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The influence of meteorological conditions on noise propagation outdoors and sustainable planning of roads and motorways

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Adequate road planning that allows for the separation of built-up areas and travel routes is one of the basic prevention strategies of hazards resulting from road usage. If possible, international roads should never be routed across cities and residential districts. However, if for some reason a busy road must be located near a built-up area, long-term meteorological conditions, characteristic of the area, must be examined prior to the execution of any work. Road planning on the basis of the analysis of the "rose of conditions favourable" to noise propagation will help minimise the road's negative acoustic influence on the adjacent buildings and facilities.

1 Introduction

The acoustic profile of two selected sites is examined below. Conditions favourable to propagation differ significantly in both cases depending on the position of the source-to-receiver direction in relation to the directions of the world.

In the two case studies, the road direction changed by 20° form 0° to 360° in relation to the north. The distance of the built-up area from the road was accepted to be 1 200m, that is to be equal to the values for which meteorological influences are the greatest [1]. "The rose of long-term meteorological influences" on the noise level as a function of the receiver point height was obtained.

The impact of meteorological conditions on the noise level was analysed using simulation calculations performed with the Mithra software.

2 Acoustic analysis of road planning near the city of Łódź (Poland)

Noise levels generated by a hypothetical road [1] were calculated based on the rose of favourable conditions determined for daytime (Fig.1)using the data given in [2,3]. They were then compared to the noise level determined for homogenous conditions in order to evaluate the influence of real meteorological conditions on the noise level at the receiver points, located at a number of heights (Fig. 2). Fig. 2 shows the "rose of the influence of meteorological conditions", calculation results, in the Łódź Region (Poland) for 2000.

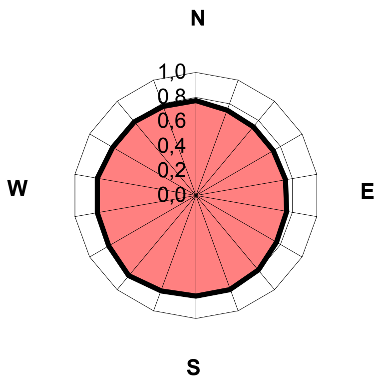

Fig. 1 The rose of the occurrence of conditions favourable to noise propagation at the Łódź-Lublinek meteorological station in 2000 (night time) [3]

In the Region, planning transport roads whose direction ranges between 50° and 170° in relation to the north, that is on the south-western side of the built-up area, is definitely least favourable from the point of view of the acoustic climate as meteorological influences are most perceptible in the direction between 140° and 260°. The greatest influences occur at the level of the second/third floor and exceed 7 dB.

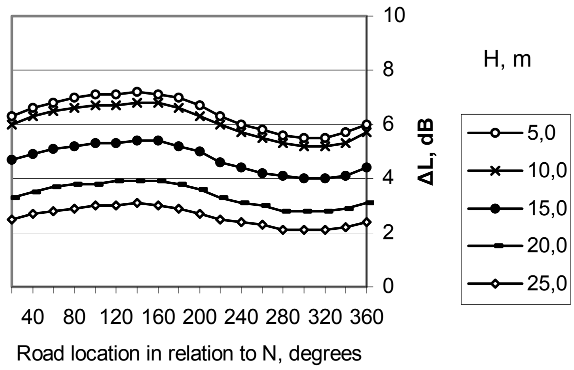

Fig.2 Meteorological influences on long-term noise as a function of the road location in relation to the north for the Łódź Region for various positions of the receiver point

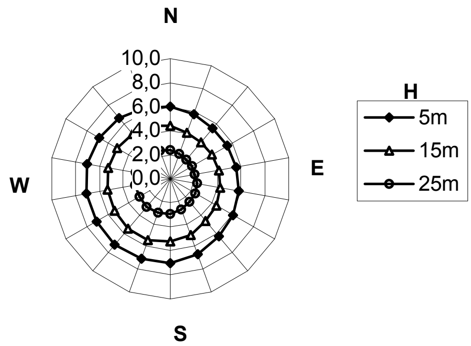

Fig. 3 Rose of meteorological influences for the Łódź Region (night time)

3 Acoustic analysis of road planning near the city of Montelimar (France)

Noise levels were calculated for the city of Montelimar in southern France (Rhone Valley). The rose of favourable conditions (over a period of 30 years) determined for daytime in accordance with the data given in the Mithra software [4] (Fig. 4) was used. They were then compared to noise levels determined for homogenous conditions to evaluate the influence of real meteorological conditions on the noise level at the receiver points, located at a number of heights (fig.5). Fig. 6 shows the "rose of the influence of meteorological conditions", calculation results, in this region.

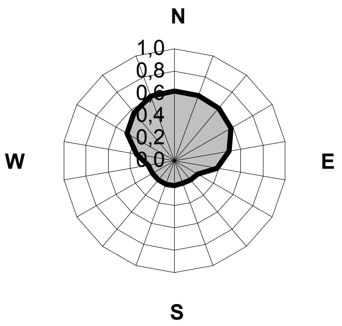

Fig. 4 Rose of occurrence of conditions favourable to noise propagation for the meteorological station in Montelimar for day time

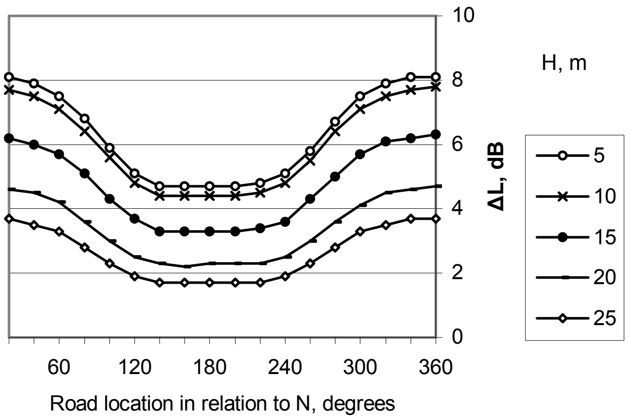

Fig. 5 Meteorological influences on long-term noise as a function of the road location in relation to the north for the area of Montelimar (daytime)

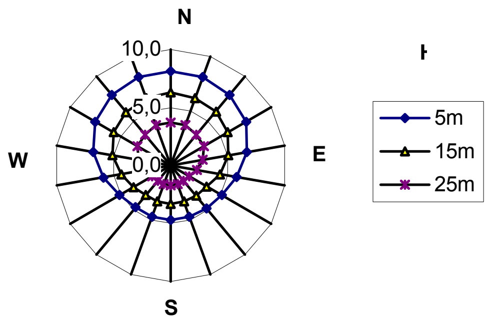

Fig.6 Rose of occurrence of conditions favourable to noise propagation for the meteorological station in Montelimar

In the region of Montelimar, planning transport roads whose direction ranges between 230° and 310° in relation to the north, that is on the south-western side of the built-up area, is definitely least favourable from the point of view of the acoustic climate as meteorological influences are most perceptible in the direction between 340° and 40°. The greatest influences occur at the level of the second/third floor and exceed 8 dB.

5 The influence of meteorological conditions on noise increace: a comprehesive description

The influence of meteorological conditions on the noise level for a range of geometric settings and geographic factors is predicted based on research studies [1,2] and the present analysis. The following general relationships are described: geographic location of the study area / road position / receiver point position, or, more specifically, the position of the road and the observation point in relation to the directions of the world / the distance between the observation point and the noise source / the height of the receiver point position.

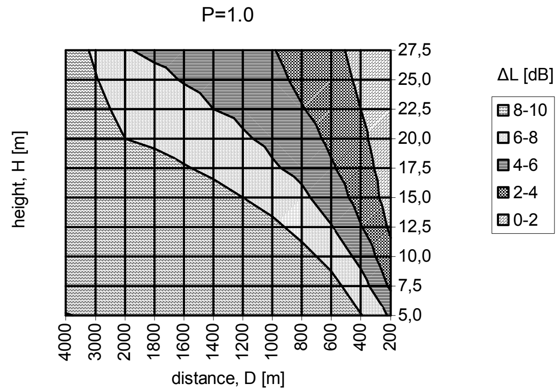

Fig. 7 Influence of distance between the source and the receiver point (D) and height of the receiver point location (H) on the change of long-term noise level for P=1.0

The relative location of the road and the observation point referred to the directions of the world is determined with the method described in point 2 and 3. The influence of the distance of the receiver point from the road and its height above the terrain as a function of parameter P is presented as collective nomograms [2]. Examples of such nomograms are given in figures 7÷10.

6 Conclusion

The conducted above numerical calculations of rose of meteorological influences, together with the relationships between the geometry of the system: source – receiver point, meteorological influences and the noise level establish correlations between these all parameters. Its permit to sustainable planning of roads and motorways.

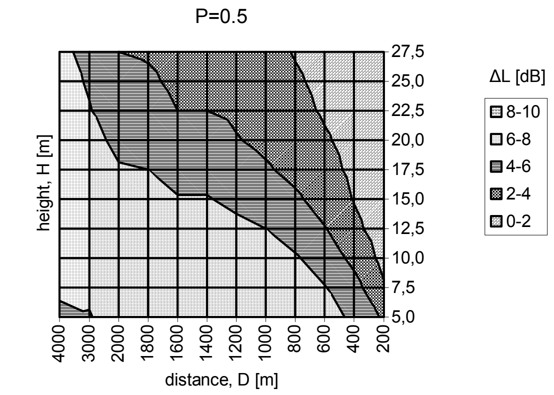

Fig. 8 Influence of distance between the source and the receiver point (D) and height of the receiver point location (H) on the change of long-term noise level for P=0.5

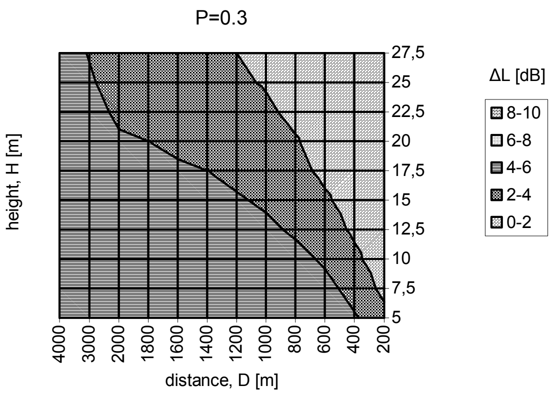

Fig. 9 Influence of distance between the source and the receiver point (D) and height of the receiver point location (H) on the change of long-term noise level for P=0.3

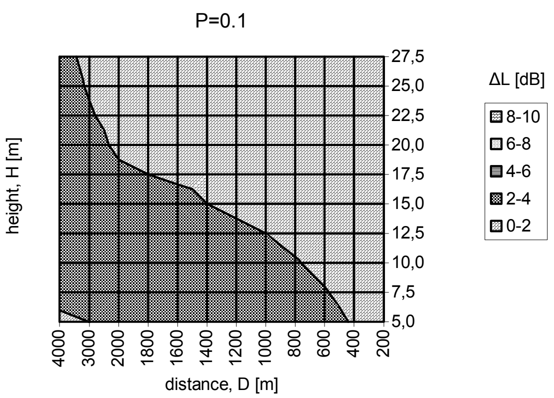

Fig. 10 Influence of distance between the source and the receiver point (D) and height of the receiver point location (H) on the change of long-term noise level for P=0.1

Diagrams (Fig.7÷10) present selected examples of correlations between these parameters. The understanding of these phenomena helps predict noise increases as a function of site configuration and meteorological factors. An advantage of this method is also its applicability in practice and its contribution to urban development. The method would be of great value in planning the distribution of linear noise sources, for instance roads or streets, in relation to buildings and protected zones (built-up areas, residential estates, parks, nature reserves) that would be optimum for the acoustic comfort as early as at the design stages.

References

[1] B.Lebiedowska, „Practical analysis of the influence of basic meteorological phenomena on long-term noise level", *Proceeding of Acoustics08*, Paris (2008).

[2] B.Lebiedowska, Parameters of noise propagation outdoors" *Akademia Humanistyczna im.A.Gieysztora,* Pułtusk (2007).

[3] B.Lebiedowska, J.Defrance, J.M.Rapin, „Calcul des roses d'occurrences meteorologiques de long termes des conditions favorables a la propagation du son en Pologne". *Proceeding of the Congress: VIII Konferencja Naukowo-Techniczna – Fizyka Budowli w Teorii i Praktyce*. Łódź, 348-355 (2001)

[4] Mithra 5, Manual, 2001