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TESTING OF SOFTWARE FOR OUTDOOR NOISE PREDICTION

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1. INTRODUCTION

We have tested a computer program for prediction of environmental noise. The program SoundPLAN [1] calculates the noise level in individual points as well as in a large number of grid points. The testing comprises the joint Nordic methods [2], [3], [4] which among others are implemented in the program. So far, only flat terrain has been considered.

The scope of this paper is to illustrate some of the complications encountered during the testing and to point out the necessity of carrying out a thorough test of such software. Approximately 700 test examples were constructed distributed among road traffic noise, railway noise, and noise from industrial plants.

After some initial corrections of the software the testing generally showed good agreement with test results calculated with our own software. In some situations, however, it was not possible to calculate strictly according to the Nordic calculation methods. In some situations strict application of the Nordic calculation methods leads to noise contours with a non-physical appearance.

2. DOCUMENTATION

The joint Nordic method for prediction of environmental noise from industry is used in planning situations and can be used as a basis of compulsory action e.g. to impose on a factory to reduce noise or even to shut it down. The purpose is to secure a satisfactory acoustical environment for people to live in. Hence it is of great importance that measurements as well as calculations are as correct as possible. This can be secured by among others maintaining a high level of documentation. In Fig. 1 some of the main components of a noise study are shown.

Of these "boxes" we believe that the software part often has the lowest level of documentation.

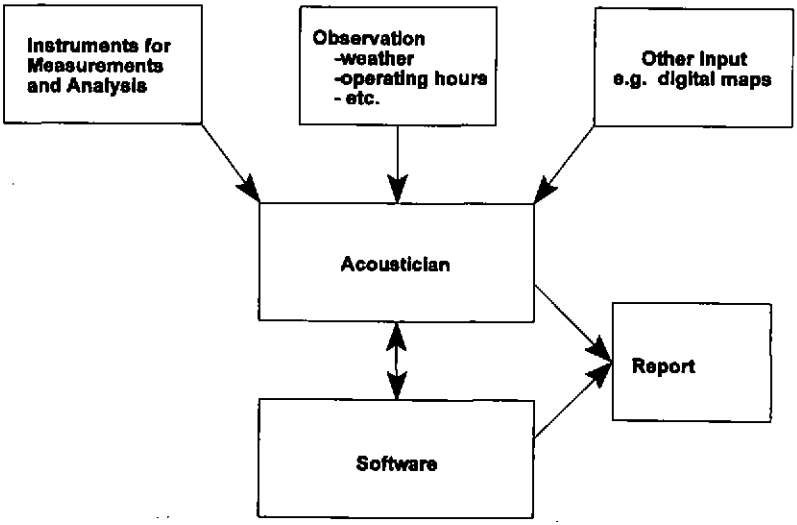

Fig. 1

3. TESTING

The testing of the implemented Nordic method for prediction of environmental noise from industry was carried out by constructing simple situations and then varying one parameter at a time in order to cover as many situations as possible. In the test, the results obtained from SoundPLAN were compared to results from our program ILYD [5]. This program uses the equations from the original version of the joint Nordic method and leaves the decision about detailed modelling to the user, where SoundPLAN automatically does the entire calculation. The program ILYD was initially tested by comparison to manual calculations.

The testing comprised situations covering the effect of ground, screening, screening combined with ground, height, distance, and reflection. These were divided up into tests covering the effect of e.g. height of screen, distance between source and screen, angle of incidence, reflection coefficient, etc. A test situation could e.g. be a source with constant source strength and an immission point at a fixed distance from the source. The varying parameter could be the distribution of acoustically hard and soft ground according to the Nordic method. In Fig. 2 and 3 other examples are shown. Fig. 2 shows an example where the length of an obstacle is modified to test the effect of reflection as a function of the length of the reflecting obstacle.

Fig. 3 shows an example with 5 screens to test whether the program selects the two most effective screens according to the Nordic method for prediction of environmental noise from industry.

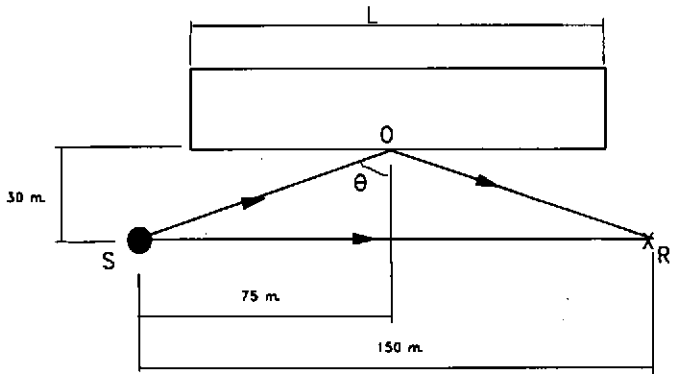

Fig. 2

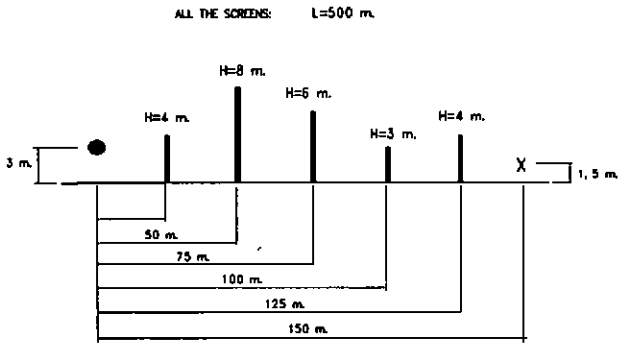

Fig. 3

The implementation of the methods for road traffic noise and noise from railway was tested in an analogous manner as for the method for noise from industry. The results were compared to results obtained with NBSTOY [6] for road traffic noise and our program JLYD [7] for noise from railways.

4. RESULTS OF TESTING

The result of the testing so far showed that in general the difference between the results obtained with SoundPLAN and the "reference" was less than 0.2 dB on the A-weighted levels. For the results for noise from industrial plants the deviation was generally less than 0.2 dB in each octave band, but in a few cases deviations of up to 1 dB were found in single octave bands.

For road traffic noise most test results deviated by less than 0.2 dB, and all results deviated by less than 0.4 dB.

For noise from railways nearly all results deviated by less than 0.2 dB with a few results deviating up to 2 dB.

During the still ongoing testing, results deviating more than 0.2 dB are checked to see whether the deviation is caused by SoundPLAN, by the "reference" or maybe is a derived effect arising from modification of the Nordic method implemented in SoundPLAN.

New versions are checked by recalculation of all the test examples looking for discrepancies. Hereby the risk that new errors are introduced is prevented.

5. PROBLEMS WITH THE JOINT NORDIC METHODS

Implementing the joint Nordic method in SoundPLAN revealed that in some situations it was not possible to calculate strictly according to the method. These situations could be separated into two cases which are illustrated below:

1. Where decisions have to be made manually

In some situations the Nordic method demands a decision to be taken by the user. This is e.g. the case when the reflection plane has to be determined in road traffic noise calculation. In order to be able to make calculations in a large number of grid points the method had to be modified with an automated procedure. This was done by dividing the ground between source and receiver into a maximum of 5 sections. If more coordinates are found within each section, a substitution line is calculated with the method of linear regression. The program evaluates which of the sections is the major reflection plane.

2. Where discontinuities lead to non-physical noise contours

In the joint Nordic method for calculation of noise from industry the ground attenuation is changed when significant screening occurs. In these cases the height h_r of the receiver or the height h_s of the source is corrected to a higher position if h_s or h_r is less than 5 m. This means that a receiver (or source) 4.99 m above ground would be lifted to a higher position in the calculation than a receiver (or source) at a height of 5.01 m. As higher position means less ground effect, this leads to non-physical discontinuities in the noise contours. In SoundPLAN the method has been modified so that all heights are corrected whether they are smaller than 5 m or not.

In case of tall and narrow screens another problem arises from the criterion that if the effective screen height is positive, the heights of source or receiver have to be modified. Due to screens with large effective height this modification is large, and the ground effect almost disappears. If at the same time an essential contribution of noise is transmitted horizontally around the screen, it is no longer effective, but

nevertheless the ground effect disappears according to the method. This may lead to an increase in noise behind the screen which does not agree with our usual understanding of the physical world. An improvement of the method is needed.

Buildings are regarded as double screens when the distance between the screens is more than 20-30% of the total distance from source to immission point. As the insertion loss for a single screen is limited to 20 dB and the insertion loss for double screens are limited to 40 dB, substantial discontinuities can be observed in the noise contours when the immission point moves away from a building. Fig. 4 shows the result of a calculation in a 1 m x 1 m grid in a case with one source at a height of 2 m above ground and two parallel screens 5 m from the source and 5 m apart from each other. The ground is acoustically hard. The heights of screens No. 1 and 2 are 6 m and 10 m, respectively. The calculation height is 1.5 m above ground.

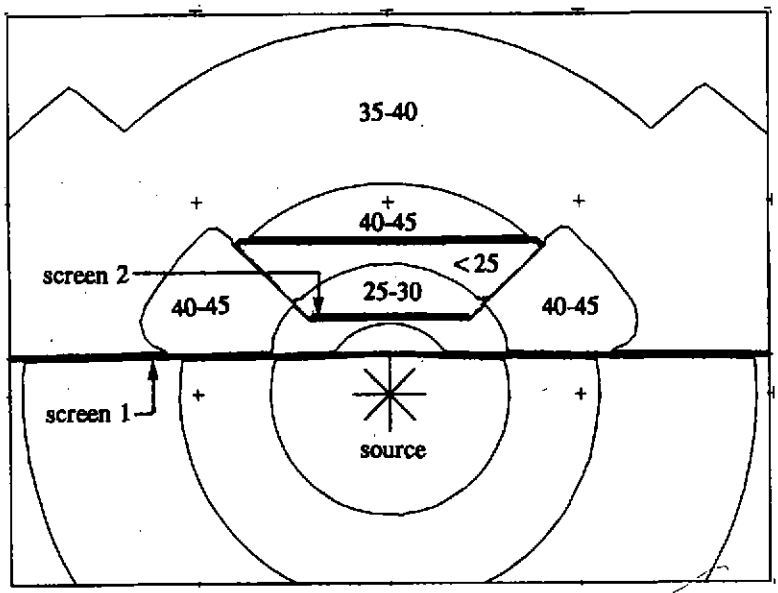

Fig. 4 Noise contours showing the effect of double screening according to the Nordic method calculated with SoundPLAN.

From the figure it is seen that 25 m from the source perpendicular to the screens a large discontinuity of 20 dB is introduced. No modification has been made to deal with this in SoundPLAN, but it shows the need for an improvement of the Nordic method.

6. DISCUSSION AND SUMMARY

The joint Nordic methods were developed at a time when calculations were done for only a few immission points. Our test has indicated that the methods need to be revised and adapted to be able to calculate noise contours with an appearance that agrees with our physical understanding of acoustics.

Colour maps with noise contours has a tendency to be more trustworthy than a few numbers in a table and some text. At the same time they can be more difficult to verify. This emphasizes the need for a standardized test procedure. One suggestion for such a procedure could be to prepare a number of standard test cases which the software should be able to calculate with a deviation from a reference less than 0.2 dB in octave bands.

The testing showed that it is not always possible to calculate strictly according to the joint Nordic methods, and therefore a few minor modifications of the methods had to be made in SoundPLAN. In other situations calculation strictly according to the method leads to noise contours with non-physical discontinuities as for calculation of double screening using the Nordic method for calculation of environmental noise from industry. No modifications have been made in SoundPLAN to deal with this, but improvement of the Nordic method is needed.

Acknowledgment

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References

[1] "English Users Manual for SoundPLAN", 1996, Braunstein + Berndt Int., Leutenbach, Germany.

[2] "Prediction Method for Road Traffic Noise" (in Danish), Report from the Danish Road Directorate, Report 93, 1991.

[3] "Calculation of Environmental Noise from Railways' (in Danish), Danish Environmental Protection Agency Guideline No. 5/1985

[4] "Calculation of Industrial Outdoor Noise" (in Danish), Danish Environmental Protection Agency Guideline No. 5/1993.

[5] ILYD Program developed by DELTA Acoustics & Vibration, Lyngby, Denmark.

[6] NBSTOY Program developed by SINTEF-DELAB, Trondheim, Norway.

[7] JLYD Program developed by DELTA Acoustics & Vibration, Lyngby, Denmark.