It can be shown that driver performance differences are directly relatable to differences in visibility demanded by different drivers, a key underlying variable being driver age. It is possible to calculate readily the distribution of levels of driver performance provided to different members of the driver population when any criterion value of time-to-obstacle is selected by traffic engineering. It is also possible to calculate readily the average visibility demand corresponding to any desired value of time-to-obstacle. (The visibility demand level may be expressed as in the figure in terms of equivalent visibility, $\tilde{V}$, or in terms of visibility index, VI, with values of VI = $\tilde{V}$/7.111.)

Visibility Supplied by Differing Road Lighting Installations

Current work is in progress in the U.S.A. by Keck and associates in which the visibility supplied by actual road lighting installations is being measured. Both psychophysical measurements with contrast-reducing visibility meters and physical measurements with suitable luminance photometers are being used. Reference visibility of sample targets (i.e., no account being taken of Disability Glare Factor (DGF) or Transient Adaptational Factor (TAF)) is being measured with both a conventional visibility meter involving an on-board light veil and a newly developed visibility meter which draws its light veil from existing road luminance. Allowance for the effects of DGF and TAF is to be made subsequently taking advantage of new developments in the technologies of defining and measuring these factors which modify reference visibility. It is now possible to allow for the effects of luminance non-uniformities in the area of road near the target by means of a model of the transient adaptational factor. This is based upon the effective contrast compression created when visual adaptation fails to track the changes in target background luminance that result when eye movements change ocular fixation from point to point in the non-uniform road environment.

Keck and associates are also working to develop practical predetermination programs for computing target visibility under different lighting installations, taking account of variations in target reflectance and placement.

The New Visual Performance Index, VPI

Once values of target visibility are available, either from field measurements or from predetermination calculations, it is a simple matter to assess the overall visual performance potential of a given lighting installation by means of the new Visual Performance Index, VPI. (This index is intended to supersede the similar concept described in CIE Report No. 19/2. The differences between new and old VPI involve only the means of calculation, the new VPI being distinctly easier to calculate.) Considering a broad distribution of target reflectances and locations along and across the road, VPI gives its overall assessment of an installation in terms of the percentage of instances in which one or another target reflectance to be found in one or another location supplies at least as much visibility as the criterion visibility corresponding to the criterion value of time-to-obstacle. The visibility supply data may be described in terms of either equivalent visibility, V, or visibility index, VI. Use of VI implies that the cone target of Gallagher and Meguire is accepted as the assessment target in all future measurements and predetermination calculations. Use of V allows selection of any desired target, the V/VI ratio being determined by measurement or calculation. We favor the use of V to allow such flexibility of choice with respect to assessment target. Incidentally, our simulator data show clearly that visibility of either two- or three-dimensional targets of differing size is most accurately assessed using a fairly large target, such as our original 12 x 32 inch two-dimensional target.

VISUAL PERFORMANCE UNDER NIGHT DRIVING CONDITIONS

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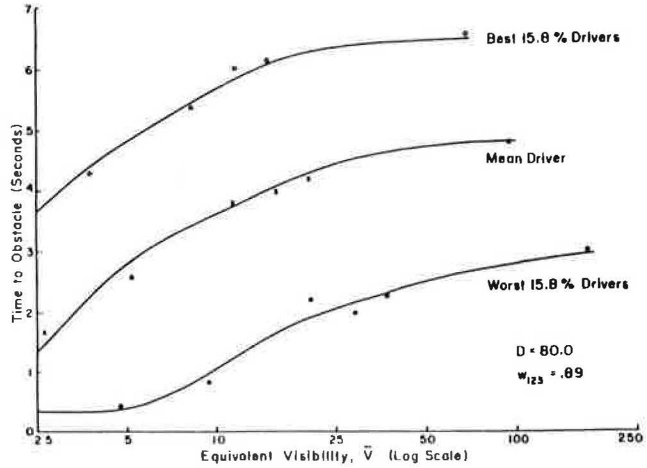
Traffic safety is closely linked with the amount of visual information the driver can obtain on the road and its environment. The ability of perception can be described by the basic visual functions such as luminance contrast sensitivity and form perception and the influence that age has in these functions due to changes in the optical properties of the eye media.

The luminance difference threshold as obtained in the laboratory can serve only as a basis to reveal the perceptibility of objects because the observation conditions are different from those given in practice. Roper and Howard found a factor of four to account for that difference. This threshold elevation facilitates perception of the form of the object. Consequently, the criterion of form perception, measured in terms of visual acuity, was used to investigate the visual behaviors in road lighting luminance levels. It occurred that for the perception of certain details the product of the contrast of the object ($C = \Delta L/L$) and the level of the surrounding luminance L remains constant. This reveals the fact that in the range of road lighting levels form perception is dependent only on the luminance difference L of the objects to their background (see Figure 1). The influence of age will be briefly discussed.

Figure 1 -- Visual acuity as obtained with Landolt rings of different contrast $C = \Delta L/L$ on a background luminance L ranging from 0.05 to 32 cd/m., 8 observers, p = 80% detectability, age 20-30 years.



which are R1, R2, R3 and R4. The parameter Q_o determines the lightness of pavement color (degree of whiteness or blackness).

Table 1 contains a summary of information from the Canadian measurements.

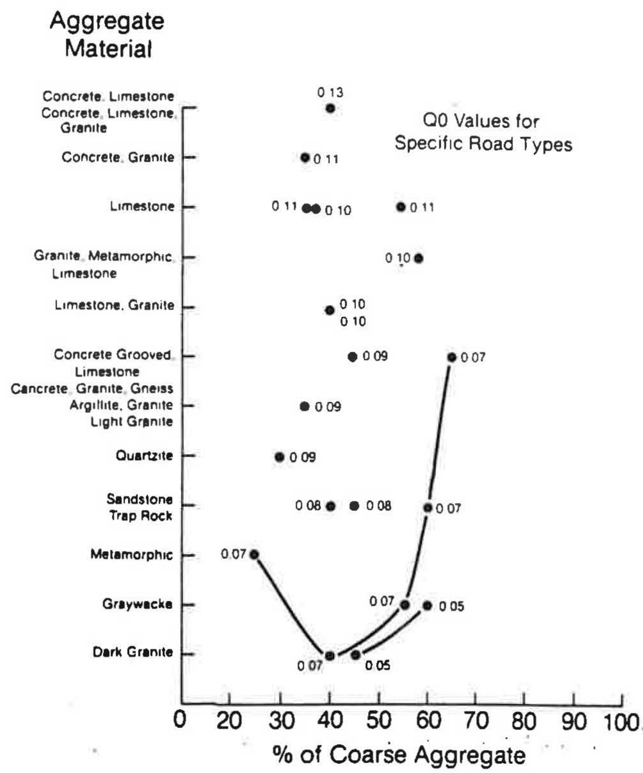
Table 1 - Recommended Design Values for Canadian Pavements

COMPOSITION	CIE CLASS	AVG.LUMINANCE COEFF. QO
limestone dense friction course	R2 R3	0.104
limestone, granite open grade	R2	0.068
limestone, granite dense friction course	R1	0.095
sandstone* open grade	R1	0.070
sandstone dense friction course	R2	0.080
quartzite dense friction course	R2	0.090
graywacke* open grade	R1	0.052
graywacke dense friction course	R2	0.070
dark granite open grade	R3	0.047
dark granite dense friction course	R3	0.069
light granite dense friction course	R2	0.087
granite,metamorphic,lime-stone open grade	R2	0.095
argillite, granite dense friction course	R3	0.085
traprock dense friction course	R4	0.077
metamorphic dense friction course	R2	0.068
concrete, limestone plain	R2	0.129
concrete, limestone lateral grooves	R3	0.094
concrete,limestone,granite plain	R2	0.129
concrete, granite plain	R2	0.110
concrete,granite,gneiss lateral grooves	R1	0.091

Open grade: 5-8% voids; dense friction course: <5% voids (9).
*Classed as open grade as a result of the seal coat.

It should be noted that aggregates have a tendency to get polished under traffic, depending on their wear resistance, which is low for limestone and higher for traprock, for instance. Correspondingly the specularity class may shift with age, for instance from R2 to R3 or from R3 to R4. On the other hand, changes in Q_o may occur due to contamination or bleaching. Thus concrete darkens with time and asphalt brightens. Laterally grooved concrete appears darker (shadow effect) than the same concrete nongrooved. Figure 1 shows some details of Q_o relationships to aggregate composition.

Figure 1 - Aggregate material vs. % coarse aggregate



USE OF COMPUTER GRAPHICS TO AID IN DESIGN OF PUBLIC LIGHTING SYSTEMS

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The present work at TRRL arose from a combination of two existing projects, VIGIL and STAN.

VIGIL was a computer graphics system used to produce color-shaded perspective views of road scenes. This was a two-stage process, the first being the writing of a FORTRAN program defining the assembly of "primitives", such as spheres and cones, into an approximation of the real world. Subroutines were also written for the definition of common objects, such as lighting columns, signs and trees, enabling their generation by a simple subroutine call. The output of this stage was a computer file representing a mathematical description of the complete model.

The second stage used this output, together with viewing and lighting commands, to draw a color-shaded perspective display on a TV screen. This stage was interactive, in that viewing positions could be re-defined and a new perspective produced in less than a minute.

The limitations of this system were that the colors of materials were set subjectively, and severely limited in number. The total size of the model was also limited, as the hidden surface removal algorithm needed the whole model definition available at once. The advantages were that the picture output was geometrically correct and the viewpoint unlimited.

STAN is the CIE computer program for the calculation of road luminance patterns. This uses