U	U	U	U	U	U	o
9a	139	U	U	U	U	U	U	U	U	U
Cb	141	U	U	U	U	U	U	U	U	U
5c	142	U	U	U	U	U	U	U	U	U
9b	147	U	U	U	U	U	U	U	U	U
8a	151	U	U	U	U	U	U	U	U	U
Bd	152	U	U	U	U	U	U	U	U	U
5b	154	U	U	U	U	U	U	U	U	U
Bc	155	U	U	U	U	U	U	U	U	U

shaded = obstructed Unshaded = Unobstructed

FIGURE 4. Visibility of signal heads by zenith angle.

ID	DIST FROM STOP BAR (FT)	ZENITH ANGLE (Degrees) / DRIVER EYE HEIGHT (Inches) 22.38 / 42	20.85 / 66	16.39 / 45	13.24 / 46	12.80 / 42	11.31 / 50	8.43 / 66	7.77 / 45	5.19 / 46
7d	41	U	U	*O*	*O*	*O*	*O*	*O*	*O*	*O*
4a	48	U	U	*O*	*O*	*O*	*O*	*O*	*O*	*O*
7c	60	U	U	U	*O*	*O*	*O*	*O*	*O*	*O*
4b	61	U	U	U	*O*	*O*	*O*	*O*	*O*	*O*
3a	64	U	U	U	*O*	*O*	*O*	*O*	*O*	*O*
6d	70	U	U	U	U	*O*	*O*	*O*	*O*	*O*
4d	72	U	U	U	U	*O*	*O*	*O*	*O*	*O*
3b	74	U	U	U	U	U	*O*	*O*	*O*	*O*
4c	74	U	U	U	U	U	*O*	*O*	*O*	*O*
2b	77	U	U	U	U	U	*O*	*O*	*O*	*O*
6b	77	U	U	U	U	U	*O*	*O*	*O*	*O*
Ab	79	U	U	U	U	U	*O*	*O*	*O*	*O*
6a	80	U	U	U	U	U	U	*O*	*O*	*O*
6c	80	U	U	U	U	U	U	*O*	*O*	*O*
2a	82	U	U	U	U	U	U	*O*	*O*	*O*
Ad	82	U	U	U	U	U	U	*O*	*O*	*O*
Dc	84	U	U	U	U	U	U	*O*	*O*	*O*
Aa	86	U	U	U	U	U	U	*O*	*O*	*O*
Bb	86	U	U	U	U	U	U	*O*	*O*	*O*
1c	87	U	U	U	U	U	U	*O*	*O*	*O*
Ac	87	U	U	U	U	U	U	*O*	*O*	*O*
1a	88	U	U	U	U	U	U	*O*	*O*	*O*
1b	88	U	U	U	U	U	U	*O*	*O*	*O*
7b	90	U	U	U	U	U	U	*O*	*O*	*O*
3c	93	U	U	U	U	U	U	*O*	*O*	*O*
2d	96	U	U	U	U	U	U	*O*	*O*	*O*
9c	96	U	U	U	U	U	U	*O*	*O*	*O*
2c	97	U	U	U	U	U	U	*O*	*O*	*O*
3d	97	U	U	U	U	U	U	*O*	*O*	*O*
Db	99	U	U	U	U	U	U	U	*O*	*O*
Ed	99	U	U	U	U	U	U	U	*O*	*O*
1d	104	U	U	U	U	U	U	U	*O*	*O*
Eb	105	U	U	U	U	U	U	U	*O*	*O*
Ec	105	U	U	U	U	U	U	U	*O*	*O*
Ba	106	U	U	U	U	U	U	U	*O*	*O*
9d	108	U	U	U	U	U	U	U	*O*	*O*
Cc	113	U	U	U	U	U	U	U	*O*	*O*
Da	113	U	U	U	U	U	U	U	*O*	*O*
Ea	114	U	U	U	U	U	U	U	*O*	*O*
8b	116	U	U	U	U	U	U	U	*O*	*O*
Dd	116	U	U	U	U	U	U	U	*O*	*O*
8d	124	U	U	U	U	U	U	U	U	*O*
8c	127	U	U	U	U	U	U	U	U	*O*
Cd	127	U	U	U	U	U	U	U	U	*O*
5a	133	U	U	U	U	U	U	U	U	*O*
5d	134	U	U	U	U	U	U	U	U	*O*
Ca	137	U	U	U	U	U	U	U	U	*O*
9a	139	U	U	U	U	U	U	U	U	*O*
Cb	141	U	U	U	U	U	U	U	U	*O*
5c	142	U	U	U	U	U	U	U	U	*O*
9b	147	U	U	U	U	U	U	U	U	*O*
8a	151	U	U	U	U	U	U	U	U	*O*
Bd	152	U	U	U	U	U	U	U	U	*O*
5b	154	U	U	U	U	U	U	U	U	*O*
Bc	155	U	U	U	U	U	U	U	U	*O*

shaded = observed obstructed   Unshaded = observed unobstructed   *O* = Calculated obstructed   **U** = Calculated unobstructed

FIGURE 5. Comparison of calculated vs. observed results.

With this mathematical model, if the equation is true, then the heads are visible, and if it false, the heads are obstructed. Each of the datasets observed were modeled using this mathematical model, the results of which are shown in **Figure 5**. As can be seen from **Figure 5**, for most data points, the predicted signal head visibility correlates closely with observed signal head visibility. For all 495 observations, the model incorrectly predicted visibility for only 50 data points, or 10.1 percent of all the data, with most of the error occurring for zenith angles less than 10 degrees. For the 330 data points with zenith angles greater than 10 degrees, the model correctly predicted 311, or 94 percent. For zenith angles greater than 12 degrees, the model's accuracy improved to greater than 96 percent. At zenith angles greater than 20 degrees, the model's prediction was correct for all observed data points.

Given that the model assumes no grade, these results are logical. At greater zenith angles, the effect of grade will be minimal, because the size of the angle makes the trigonometrically calculated distance large, and thus the difference between the actual distance and the calculated one will be proportionally small. However, when the zenith angle is small, the calculated distance is also small, and the same differential becomes proportionally large.

CONCLUSION

The following conclusions may be drawn as a result of this study. First and foremost, existing signal standards are inadequate and do not provide adequate signal head visibility for many motorists. As the locations studied exceeded the minimum standards, it is logical to assume that the signal heads are visible for all vehicle-driver combinations. The data clearly show that for most driver-vehicle combinations, many signal heads are obstructed and cannot be seen by the driver at the stop bar, and when the sun visor is in use, most signal heads cannot be seen from the stop bar. This inability to see signal indications is hazardous to motorists, as many motorists may not be able to see a change to a red indication, resulting in red light running, vehicular collisions, injuries, and death.

Secondly, using a simple mathematical model, signal head visibility from the stop bar can be predicted for any driver-vehicle combination. For designers, a reasonable design standard for the zenith angle could be established, and, used in combination with existing design standards for driver eye height, traffic signals could then be designed to these standards to minimize the signal head obstruction issue. For example, designers could select a standard zenith angle of 10 degrees and a driver eye height of 42 inches, and those signals that the model predicts will be obstructed would require a supplemental low head, while those that the model predicts will not be obstructed would not. The mathematical model is also useful to accident investigators, as an investigator can mathematically determine whether or not the signal was visible to the motorist, which would help in drawing the correct conclusions about the accident and recommending the correct preventive course of action.

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