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VERTICAL ILLUMINANCE AS A CRITERION FOR TUNNEL LIGHTING DESIGN

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From experiments conducted at the Ministry of Transportation and Communications' (Ontario) laboratory, and measurements taken at the Thorold and East Main Tunnels (Ontario), it was concluded that lighting geometrics which favor vertical illuminance will result in enhancement of visibility conditions with respect to the eye adaptation process at the threshold zone and object detection in the tunnel interior.

From the findings of these investigations it was concluded that with respect to drivers' visibility needs, a tunnel should not be isolated from the rest of the traffic system. A motorist, in performing his driving task, should consider a tunnel as an integral part of a complex scene.

It is understood that data required for steering and vehicle guidance are drawn from the immediate surroundings; however, in planning the overall trip strategy a driver requires visual contact with 3-dimensional space. In that case, the road surface forms only part of the complex scene and data on contrast are only part of the visual information.

At a distance of approximately 80-100 m from the tunnel portal <u>all</u> drivers are concentrating on the tunnel portal, at which time the eye adaptation process begins to take place.

The most difficult visibility obstacle for a driver is to overcome the sudden drop in luminance level at the tunnel threshold zone. The main factors of this phase contributing to eye adaptation are vertical planes ahead of him -- tunel portal and tunnel walls. Therefore it is very important in designing a tunnel lighting system to ensure that the luminances of these vertical planes are properly coordinated and related to eye adaptation requirements.

From our observations conducted at many tunnels we have noticed an important phenomenon which is very easy to check in the field: <u>as soon as a driver crosses the threshold</u> into the tunnel eye adaptation takes place very quickly. The problem of visual difficulty disappears, even under mediocre lighting conditions. (We have experienced this phenomenon under luminance levels as low as 30 cd/m^2). This phenomenon indicates that the contrasts between objects and their backgrounds are factors of lesser importance than that of luminance of walls.

From experiments conducted in laboratories and in the field, using asymmetrical directional light distribution, the following conclusions were drawn:

a. When the main light beam is directed at an angle of 30-50 degrees to the driver's line of vision, it assures adequate vertical object illuminance for visibility by positive contrast (better in object identification than those of silhouette viewing).

b. It provides a high value of vertical illuminance on the walls, making eye adaptation less difficult to the approaching driver at the most critical time.

Using similar lighting sources, and with the main beam directed against the driver's line of vision, the contrast between test objects and pavement were found to be of lower values and considerable glare from the light sources interfered with the driver's visibility.

The counterbeam system advocates assume that the only visibility problem in a tunnel interior is to detect relatively small objects; therefore, they concentrate their efforts on creating a high brightness on the tunnel pavement. From our investigations we have concluded that counterbeam lighting, although by using directional light creates better contrasts on the pavement, at the same time ignores the more important aspect in the visual process by neglecting to emphasize <u>the wall luminance</u>.

From data obtained in these investigations it was concluded that asymmetrical directional light distribution offers better visibility (compared with lateral or counterbeam methods) by increased vertical wall and object illuminance, and offers the possibility of reduction in energy requirements in tunnel lighting design.

A SYSTEMS APPROACH TO THE OPTIMIZATION OF VISUAL CONDITIONS IN LOW BEAM ILLUMINATION

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The beam pattern of the low beam is designed to illuminate the road in front of the vehicle as well as possible and at the same time to cause as little glare as possible for oncoming drivers. The net effect of the beam pattern should be an optimized visibility of the road and of objects on the road in opposing situations.

In order to optimize visibility, all beam patterns of the low beam have a strong light intensity directed towards the road surface and the near edge of the road and a weak light intensity directed towards the lane of opposing traffic. Between these areas of strong and weak light intensities there is a more or less steep gradient of light.

On straight level roads the optimum beam pattern should not be much of a problem. But this is not the normal appearance of a road. On the contrary, there are horizontal as well as vertical curves of different radius. Besides this variation there is a large variation in low beam aiming. The important vertical aiming varies to a high degree as a consequence of vehicle attitude deviations due to load.