ARCHIVES OF ACOUSTICS
10, 4, 327-334 (1985)

COMPARISON OF PREDICTION METHODS FOR ROAD TRAFFIC NOISE

L. CZABALAY

National Authority for Environment Protection and Nature Conservation, Arany J. Str. 25, H-1051 Budapest, Hungary

L. SÁRVÁRI

Sanitary-Epidemiological Station of County Győr-Sopron, Jósika Str. 16, H-9024 Győr, Hungary

The Sanitary-Epidemiological Station of County Győr-Sopron has accomplished some analysis of road traffic noise. On the basis of these investigations an answer should be given to the question of how far prediction methods for road traffic noise are reliable and to what extent they can be used for planning. The investigations will take 2 years (1984–1985). Research work was sponsored by the National Authority for Environment Protection and Nature Conservation. This report outlines the investigations performed in 1984, and the data published therein may be modified as required according to the 1985 investigations.

1. Method of investigation

In 1984 there were 11 locations in residential areas selected for the purpose of the measurements. At each location there was a basic measuring point at a distance of 7.5 metres from the centre line of the outmost traffic lane of the road. All the other measuring points, 2 to 6 for each location, were arranged inside the residential area. In each case the measurements were done simultaneously by using two instruments; one instrument was used at the basic point, while the other was used at one of the measuring points inside the residential area. The instruments used were Brüel et Kjaer Noise Level Analyzer, type 4426, and Precision Integrating Sound Level Meter, type 2218.

The equivalent continuous A-weighted sound pressure levels were determined from measurements. The noise measurements were completed with a traffic census. The number of the vehicles was recorded for each traffic lane, and this figure devided according to the categories of vehicles. The duration of each measurement was 10–15 minutes. The equivalent continuous A-weighted sound pressure levels were also predicted theoretically for each investigated measuring point. Five prediction methods were applied.

The results obtained at 7.5 m from the centre line of the outermost lane of the public road and those obtained inside the dwelling area were evaluated separately. The different calculating methods supply the equivalent continuous A-weighted sound pressure levels, calculated from the traffic data, for different distances. All this data has been converted into figures relating to a distance of 7.5 m from the centre line of the outermost lane, so that they could have been compared.

2. Prediction methods used for the evaluation

There were altogether five prediction methods used in the investigation. Three of these methods had been published in Standards or Technical Reports, while two of them had been elaborated by the authors. The five methods are as follows:

A. Method. *MI–07.3704–81.* Reduction of traffic noise by road design methods. Hungarian State Technical Report [4].

B. Method. Calculation method for the prediction of road and railway traffic noise [2].

C. Method. Investigation and evaluation of road traffic noise [1].

D. Method. *DIN 18005,* Part 1. Noise control in town planning. Draft, 1976 [3].

E. Method. The computing model for road traffic noise Nordic method [5].

An abstract of methods A, B and C will be given, while we refer to the literature as far as methods D and E are concerned.

Method A. The equivalent continuous A-weighted sound pressure level at a distance of 7.5 m from the centre line of the outermost traffic lane is

$$L'_{Aeq} = 10\log Q + L_{eq1} + 10\log\left(\frac{p_1}{100} + \frac{p_2}{100}\cdot 10^A + \frac{p_3}{100}\cdot 10^B\right),$$

where

$$A = \frac{L_{eq2} - L_{eq1}}{10}; \quad B = \frac{L_{eq3} - L_{eq1}}{10},$$

and

$$L_{eq1} = 39.6 - 0.1\log v_1; \quad L_{eq2} = 46 - 0.6\log v_2; \quad L_{eq3} = 54.4 - 3.7\log v_3,$$

and Q is the density of traffic related to one hour of the busiest eight hours, vehicle/hour; p_1 is the percentage of passenger cars, %; v_1 is the average speed of passenger cars, km/h; p_2 is the percentage of heavy vehicles with two axles, %; v_2 is the average speed of heavy vehicles with two axles, km/h; p_3 is the percentage of heavy vehicles with more than two axles, %; v_3 is the speed of heavy vehicles with more than two axles, km/h.

The calculation should be performed separately for each traffic lane and the results should be summed. The equivalent continuous A-weighted sound pressure level at a distance more than 7.5 m from the centre line of the outermost traffic lane is

$$L_{Aeq}d = L'_{Aeq} - \Delta L_d - \Delta L_L - \Delta L_G - \Delta L_B - \Delta L - \Delta L_E,$$

where ΔL_d is the noise attenuation due to the distance; ΔL_L is the noise attenuation due to the absorption of the air; ΔL_G is the allowance for the ground effect; ΔL_B is the noise attenuation due to the plants; ΔL is the noise screening effect of barriers; ΔL_E is the effect of other factors.

Method B. The equivalent continuous A-weighted sound pressure level, L'_{Aeq}, at a distance of 25 m from the centre of the road is

$$L_{Aeq}(25\ \text{m}) = 36 + 10\log N,$$

where N is the average traffic density in passenger car-unit vehicle/hour (p.c.U./h) during the reference time interval.

The formula applies to a speed of $v \leqslant 60$ km/h. The traffic in passenger car-unit vehicles (p.c.U.): passenger car, or scooter = 1 p.c.U.; heavy motor-vehicle = 6 p.c.U.; motorcycle = 3 p.c.U.; tram = 6 p.c.U.

The equivalent continuous A-weighted sound pressure level, L'_{Aeq}, of the road traffic at a random point of the invesigated area is

$$L_{Aeq} = L_{Aeq}(25\ \text{m}) + (K_s + K_t + K_f + K_b + K_e + K_h + K_r).$$

The individual terms of the equation are as follows:

a) correction depending on the speed of the vehicles, K_s, dB. When the speed, v, is: $v \leqslant 60$ km/h: $K_s = 0$; $v > 60$ km/h: $K_s = 26.9\log v - 47.8$.

b) correction depending on the distance between the road and the observer, K_t, dB. It is calculated for the case of a perpendicular distance r [m], from the road as follows

$$K_t = 10\log 25/r.$$

In the case of soft ground at a distance over 25 m, if the height, h, of the observer from the ground surface is less than one-tenth of the distance r

$$K_t = 13.33\log 25/r.$$

The first formula should be used, if K_f and K_h are applied.

c) correction depending on a forest belt or a sparse construction, K_f, dB

$$K_f = -0.05 d_f,$$

where d_f is the distance measured through the forest belt, or the sparse construction.

The correction can be used, when $d_f = 30$ m at least, however, K_f can not be lower than -10 dB.

d) correction depending on reflection, K_b, dB. In the vicinity of larger surfaces (e.g. facades) $K_b = 3$ dB. In a street with a closed construction on both sides

$$K_b = 3 + 10 \log\left(1 + \frac{h}{b}\right),$$

where h is the mean building height; b is the distance of the facades.

e) correction referring to the incline of the road and crossings, K_e, dB: up to 6 % incline of the road $K_e = 0$; over 6 % incline of the road $K_e = 2$ dB; within 100 m measured from the centre of the crossing $K_e = 2$ dB.

f) correction depending on screening, K_h, dB. The value of correction K_h should be determined as illustrated in Fig. 1.

g) correction referring to the angle of view, K_r, dB:

$$K_r = 10 \log \beta_i / 180,$$

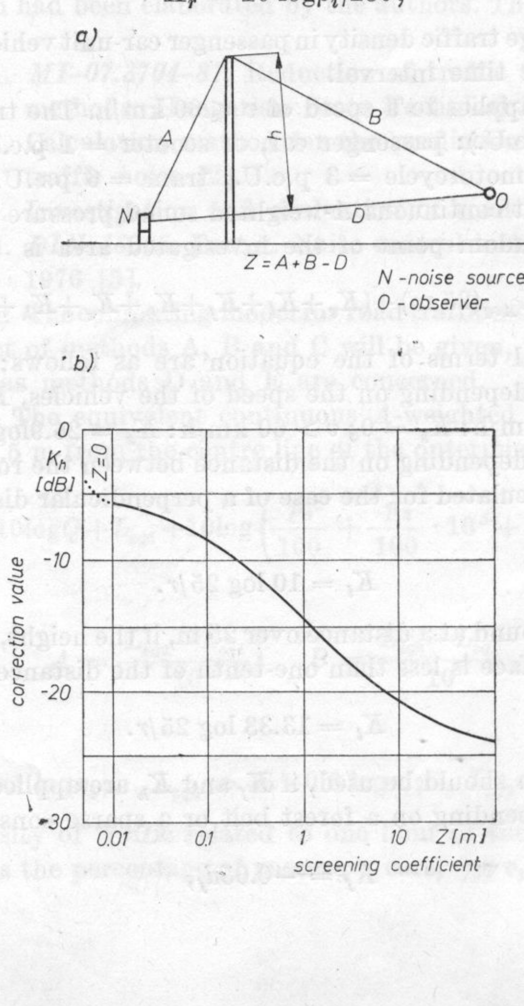

Fig. 1

where β_i is the angle of view in degrees of the ith section.

The equivalent continuous A-weighted sound pressure levels of each section should be summed.

Method C. The equivalent continuous A-weighted sound pressure level at 7.5 m from the centre line of the outermost traffic lane is

$$L_{Aeq} = 24 + 22 \log N - 2.2 (\log N)^2,$$

where N is the average traffic density expressed in passenger car-unit vehicle/hour, as defined in Method B.

Correction referring to the distance r, K_t, dB:

$$K_t = 10 \log \frac{7.5}{r}.$$

All further calculations are as described in Method B.

3. Results of the investigation

The analyzed locations were of different construction. There are two locations shown in Fig. 2 and 3, as examples of the arrangement of measuring points (B is the basic point).

Altogether there were 102 measurements done on the 11 locations at a distance of 7.5 m from the centre line of the outermost lane. Measurement results and those of the calculations were averaged for each location, thereafter the mean and the standard deviation of the differences between the calculated and

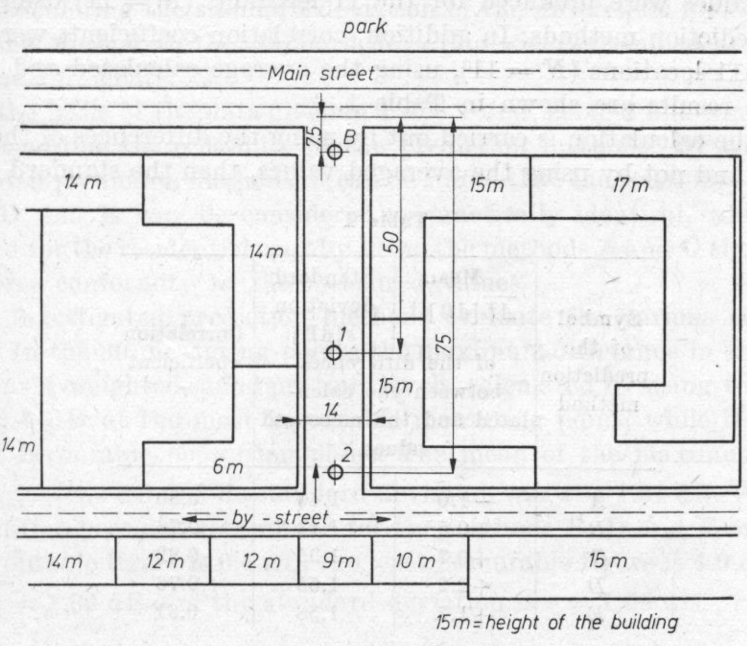

Fig. 2

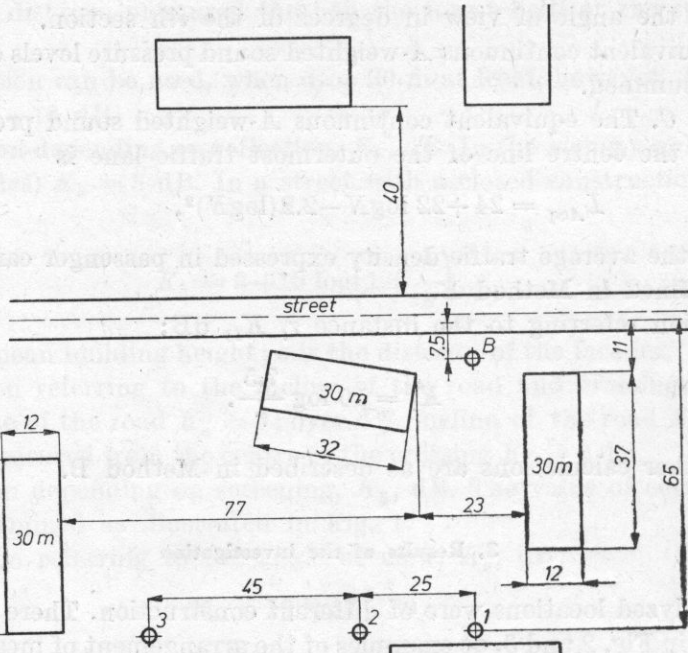

Fig. 3

measured values were produced for the 11 locations ($N = 11$) using the five different prediction methods. In addition, correlation coefficients were calculated for the 11 locations ($N = 11$), using the average calculated and measured values. The results are shown in Table 1.

When the calculation is carried out by using the differences of the 102 measurements and not by using the averaged values, then the standard deviation

Table 1

Symbol of the prediction method	Mean $\overline{\Delta L}$ [dB] of the differences between the calculated and the measured values	Standard deviation s [dB] of the differences between the calculated and the measured values	Correlation coefficient r
A	−1.0	1.40	0.80
B	+0.5	1.43	0.76
C	+0.7	1.35	0.82
D	+2.2	1.55	0.76
E	+1.7	1.38	0.81

of the differences amounts to $s = 2.33$ dB instead of $s = 1.43$ dB, when Method B is used.

The calculated and measured values obtained at the measuring points inside the residential area were evaluated in the same way. The evaluation was performed for 30 measuring points at the 11 locations, the number of the measurements was 55. At some measuring points several measurements were done, the results of which were averaged first. Thereafter the differences between the calculated and measured levels were determined and the mean and the standard deviation of 30 differences was calculated. In addition, the correlation coefficients of the calculated and measured levels were also determined. The results are shown in Table 2. The maximum deviations from the measured values are also indicated in the table.

Table 2

Symbol of the prediction method	Mean $\overline{\Delta L}$ [dB]	Standard deviation s [dB]	Maximum deviation [dB]		Correlation coefficient r
	of the differences between the calculated and the measured levels				
A	−2.5	1.91	+0.8	−7.7	0.92
B	+0.7	1.39	+3.2	−1.4	0.96
C	−0.9	1.57	+1.7	−3.5	0.93
D	+0.9	1.47	+3.5	−2.5	0.96
E	+0.9	1.36	+3.0	−2.3	0.95

By calculating the standard deviation of the differences for each measurement using Method B, the standard deviation was determined at $s = 2.19$ dB for 55 measurements.

On the basis of the data given in Table 1 and Table 2 one can draw a conclusion regarding the reliability of the prediction methods. By comparing the investigated prediction methods, it can be stated that the reliability of the methods B, D and E can be considered as practically identical, while the levels calculated for the residential area by using the methods A and C showed a somewhat worse conformity to the measured values.

The investigated prediction methods evaluate the various situations differently. In the 30 measuring points the maximum difference in the equivalent continuous A-weighted sound pressure levels, calculated by using the five methods, is 2.4 dB at the most favourable measuring point, while it is 8.6 dB at the least favourable measuring point. The mean of the maximum differences was $\overline{\Delta L_{max}} = 4.6$ dB and its standard deviation was $s = 1.51$ dB. When the maximum differences are determined for the methods B, D and E only, then the most favourable figure is 0.4 dB, the least favourable figure is 4.0 dB, the mean is $\overline{\Delta L_{max}} = 1.80$ dB and the standard deviation is $s = 1.09$ dB.

References

[1] L. Czabalay, *A közuti zaj vizsgálata és értékelése Kép-és*, Hangtechnika, **24**, 165–168 (1978).

[2] L. Czabalay, F. Hirka, *Számitási eljárás a közuti és cvasuti zaj elorejelzésére*, 6th Days of Environmental Protection in Engineering, Győr (1984).

[3] DIN 18 005 Teil 1. Schallschutz im Staedtebau. Berechnungs- und Bewertungsgrundlagen, Entwurf 1976.

[4] MI-07.3704-81. A közlekedési zaj csökkentése uttervezési módszerekkel, 1981.

[5] *The computing model for Road Traffic Noise Statens Planverk*. Nordic Council of Ministers' project, Report No. 48 (1980).