

## Methods and criteria for the lighting of short and medium long underpasses at daytime

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### Introduction

This note concerns methods and criteria for the lighting of short and medium long underpasses at daytime as found in these publications:

- Handbook for road lighting 2020 (in Danish)
- <http://leverandorportal.vejdirektoratet.dk/Lists/TenderDocuments/Indk%C3%B8b%20af%20armaturer%20til%20vejbelysning/Udbudsdokumenter/HB%20Vejbelysning%20-%20IND-VB-DK-2020.PDF>
- CIE 88:2004 "*Guide for the lighting of tunnels and underpasses*".
- CEN/CR 14380:2003 "*Lighting applications – Tunnel lighting*"

The CIE 88:2004 provides the same methods and criteria as in the earlier version of 1990. The earlier version is, therefore, also covered by this note.

The three sets of methods and criteria are described in sections 1, 2 og 3 and a comparison is given in section 4. Additionally, an overall discussion is provided in section 5.

There is no focus on any of the three methods, which are all lacking in some respects. However, it is pointed out that a combination of the methods in the handbook for road lighting and CEN/CR 14380:2003 could be useful.

It is the intention eventually to select criteria for lighting and types of lighting among those specified in the publications.

## 1. Methods and criteria in handbook for road lighting

The criteria are shown in table 1.

**Table 1: Separate lighting of road underpasses in accordance with the handbook for oad lighting.**

Length of underpass	Separate lighting during daytime
<b>Up to 60 m:</b>	None
<b>60 til 120 m:</b>	
Good visibility conditions	A central zone of 30-40 m is illuminated to a luminance of the carriageway of 60 to 200 cd /m <sup>2</sup> depending on the daylight
Less good visibility conditions	Full tunnel lighting in accordance with NVF Report No. 4 " <i>Road tunnel lighting</i> "
<b>Above 120 m:</b>	Full tunnel lighting in accordance with NVF Report No. 4 " <i>Road tunnel lighting</i> "

The visibility conditions are good if the exit of the underpass is fully visible from the stopping distance from the entrance, and that the exit occupies at least 2° in area of view. This can be checked as follows:

The area A, which is occupied by a 2° field of view at a distance D, can be calculated by  $A = \pi \cdot (D \cdot \pi / 180)^2 = 0,000957 \cdot D^2$ , where D is the sum of the length of the underpass and the stopping distance.

The area A is calculated and it is checked that the area of the exit determined as the height times the width is at least as large. If the width of the exit is more than twice the height, a width twice the height is used.

This procedure is copied from DIN 67524-1: 2019 "Beleuchtung von Straßentunneln und Unterführungen - Teil 1: Allgemeine Gütemerkmale und Richtwerte", where it is expressed a little differently.

The requirement that the exit of the underpass is fully visible from the stopping distance from the entrance seems unreasonable, as just a slight curvature of the underpass can cause a small part of the exit to be hidden.





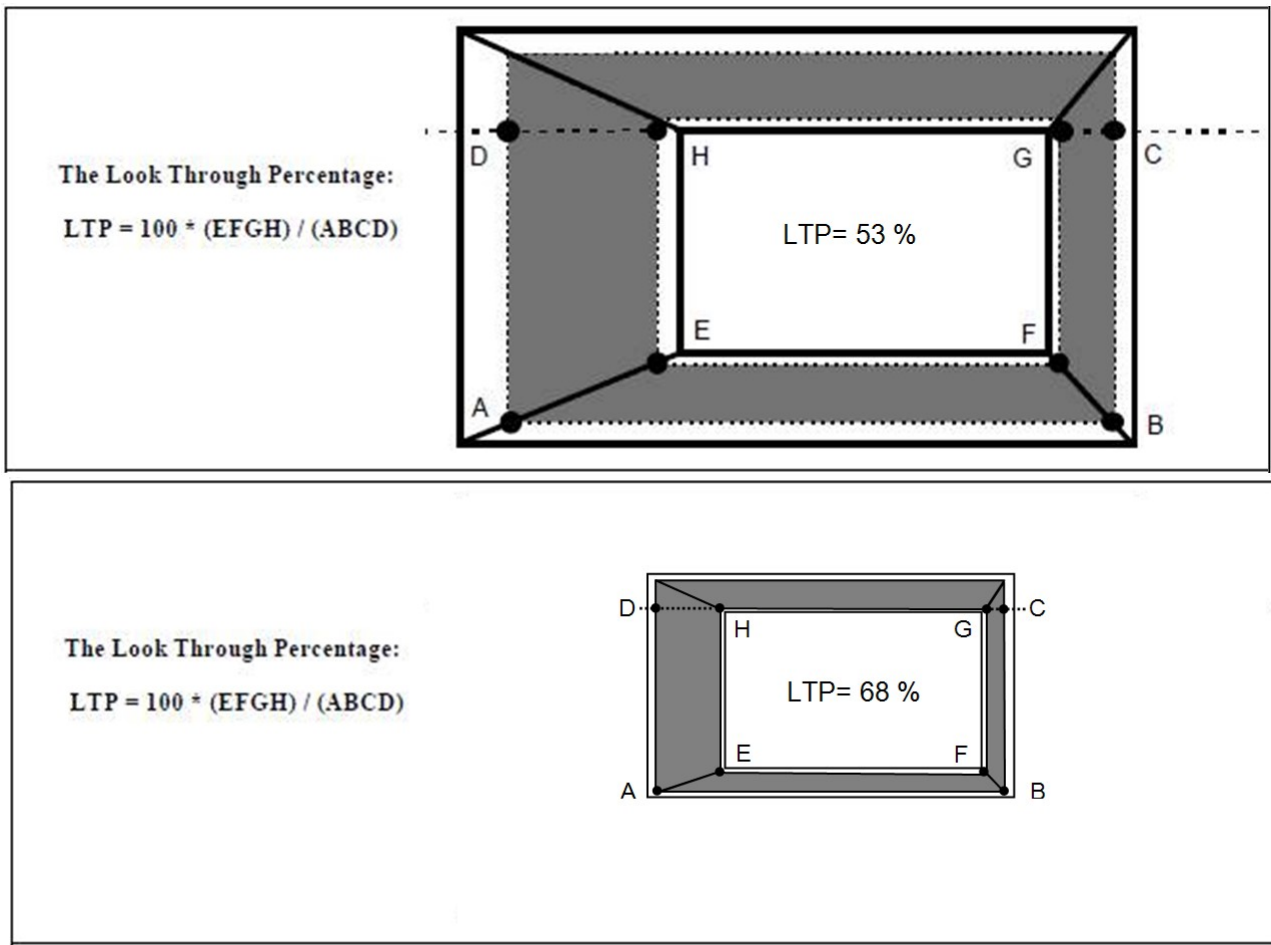


Figure 3: A road underpass seen from a short distance (top) and a longer distance (bottom).

#### 4. Comparison of criteria for separate lighting

It is shared among the methods that road underpasses, which are shorter than a lower limit value, do not need separate lighting during the daytime. These limit values are 60 m, 25 m and 25 m for the handbook for road lighting, CIE 88:2004 and CEN /CR 14380:2003 respectively.

Similarly, it is shared among the methods that road underpasses that are longer than an upper limit value must have full tunnel lighting. These limit values are 120 m, 125 m and 200 m for the handbook for road lighting, CIE 88:2004 and CEN /CR 14380:2003 respectively.

Furthermore, it is shared among the methods that at lengths between the lower and the upper limit values there are additional criteria for lighting. These are:

- a) Handbook for road lighting (60 to 120 m): Lighting of a central zone on the road for good conditions, otherwise full tunnel lighting,
- b) CIE 88:2004 (25 to 125 m): No separate lighting, 50% of full tunnel lighting or full tunnel lighting depending on conditions (good or bad) and length (below or above 75 m),
- c) CEN /CR 14380: 2003 (25 to 200 m): No separate lighting, separate lighting or full tunnel lighting depending on LTP.

It can be seen that the cases of no separate lighting, separate lighting or full tunnel lighting are used in all three methods, but that the types of lighting and the lengths of the road underpasses are different.

#### 5. Overall discussion

The method in the handbook for road lighting as described in section 1 is concrete and easy to use. But the requirement that the entire exit be visible seems unreasonable. It is proposed that the requirement be changed so that it is the visible part of the exit that must fill at least 2° in the field of view.

The method in CIE 88:2004, see section 2, has probably been tested in practice, and probably covers relevant situations given the number of additional criteria. On the other hand, there are some criteria that can be difficult to decide on, such as the penetration of daylight and the severity of the traffic.

The method in CEN /CR 14380:2003, see section 3, is concrete and relatively easy to use, and is used in Norway and Sweden. But the mentioned unreasonable condition - that the LTP is low at short stopping distances - should be remedied.

It is proposed that when the LTP at the stopping distance is not sufficiently high (minimum 50%), LTP values at greater distances - up to twice the stopping distance - are also taken into account.

It may be considered to apply criteria from different methods. In particular, it is interesting to combine the two methods in the handbook for road lighting and the CEN /CR 14380:2003.

One method gives priority to short stopping distances, while the other gives priority to long stopping distances. So, a combination should be able to lead to a reasonable priority to the stopping distance while handling the geometry of the underpass sensibly.

It is noted that there is a spreadsheet "Calculation of the look through in short curving tunnels - version 6", which calculates the LTP. The spreadsheet can be extended to also check that the visible part of the exit fills at least 2° in the field of view.