inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 56

TEMPORAL DISTRIBUTIONS OF OUTDOOR NOISE LEVELS IN DENSELY BUILT-UP AREAS

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1. SOME LITERATURE ON THE NOISE TEMPORAL DISTRIBUTION

Olson [1] recorded sound levels over a 24-h period at different locations in the City of Ottawa. The obtained percentile distributions fell into one of two distinct classes: the former with more or less symmetrical distributions and the latter with skewed distributions, which were more common.

Safeer et al. [2] considered three different 60-minute noise distributions. The third referred to a wooded area, about 80 m from the center of a major interstate highway during morning rush-hour traffic and was similar to a gaussian with a standard deviation $\sigma = 2$ dB. These authors hypothesized that for locations of the third type estimates of the shape of the distributions based on relatively short period samples (e.g., five minutes) should be accurate within ± 1 dB.

Don and Rees [3] deduced that the temporal distributions of sound levels were rarely gaussian. Indicating skewness by s and kurtosis by k, they called "pseudo-gaussian" a distribution characterized by: (a) $-.1 < s < .1$; (b) $2.85 < k < 3.15$; (c) a correlation coefficient greater than .998 for L_N values drawn on normal probability graph paper.

Mori et al. [4] carried out many surveys: the obtained results were compared with four probability distributions: the exponential, the normal, the log normal and the Weibull distribution; it followed that the Weibull distribution matched the actual road traffic noise more closely.

2. TEMPORAL DISTRIBUTIONS IN RECENT NOISE SURVEYS

For various positions (P.) located in densely built-up areas, A-weighted acoustic surveys have been carried out along 24 h periods. Equivalent level, L_{eq}, and percentile levels L_1, L_{10}, L_{25}, L_{50}, L_{60}, L_{75}, L_{90}, L_{95}, L_{99}, $L_{99.9}$ have been recorded.

Table 1 - Equivalent Levels and Traffic

P.	L_{eqd}	L_{eqn}	L_{eq}	Light vehicles	Heavy vehicles	Time
1	75.0	71.0	74.4	2856	118	3-4 p.m.
2	67.6	65.0	66.8	1758	84	2-3 p.m.
3	64.8	57.9	63.4	1008	24	3-4 p.m.
4	73.8	70.7	73.0	5992	84	8-9 a.m.
5	72.2	65.4	70.8	2172	66	1-2 p.m.
6	73.0	68.0	71.8	2964	18	6-7 a.m.
7	74.8	68.3	73.5	3006	198	9-10 a.m.
8	75.9	68.6	74.5	2826	192	7-8 a.m.
9	69.5	64.2	68.3	3846	66	11-12 a.m.
10	75.1	71.8	74.2	3078	11	4-5 p.m.
11	74.4	69.4	73.3	3828	174	8-9 a.m.
12	76.3	72.1	75.2	2598	90	10-11 a.m.
13	76.7	72.2	75.6	2418	216	1-2 p.m.
14	72.8	66.6	71.5	1848	90	3-4 p.m.
15	75.6	71.0	74.5	1020	48	1-2 p.m.
16	77.4	70.7	76.1	2874	120	2-3 p.m.
17	73.2	67.5	71.9	1578	39	4-5 p.m.

In Table 1 the values of L_{eqd} (from 6 a.m. to 10 p.m.), L_{eqn}, L_{eq} are reported for 17 characteristic outdoor locations. In addition, the values of traffic (split in light and heavy vehicles) in a given time are reported for the same locations. One remarks that the mean difference between L_{eqd} and L_{eqn} is about 5 dB, while according to the Italian legislation the allowed values in day- and night-time differ 10 dB between them. These results are in agreement with those of other surveys, e.g. [5]. In all the locations of Table 1, the noise of road traffic sources is the prevailing one.

In Table 2 the equivalent and the percentile levels during day-time (D) and night-time (N) are reported for the position 16. By means of the percentile levels, the standard deviation, σ, skewness, s, kurtosis, k and the parameters $A=(L_{99}-L_{50})/\sigma$, $B=(L_{90}-L_{50})/\sigma$, $C=(L_{10}-L_{50})/\sigma$, $D=(L_1-L_{50})/\sigma$ were obtained for all locations. In Table 3 the values of the above parameters are reported for the distributions of Gauss and Rayleigh (a particular case of Weibull distribution).

Table 2 - Equivalent and Percentile Levels for Position 16

	L_{eq}	L_1	L_{10}	L_{25}	L_{50}	L_{60}	L_{75}	L_{90}	L_{95}	L_{99}	$L_{99.9}$
D	77.4	85	80	77	74	73	72	70	68	65	61
N	70..6	81	73	70	66	64	60	55	53	49	47

Table 3 - Characteristic Parameters of two Statistical Distributions					
	Gauss	Rayleigh		Gauss	Rayleigh
$(L_{99}-L_{50})/\sigma$	- 2.326	- 1.581	$(L_{10} - L_{50})/\sigma$	1.282	1.478
$(L_{90}-L_{50})/\sigma$	- 1.282	- 1.097	$(L_1 - L_{50})/\sigma$	2.326	2.835

Table 4 - Various Acoustical Parameters of Day-time

P.	L_{eqd}	μ	σ	s	k	m	A	B	C	D
1	75.0	71.5	6.0	-.761	3.014	1	-3.000	-1.833	0.833	1.500
2	67.6	64.9	4.0	-.205	3.889	1	-2.750	-1.250	1.250	2.500
3	64.8	61.8	3.5	.814	5.255	1	-2.286	-0.857	1.143	4.000
4	73.8	72.1	3.4	-.196	3.458	1	-2.353	-1.176	1.176	2.353
5	72.2	69.7	4.0	-.893	4.810	1	-3.250	-1.250	1.000	2.000
6	73.0	68.5	6.6	-.377	2.285	2	-2.424	-1.818	0.909	1.667
7	74.8	71.4	5.1	- 214	3.046	2	-2.549	-1.176	1.373	2.353
8	75.9	72.7	4.0	.322	3.212	1	-2.250	-1.000	1.500	3.000
9	69.5	68.0	3.1	-.331	4.220	1	-2.581	-1.290	0.968	2.581
10	75.1	72.7	4.4	-.450	3.907	1	-2.955	-1364	1.136	2.273
11	74.4	72.6	3.5	-.202	3.209	1	-2.571	-1.143	1.429	2.571
12	76.3	73.3	4.4	-.077	3.208	1	-2.500	-1.136	1.364	2.500
13	76.7	73.7	4.9	-.289	2.955	1	-2.653	-1.429	1.020	2.245
14	72.8	68.4	4.9	.210	2.990	1	-2.245	-1.224	1.429	2.653
15	75.6	70.3	6.7	-.435	3.574	1	-2.985	-1.493	1.045	2.239
16	77.4	74.8	4.1	.080	3.309	1	-2.195	-0.976	1.436	2.683
17	73.2	69.7	4.8	.118	3.769	1	-2.500	-1.042	1.458	2.917

Table 5 - Various Acoustical Parameters of Night-time

P.	L_{eqn}	μ	σ	s	k	m	A	B	C	D
1	71.0	64.0	9.0	-.761	2.153	1	-2.444	-1.778	1.000	1.556
2	65.0	59.6	7.9	-.634	2.871	1	-2.785	-1.646	1.013	1.519
3	57.9	53.1	6.4	-.148	2.419	1	-2.187	-1.406	1.250	2.187
4	70.7	66.9	6.1	-.569	2.864	1	-2.787	-1.639	0.984	1.639
5	65.4	58.9	8.1	-.071	1.899	2	-1.852	-1.482	1.235	1.852
6	68.0	61.1	7.5	.329	2.003	2	-1.467	-1.067	1.600	2.267
7	68.3	63.0	6.8	-.156	2.630	1	-2.353	-1.324	1.176	2.206
8	68.6	64.0	6.3	-.078	2.356	2	-2.222	-1.429	1.270	2.222
9	64.2	58.5	8.3	-.669	2.718	1	-2.771	-1.687	0.964	1.446
10	71.8	64.3	9.6	-.458	2.242	1	-2.396	-1.667	0.937	1.458
11	69.4	65.2	6.4	-.467	2.771	1	-2.656	-1.562	0.937	1.875
12	72.1	67.2	6.0	.162	2.611	1	-2.000	-1.333	1.333	2.500
13	72.2	65.5	7.6	.147	2.171	2	-1.711	-1.316	1.316	2.237
14	66.6	57.7	8.8	-.078	2.462	1	-2.045	-1.250	1.364	2.386
15	71.0	58.9	11.6	-.060	2.114	1	-1.983	-1.466	1.293	1.983
16	70.7	65.2	6.8	-.192	2.552	1	-2.500	-1.618	1.029	2.206
17	67.5	58.8	9.7	-.353	2.350	2	-2.268	-1.753	1.031	1.856

In Tables 4 and 5, respectively for day- and night-time, the values of σ, s, k, A, B, C, D are shown for the same 17 locations; in addition, the number of the maxima (m) of the actual distribution is reported.

The values of the standard deviation are always higher in night-time; but the differences between night- and day-time are different according to locations. The values of the skewness are generally negative; however, also some positive values have been recorded.. The values of the kurtosis are higher in day-time for all positions. In addition, almost always the values of the skewness and kurtosis are outside the range, which was chosen by Don and Rees to characterize the "pseudo-gaussian" aspect. The actual values of the parameters A, B, C, D are very unlike from those of Gauss and Rayleigh distributions. When there are distinctly two maxima in the actual distribution, the experimental data fit only with the superposition of two theoretical distributions.

3. CONCLUSIONS

In this research the purpose was that of examining a limited number of characteristic positions in both day- and night-time.

There is no theoretical basis for any temporal distribution function of town noise levels. The experimental data reported in this paper do not fit with any of the known statistical distributions both considering day- and night-time together and considering them separately. In various cases the actual statistical distribution has two maxima and the experimental data fit quite well with the superposition of two Weibull or Gauss distributions.

The mean difference between the day and the night equivalent levels is about 5 dB, while according to the Italian legislation the allowed values in day-time and night-time differ 10 dB between them. These results are in agreement with those of other surveys in different towns. However, it is to be noted that the actual values both in day- and night-time are well above the limits established by the legislation.

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