

Criteria for the daytime lighting of short tunnels

Kai Sørensen, February 2023

History, contents and discussion

History

This note is a continuation of the note “Methods and criteria for the lighting of short and medium long underpasses at daytime” Kai Sørensen, 17 February 2022.

<https://nmfv.dk/wp-content/uploads/2022/12/Methods-and-criteria-for-the-lighting-of-short-and-medium-long-underpasses-at-daytime.pdf>

It has been drafted on a request from the NMF road and tunnel lighting group.

The obvious criterion for daytime lighting of short tunnels is the Look Through Percent, LTP as defined in Annex E “Determination of the need for daytime lighting of short tunnels” of CEN CR 14380:2003 “Lighting applications – Tunnel Lighting”.

The values of LTP can be calculated by means of the excel file “Calculation of the look through in short curving tunnels”.

<https://nmfv.dk/wp-content/uploads/2023/02/Calculation-of-the-look-through-in-short-curving-tunnels-version-6.xls>

The excel file is described in a note “An excel file to calculate the look through in short curving tunnels”.

<https://nmfv.dk/wp-content/uploads/2023/02/An-excel-file-to-calculate-the-look-through-in-short-curving-tunnels-version-6.pdf>

Section 1 provides results for the LTP for different situations regarding the curve of the tunnel, the distance of view to the tunnel entrance portal and the length of tunnel.

It is concluded that the LTP increases with the stopping distance to the tunnel entrance portal and thereby increases with the driving speed. This is fault of the LTP method as also concluded in the above-mentioned note.

The purpose of this note is to “repair” the LTP method and/or to find alternative criteria.

Section 2 provides results for a criterion provided in DIN 67524-1:2019 “Beleuchtung von Straßentunneln und Unterführungen – Teil 1: Allgemeine Gütemerkmale und Richtwerte” which is based on the solid angle of the visible part of the exit portal of the tunnel as seen from the location of a stopping distance in front of the tunnel entrance portal.

The criterion is that daytime lighting is not needed when the solid angle is at least as large as the solid angle of a 2° field of view.

For this purpose, the excel file “Calculation of the look through in short curving tunnels” has been equipped to calculate the actual value of the solid angle and to convert the value to a field of view as an output. This new version of the excel file is called “Calculation of the look through and diameter of exit in short curving tunnels”.

<https://nmfv.dk/wp-content/uploads/2023/02/Calculation-of-the-look-through-and-diameter-of-exit-in-short-curving-tunnels.xlsx>

It is concluded that this criterion results in natural variations with all the variables (the curve of the tunnel, the distance of view from the tunnel entrance portal and the length of tunnel).

Section 3 provides results for a mixed criterion, which is the LTP multiplied by half the field of view. It is labelled LTP*.

The mixed criterion results in natural variations of all the variables and may represent the above-mentioned repair of the LTP.

Discussion

The LTP criterion cannot be used directly as stated in the above.

The solid angle criterion of EN 67524 can perhaps be used but has the weakness that it does not allow the various aspects of the CEN CR 14380 like visibility of relevant objects.

The mixed criterion LTP* is probably the best.

1. The Look Through Percent

Table 1 shows values of the Look Through Percent (LTP) for different situations regarding the curve of the tunnel, the distance to the entrance portal, and the length of the tunnel:

- The tunnel curves upward with the radii of respectively 500, 1000 and 2000 m,
- The distances indicated are the distances of the observer in front of the tunnel entrance portal, and represent stopping distances at given driving speeds,
- The LTP is marked in red whenever the value is 50 % or higher, lower values are marked in black.

CEN/CR 14380 provides these statements:

- For LTP > 50 % artificial day-time lighting is never needed,
- For LTP < 20 % artificial day-time lighting is always needed,
- For 20 % < LTP < 50 % artificial day-time lighting may be needed.

Additionally, the tunnel has a width of 8 m and a height of 6 m. The road in front of the tunnel is straight.

Table 1: Values of the LTP for different situations regarding curve, distance, and length of tunnel.

Radius of curve up 500 m				Radius of curve up 1000 m				Radius of curve up 2000 m			
Distance (m)	Length of tunnel (m)			Distance (m)	Length of tunnel (m)			Distance (m)	Length of tunnel (m)		
	60	70	80		60	70	80		60	70	80
60	37	29	21	60	44	37	31	60	47	41	35
95	45	34	24	95	53	45	38	95	58	51	45
115	46	35	25	115	57	49	41	115	62	55	49
150	49	37	25	150	61	53	45	150	67	60	55
190	51	38	25	190	64	56	48	190	71	65	59
230	52	39	25	230	66	58	50	230	73	68	62

Table 1 illustrates that the LTP decreases with the curve of the tunnel (a short radius of the curve means a strong curvature) and with the length of the tunnel. This is natural, and as expected.

However, table 1 also illustrates that the LTP increases with the stopping distance to the tunnel entrance portal and thereby increases with the driving speed. This is not natural, and the scope of this note is to introduce some sort of change of the criteria for daytime lighting of short tunnels.

2. Visual size of the of the tunnel exit

DIN 67524-1:2019 "Beleuchtung von Straßentunneln und Unterführungen – Teil 1: Allgemeine Gütemerkmale und Richtwerte" introduces a criterion for daytime lighting of short tunnels based on the solid angle ω of the visible part of the exit portal of the tunnel as seen from the location of a stopping distance in front of the tunnel entrance portal.

The criterion is that when the solid angle is at least as large as a 2° field of view, artificial day-time lighting is not needed.

As stated in the above, the excel file "Calculation of the look through in short curving tunnels" has been equipped to calculate the actual value of the solid angle and to convert the value to a field of view as an output.

The results for the same situations as in table 1 are shown in table 2.

Values of 2° or higher are marked in red, while lower values are marked in black.

Table 2: Field of view (degrees) for different situations regarding curve, distance, and length of tunnel.

Radius of curve up 500 m				Radius of curve up 1000 m				Radius of curve up 2000 m			
Distance (m)	Length of tunnel (m)			Distance (m)	Length of tunnel (m)			Distance (m)	Length of tunnel (m)		
	60	70	80		60	70	80		60	70	80
60	3,63	3,21	2,79	60	3,74	3,45	3,17	60	3,73	3,45	3,20
95	2,71	2,38	1,97	95	2,88	2,68	2,47	95	2,89	2,72	2,56
115	2,35	2,06	1,61	115	2,54	2,36	2,19	115	2,56	2,42	2,30
150	1,91	1,66	1,20	150	2,09	1,95	1,81	150	2,13	2,04	1,94
190	1,57	1,31	0,90	190	1,74	1,63	1,50	190	1,79	1,72	1,64
230	1,33	1,07	0,72	230	1,49	1,39	1,29	230	1,54	1,48	1,41

The values of table 2 are natural as they decrease with stronger curve of the tunnel (a short radius of the curve means a strong curvature), the distance to the tunnel entrance portal and the length of the tunnel.

It may be that this criterion is acceptable as it is. However, a mixed criterion of LTP and solid angle is introduced in the next section.

3. A mixed criterion

A mixed criterion LTP* can be the LTP multiplied by half the field of view, i.e.: $LTP^* = LTP \times \text{field of view} / 2$.

EXAMPLE: With LTP = 40 and a field of view = 2,5, LTP* is 50 %.

The new version of the excel file has the facility to calculate LTP*. The results are shown in table 3.

Table 3: Mixed criterion LTLP* for different situations regarding curve, distance, and length of tunnel.

Radius of curve up			500	m	Radius of curve up			1000	m	Radius of curve up			2000	m
Distance	Length of tunnel (m)				Distance	Length og tunnel (m)				Distance	Length of tunnel (m)			
(m)	60	70	80		m	60	70	80		m	60	70	80	
60	67	47	29		60	82	63	49		60	88	70	57	
95	61	40	24		95	77	61	48		95	83	69	58	
115	54	36	20		115	72	58	45		115	79	67	57	
150	47	31	-		150	64	52	41		150	71	62	53	
190	40	25	-		190	56	45	36		190	63	55	48	
230	35	21	-		230	49	40	32		230	57	50	44	

Table 3 shows that the mixed criterion is on the same scale as the LTP but has natural variations with the curve of the tunnel, the distance to the tunnel entrance portal and the length of the tunnel.