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In Search of the Magic Number - Guidance for Codes and Standards in Emergency Lighting

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In search of the magic number

A Canadian report on guidance for codes and standards in emergency lighting already has had an impact on U.S. life safety codes.

by Michael Ouellette
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We were faced with a small problem.

It was at one of my first meetings with the Emergency Lighting Committee of the IESNA, the association of lighting professionals. At the time, we were rewriting the Emergency Lighting chapter of the IES Lighting Handbook, an extensive guide and reference manual for lighting practice. Our objective was to publish recommendations that were practical, reasonable and supported by strong technical foundations.

The Committee had wrestled with such issues as signage, electrical supply, maintenance and lighitng measurement. The problem, however, arose with the seemingly innocuous question "What is the minimum quantity of illumination needed to provide safe movement in the event of failure of normal power?" In other words, how much emergency lighting is needed to ensure safety?

Perhaps the answer lay in building codes, written supposedly to ensure reasonable degrees of safety in buildings.

Unfortunately, the various codes in North America and abroad are quite inconsistent on this question. On one extreme, the Life Safety Code of the U.S. National Fire Protection Association (NFPA) specifies a minimum of 10 lux of illumination everywhere on the floor of the escape route. On the other hand, Britain's national code specifies a minimum of only 0.2 lux at floor level (roughly equivalent to a bare 10 watt incandescent lamp at 10 meters, or a candle at two meters).

Canada's 1990 National Building Code (Section 3.2.7.3) is somewhere in between. It recommends an average illumination of 10 lux at floor level, giving no criteria for uniformity of illumination.

Thus, even at the rather restrictive maximum/minimum uniformity ratio of 40:1 recommended by the Commission internationale de l' eclairage (Publication CIE No.49, Paris, 1981), one could find illuminations conforming to Canadian standards.

This was the point where the Committee asked me to conduct a literature review on illuminance and safety in building evacuation and to present a report providing foundations for a reasonable and defendable recommendation on this aspect of emergency lighting practice.

This is a summary of that report (Ouellette and Rea, Journal of the Illuminating Engineering Society, Vol. 18, No, 1, 1989, pp. 37-42). It applies only to smoke-free conditions, since smoke-filled spaces have considerably different illuminance requirements. This is because room lighting scatters in smoke effectively reducing visibility in much the same manner as automobile headlights in fog.

As I sifted through the literature, it became apparent that the answer was not straightforward.

Fundamentally, there are many different ways to measure safety. These include the measuring of escape time, counting people's collisions with obstacles, and even asking about subjective impressions of the lighting.

As a further complication, there are many factors that may interact to affect illuminance requirements of emergency lighting. Among these are uniformity of lighting, ages of occupants, familiarity with the space, crowd size, presence of exit markings, presence of smoke, and the presence of such special hazards as clutter and changes in floor level.

As expected, different researchers arrived at different conclusions depending on the various conditions presented and depending on the manner in which safety was measured. It should have been no surprise, therefore, to find such diversity in codes and standards.

To compare the various published studies, it was necessary to place their results in the same context as much as possible; in other words, to compare apples with apples.

For example, the data of older people were analyzed separately from those of younger individuals having perhaps better vision and different behavioural tendencies. In the same regard, observations in cluttered or furnished spaces were considered separately from those in unobstructed areas requiring less effort to navigate.

As the end of the exercise, a surprisingly consistent story emerged.

Collisions

In terms of the quantity of illumination needed for avoiding collisions with large obstacles, there was good agreement among four separate studies. Their results all showed that people need an average illuminance of somewhere between 0.2 and 0.5 lux at floor level in order to negotiate cluttered spaces without bumping into obstacles.

Based on this criterion, one might conclude that an average illuminance of 0.5 lux on the floor will provide a reasonable level of safety. Of course, collision-free movement is not the only indicator of safety in building evacuation.

Escape time and speed

Based on the criterion of egrees time, a different pattern emerges. All ex-

perimenters found that egrees time could be improved by increasing the average illuminance above 0.5 lux. At higher levels, people were less hesitant and could maneuver with greater confidence and overall speed.

But how much illumination is enough? One researcher concluded that an average of two lux seems reasonable but four lux is preferred when many seniors are expected to occupy the space.

Reasonable limit

Another researcher identified 0.2 lux as a reasonable limit, and plotted selection data on an elongated graph to emphasize the point of diminishing gains with increased illuminance. Yet another noted significant improvements in escape time when increasing illuminance to levels as high as 300 lux, but suggested the increases in safety were not necessarily worth the additional expence.

Thus, we converge towards the key to the solution: the imposition of value judgements on the tradeoff between implied safety and the economics of emergency lighting.

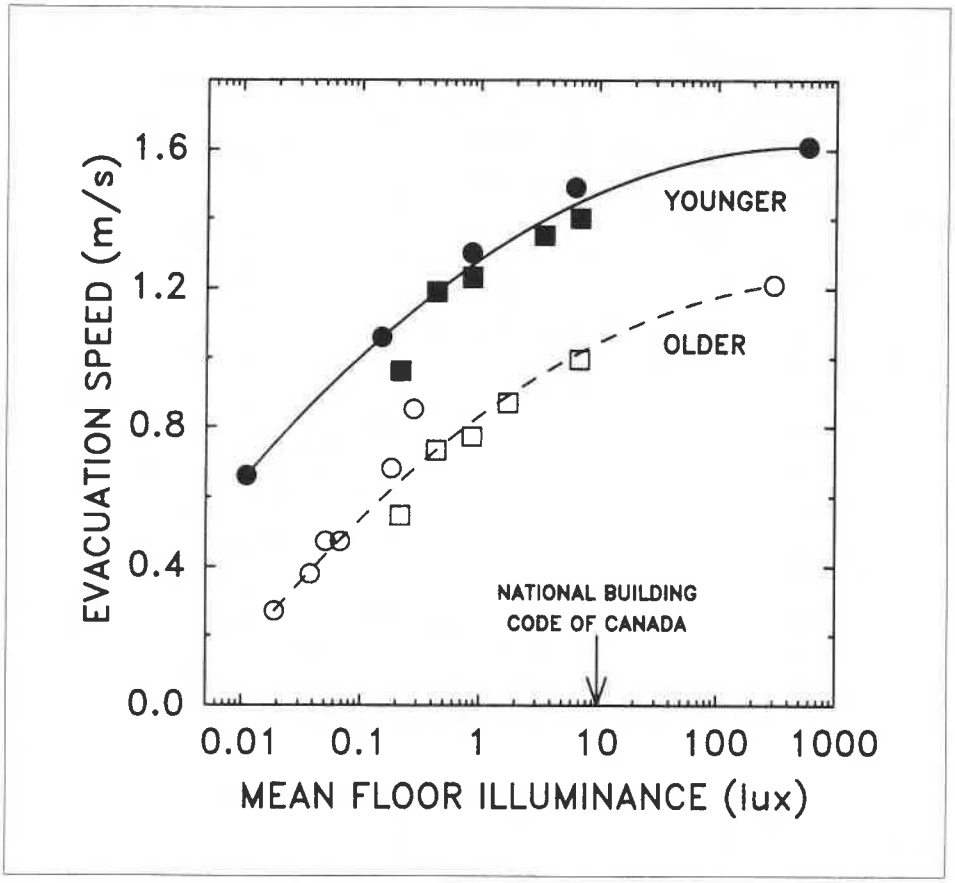

Figure 1: Evacuation efficiency in cluttered or finished spaces observed in deneral independent experiments (denoted by different symbols). Older people 50 years or more) are represented by open symbols.

No magic number

Figure 1 shows no magic illuminance level above which there exist no improvements in evacuation efficiency.

I cannot express it more elegantly than did Mr. Ken Honeycutt, chairman of the Emergency Lighting Committee upon reviewing our report:"(There exists) only a range of possible results requiring informed design judgements" and that "there is a tandency in some circles to search for a number which can be used to represent a very complex set of interactions between humans and their environment. In this context, it is important that the data be used to reveal and inform, and not in the manner that relieves designers and code-makers of their responsibility to assimilate a bigger picture in making responsible judgements. In a safety related area ... the search for a magic number is a danger we must resist. This paper not only gives us a better perspective on what we give up as illuminance levels decline, it clearly delineates where those levels are."

Mr. Honeycutt also emphasized that in making design decisions, we should allow a comfortable margin of safety in anticipation of the many unpredictables that may occur in real world situations.

Based on our report, the IESNA revised its published recommendations on emergency lighting by specifying a minimum of 0.5 lux at floor level along the centre of the escape route in order to ensure avoidance of obstacles in cluttered or furnished spaces. In addition, it maintained that an average illuminance of 5 lux is a reasonable compromise between lighting economics and ability to move quickly and confidently.

The IESNA subsequently prepared a brief for the NFPA using our report as the technical basis for sounder decisions. As a result, the Means of Egress Subcommittee of the NFPA decided to amend the Life Safety Code to reflect more closely the recommendations of the IES and, indirectly, those of the National Building Code of Canada. Pending administrative processin and public comment, the revisions will appear in the 1991 edition of the Life Safety Code.

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