Glare Screen for Divided Highways

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To make use of the full sight distances provided by modern highways, motorists must use their high-beam headlights when traveling at night. Because of the objectionable glare to oncoming motorists, some form of screening is desired and often is required.

Several forms of glare screen are in use today. These include plantings of shrubbery, wood or metal fences placed parallel to the centerline of the highway, and intermittent fences of wood or metal placed in a louvered pattern, or placed at 90° to the centerline of the highway.

Each type has advantages and disadvantages, but the screen found most satisfactory is a line of expanded metal mesh, erected in the median strip, parallel to the centerline of the highway. Because of the manufacturing process involved in making expanded metal mesh, the manufactured screen has a twist in the strands of the diamonds which will block out light normal to the surface of the strands. Although the view through the fence is impeded at small angles with relation to the centerline of the highway, the fence becomes transparent at angles greater than about 20°. At angles greater than 20°, the glare from opposing headlamps is not considered objectionable during nighttime driving. During the daytime, the fence does not interrupt the general viewing by passengers traveling in the automobiles.

Width of median strip, height of headlamps, and height of drivers' eyes all play a part in locating the required upper and lower edges of screen. To provide complete protection from glare, the upper edge of the screen should be 7 ft 2 in. above a line connecting the inner edges of the roadway. If consideration is given to the fact that heavy trucks ordinarily occupy the slow lanes of highways, the top edge of the screen can be reduced to a height of 5 ft 8 in., and be effective in preventing glare in about 95 percent of the meetings of opposing vehicles. The lower edge of the screen should be mounted 1 ft 9 in. from a line connecting the inner edges of the roadway.

On tangent lines, the cut-off angle of the screen should be about 20°. An expanded mesh having a dimension of 1 ½ in. center to center of diamond with a ¼ in. strand width will have such a cut-off angle. On curved roadways, the cut-off angle of the screen must be increased by an amount which varies with the roadway width and the curvature. A screen having a dimension of ¾ in. center to center of bridges and a 3/16 in. strand width will satisfy the requirements of curves having a radius of 1,000 ft.

Because of the manufacturing limits of expanded metal mesh, variations from these dimensions result in glare that is objectionable to a varying degree depending on the susceptibility of the driver.

•HIGHWAYS on the Primary and Interstate Highway System are designed for speeds of 50 to 70 mph. According to current AASHO specifications, corresponding minimum stopping sight distances for these design speeds will vary from 350 to 600 ft. To take advantage of these design speeds during nighttime driving, it is necessary to use high beams of headlights. This can cause objectionable glare to drivers of opposing vehicles, and, depending on the median width, may result in a sight distance so small that a definite safety hazard results.

The State of Idaho Department of Highways has conducted tests (1) in which seven different drivers drove a standard, late-model American-made automobile down a test track towards the opposing glare of the high beams of a stationary automobile's headlights. The stationary automobile was located in the opposing lane across the median strip. The run was made ten times with median widths varying from 10 to 100 ft in 10-ft intervals. An object was placed in the path of the moving vehicle and opposite the stationary vehicle, but far enough back so that the stationary vehicle's lights would not reflect on the obstacle.

There were two men in the test auto. The driver stated when he could see the obstacle, while the other man dropped a marker at that point. The driver made several runs, starting with the 10-ft median, then the 20-ft median, and so on, until there was no glare, or until he could clearly observe the obstacle with his headlights alone.

The calculated statistical average of sight distances for the seven drivers tested gave the following results:

Median Width (ft)	Distance from Object (ft)
10	184
20	262
30	335
40	389
50	416
60	457

There was no glare after the 60-ft median width.

The average sight distances for the seven drivers tested are compared with the minimum safe stopping sight distances required by AASHO:

Design Speed (mph)	Minimum Sight Distance (ft)
30	200
40	275
50	350
60	475
70	600

To take full advantage of minimum highway sight distances during the nighttime driving, the following are necessary:

1. A highway with a 10-ft median width should have a maximum design speed of 30 mph.
2. A highway with a design speed of 50 mph requires a median width of between 30 and 40 ft.
3. A highway with a design speed of 60 mph or greater requires a median in excess of 60 ft.

It is immediately recognized that median widths of this magnitude are often not possible because of the expense of land acquisition and highway construction. It is also recognized that in urban areas where there normally are narrow median strips limiting maximum speeds on a multilane divided highway to 30 mph is an impractical restriction.

Thus, to prevent intolerable glare for drivers of approaching vehicles, it becomes necessary to provide some device that will prevent glare and permit motorists to take full advantage of highway sight distances.

Types of Screening in Use

Plantings of large dense shrubbery provide a very suitable glare screen and have the added advantage of providing some degree of cushioning for vehicles tending to cross into the opposing lane of traffic. However, there are several disadvantages to shrubbery, chief among which is the fact that it takes several years for the plantings to grow sufficiently to provide glare protection.

Fences may be used in either of two ways. The fence may run continuously along the median strip and may be made of material that is either opaque or semi-opaque. It may also be made of short sections of opaque material erected across the median strip either in a louvered pattern or at 90° to the centerline of the highway. To be effective, a fence erected in the latter manner should have a spacing between lines of fence equal to about three times the length of intermittent fencing.

Expanded metal mesh is considered to provide the attributes required of a glare screen material, because it provides an opaque appearance up to about a 20° angle to the plane of the fence, but allows an unobstructed view through the fence when viewed normally. Because of the manufacturing process involved, the strands are given a twist that prevents view through the fence when viewed obliquely. This feature of expanded mesh is desirable because it allows automobile passengers a relatively unimpeded view of the surrounding countryside and also permits police surveillance of the opposite traffic lane.

Requirements for a Glare Screen

To be effective, a glare screen should shut out all glare from opposing headlights up to an angle of about 20° in relation to the centerline of highway. Beyond that angle, glare is usually not objectionable, and, therefore, the fence should allow the passengers of automobiles to see through the fence, if possible.

Because of the relationship of opposing automobiles on horizontal curves, the fence should shut out glare for angles greater than 20°. It will be seen that glare screens on horizontal curves of radius of 1,000 ft should cut off light up to about 25°.

The screen should be low enough to prevent light from the lowest sports car from shining underneath it into the eyes of an opposing driver. By the same token, it should be high enough to prevent lights from the large trucks from shining over the fence and into the eyes of a driver of an opposing truck or bus.

Variations in roadway width, median width, and roadway curvature all play a part in establishing the elevation of the upper and lower edges of the screen and the required cut-off angle.

Vertical Position of Screen with Respect to Roadway

The upper and lower edges of the screen are set by consideration of height of headlamps, height of opposing driver's eyes, and change in elevation of pavement across the roadway.

If a six-lane divided highway having a 5-ft median strip is considered and it is assumed that the nearside headlamp of an approaching car is 4 ft 6 in. from the outside lane edge and that the eye position of an approaching driver is 3 ft 3 in. from the inside lane edge, the vertical position of the glare screen can be fixed.

A sports car traveling in the slow lane of a six-lane divided highway would have its headlights about 2 ft above the pavement corresponding to 1 ft 9 in. to the lower edge of the lamp. When this car approaches another sports car in the opposite slow lane, the other driver's eye height can be as low as 3 ft. This situation will establish the criteria for fixing the lower edge of the screen. It is also necessary to consider the drainage slope of the roadway because the elevation of automobile headlights will be reduced as the car changes its position with respect to the median. For purposes of discussion the roadway slopes are considered 1 in 48 from the edge of the median strip (Fig. 1). Therefore, for this roadway cross-section the lower edge of the glare screen should be 1.80 ft above a line connecting the inner edges of the roadway. The lower and upper edge of the screen is always taken in relation to an imaginary line

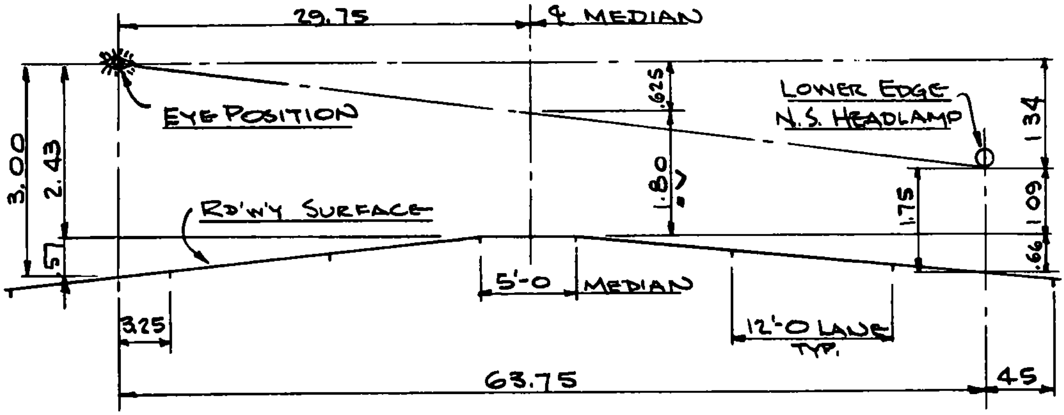

Figure 1.

$$v = 2.43 - (^{1.34}/63.75)(29.75)$$
$$v = 1.80$$

connecting the inner edges of the road and is not measured from the elevation of the median strip.

In establishing the height of the upper edge of the screen, the extreme case will be that of a driver of a large truck traveling in the fast lane meeting lamps of another large truck occupying the opposite slow lane. Taking the upper mounting height for headlamps on modern trucks at 3 ft 6 in. corresponding to a height of 3 ft 9 in. measured to the top of the lamp face, and the eyes of the opposing driver at 8 ft, have the criteria to fix the upper edge of the screen are obtained (Fig. 2). Therefore, the upper edge of the screen should be 7.23 ft above a line connecting the inner edges of the roadway.

A large truck will ordinarily occupy the slow lane throughout most of its journey. Therefore, it is wise to consider what effect this fact will have on the over-all height of the screen. Again, considering the same roadway cross-section and the same two trucks, except that both trucks occupy their respective slow lanes, the top of the screen will be fixed by the relationship shown in Figure 3. Therefore, the upper edge of the screen should be 5.40 ft above a line connecting the inner edges of the roadway.

The figures are intended to show the method of arriving at the upper and lower edges of the screen and the limiting dimensions will, of course, vary with change in roadway cross-section. Manufacturers of expanded mesh normally produce most economically in even foot increments, and a 48-in. wide sheet of expanded metal erected 1 ft 9 in. from a line connecting the innermost edges of the roadway will have its upper edge 5 ft 9 in. above the same line. It is thought that screens of this height will provide glare protection in a sufficient number of cases to warrant the economics provided.

Fixing the upper and lower edges of the screen by the previously discussed method is valid for roadways with a straight grade on tangent. In the instance of vehicles approaching in a trough or at the brow of a hill, the screen should be lowered or raised according to the degree of vertical curvature. Experience has shown that the glare experienced from opposing headlights in a trough is relatively unobjectionable, compared to the glare from headlights approaching on a brow of a hill.

Expanded Metal Glare Screen for Roadways with Horizontal Curvature

To provide the same order of glare protection on curves as on straight sections of roadway, the cut-off angle of the screen must be increased by an amount that varies with the width of the roadway and the radius of curvature of the bend; for example, Figure 4.

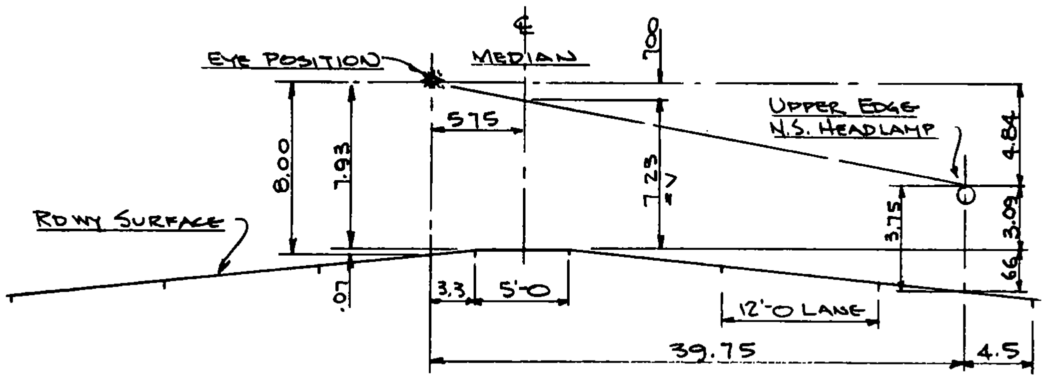

Figure 2.

v = 7.93 - (4.84/39.75) (5.75)
v = 7.23

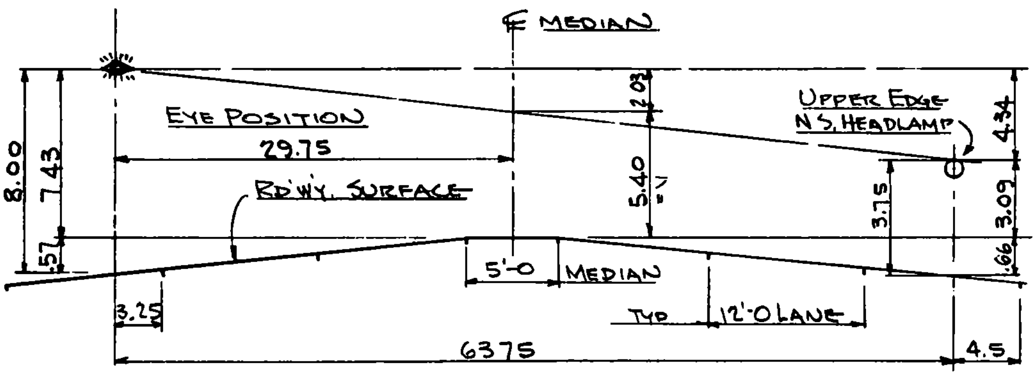

Figure 3.

v = 7.43 - (4.34/63.75) (29.75)
v = 5.40

To consider a specific example, it can be assumed that

radius = 1,000 ft;
b = width of roadway + ½ median strip = 38.5 ft;
$\alpha = 20^0$;
s = source;

and the required minimum cut-off angle is

$$\theta = \cos^{-1} \left(\frac{R-b}{R} \cos \alpha\right)$$

$$= \cos^{-1} \left(\frac{961.5}{1,000} \cos 20^0\right)$$

$$= \cos^{-1} (0.9035)$$

$$= 25^0 \text{ 20 min.}$$

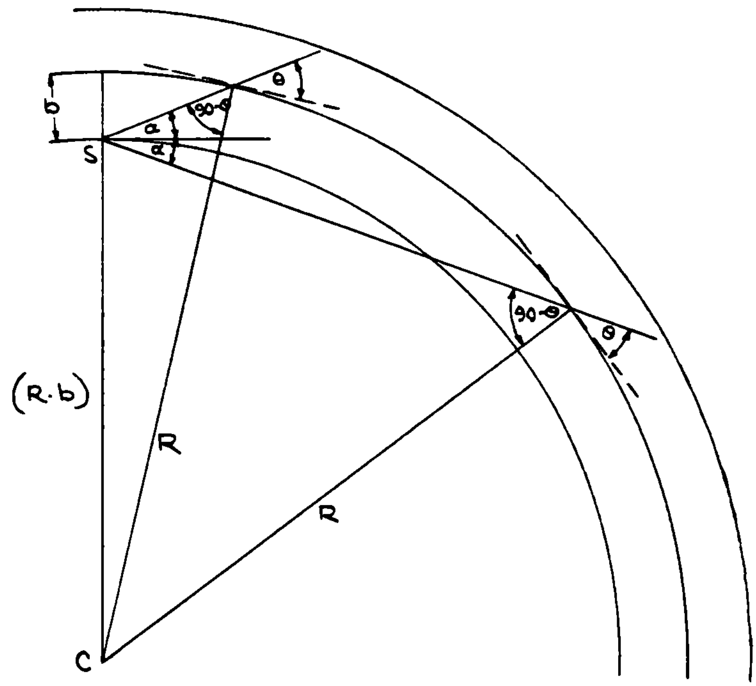

Figure 4.

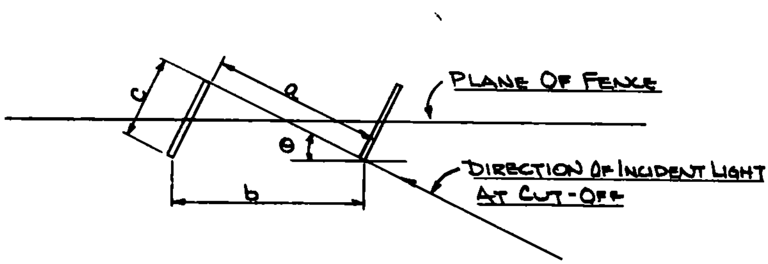

Figure 5.

Whence $c^2 = a^2 + b^2 - 2\ ab \cos\theta$ and $\cos\theta = a^2 + b^2 - c^2/2\ ab$

In this computation the angle α is ½ the angle of the headlight beam. It becomes apparent that given equal roadway plus ½ median widths, the required cut-off angle of the screen will decrease as the radius increases until it reaches the 20^0 angle required on a straight roadway.

Dimensions of Expanded Metal Mesh

During the manufacturing process of making expanded metal, the material is slit by cutting dies and then pushed, the result being that the strands have a twist. The ability to prevent headlight glare from passing through the mesh is a function of angle of twist, strand width, and distance between adjacent strands. A section through the short dimensions of expanded metal mesh would appear as shown in Figure 5.

A sample of expanded mesh was measured at several locations and was found to have the following dimensions:

$$c = 0.500 \quad b = 1.375 \quad a = 1.125$$

Therefore,

$$\cos\theta = \frac{1.125^2 + 1.375^2 - 0.500^2}{2 \times 1.125 \times 1.375}$$

$$\theta = 19^0\ 05\ \text{min.}$$

The nominal dimensions of this particular mesh are 1.500 × 4.000 center-to-center bridges × 0.250 strand width. From the cut-off angle afforded, it would appear that this particular mesh is satisfactory for use on tangents.

Another example of expanded mesh was measured at several locations and was found to have the following dimensions:

$$c = 0.375 \quad b = 0.937 \quad a = 0.781$$

Therefore,

$$\cos\theta = \frac{0.937^2 + 0.781^2 - 0.375^2}{2 \times 0.937 \times 0.781}$$

$$\theta = 22^0\ 40\ \text{min.}$$

The nominal dimensions for this particular mesh are 0.750 × 2.00 center-to-center bridges × 0.188 strand width. From the cut-off angle afforded, it would appear that this particular mesh is suitable for radii of slightly over 1,000 ft.

REFERENCE

1. "Headlight Glare vs Median Width." State of Idaho Department of Highways, Boise (Dec. 1957).