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NOISE IMPACT OF INDUSTRIAL PREMISES NEAR RESIDENTIAL AREAS IN A COMPLEX TOPOGRAPHICAL SITUATION

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1. INTRODUCTION

The legal requirement of Environmental Noise Impact Statement for industrial premises and large infrastructures is often accomplished by applying theoretical models to predict the pattern of the sound field for a given configuration of source and boundary conditions.

The modelling process for E.I.S. purposes we have adopted can be used to predict the impact associated both to new facilities and to proposed changes of the existing ones or to extrapolate the results of a limited number of field data.

2. MODELLING PROCESS

Generally speaking, the approach to be followed depends on whether it is possibile to test the noise source and/or its environment or the source is not yet existing. In both cases, one should model the noise emission, by a suitable set of elementary sources (point, line, plane), of which are known sound power level and directivity, as well as the propagation, which is affected by vegetation, meteorological parameters, ground interference and barriers, if any.

This paper presents two really faced cases of E.I.S.: the first one to evaluate the noise impact of an existing steel-works and to define the noise control techniques to be adopted, the second one for a stone-work factory to be built near a residential area and along an existing highway.

In both cases, we have applied a computer model, named Environmental Noise Model (ENM)[1].

3. PRACTICAL APPLICATIONS

3.1 A Steel Works In A Suburban Environment

The steel works is located in the industrial area of a town in the North of Italy and is surrounded by other factories and civil dwellings; the area is traversed by a railway and is close to the slope of a mountain. Sound pressure levels were measured both in the near and in the far field, at day and night time.

Noise sources were considered to be: the smelting furnace, the smoke extraction system, the rolling mill, the pickling fans. The measurement locations in the near field were defined according to the dimensions of the sources:

- for "small" sources (i.e. fans), sound pressure levels were measured at 3 to 6 locations, all around them, at a distance of 1 to 2 m. The related sound power level and directivity characteristics were then derived;
- for "large" sources (i.e. the furnace building), a preliminary investigation was

carried out to identify areas of uniform noise emission and for each of these measurements were made to get their sound power level.

On the basis of the near field data, small and large sources were represented as sets of point sources, as it has been observed that ENM, when using linear and plane sources, gives results less precise then those obtained when using point sources. To model the noise emitted by the most important source, the smelting furnace, which is tipically intermittent, only the noisiest 30 minutes of the smelting process were considered and several smelting cycles were measured so as to count for the variability associated with this process. Measurement locations in the far field were considered as "receivers" in which the program computes the energy contribution of each source; the model itself has been calibrated using data measured at locations where the noise emitted by the factory was found to be most relevant. For each source-receiver path, the ground and meteorological parameters were taken into account to model the sound propagation.

Figg. 1, 2 show the comparison between measured and theoretical third-octave spectra at two of the locations chosen for calibrating the model: for this purpose, train passings were neglected.

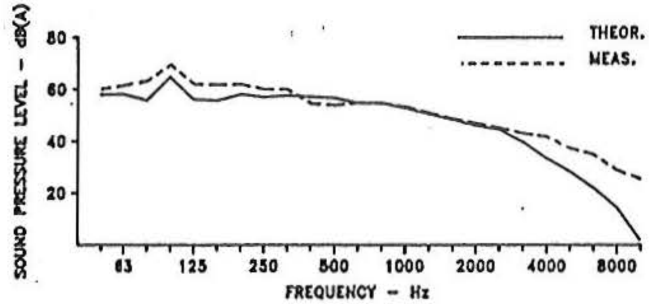

Fig. 1 - Comparison between theoretical and measured third-octave spectra at location 2

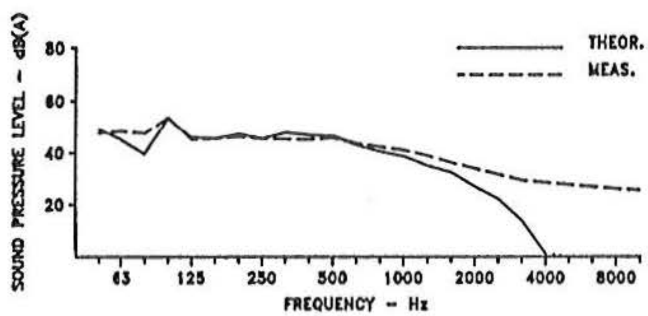

Fig. 2 - Comparison between theoretical and measured third-octave spectra at location 6

Fig. 3 shows the contour levels computed with the procedure outlined from the field data while fig. 4 displays the contour levels predicted when taking into account the proposed noise control techniques, for example the enclosure of the furnace, the silencing of the pickling fans, the improvement of the transmission loss of the walls of the rolling mill.

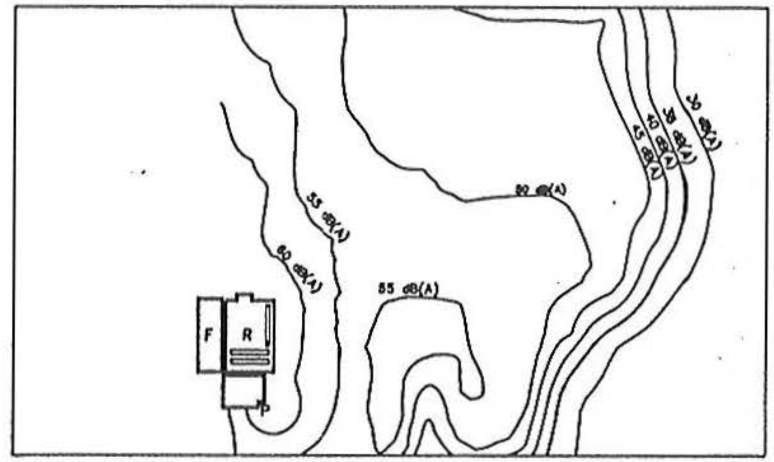

Fig. 3 - Contour noise levels emitted by the steel-works.

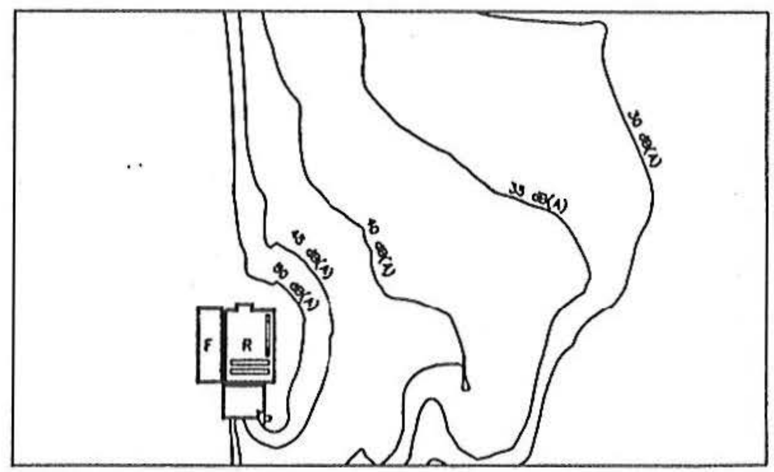

Fig. 4 - Contour noise levels emitted by the steel-works with noise control techniques

3.2 A Future Stone-Work Factory In A Rural Environment

The stone-work factory will be located near the Genoa-Florence highway, in a rural environment and shall be working also at night. There is a residential area at about 300 m; on the opposite side, at about 600 m, there is an isolated mill. E.I.S. for the future factory is requested as a mean to identify the noise control techniques that should be adopted to minimize the impact of the factory on residential houses. In this case, for the modelling process, two main sources are to be considered: the stone-work factory and the highway.

As for characterizing the first one, sound power levels of the machines which will be placed into the factory were measured at another site, while measurements of highway noise as well as of traffic flow were made at day and night time at the investigated site.

In order to estimate the contribution of highway noise in different traffic conditions (i.e. at night, during summer time, etc.), a computer model, ITST2, based on STAMINA 2.0 and developed by a joint research project of Modulo Uno and Vanderbilt University (TN, U.S.A.), has been applied to represent the noise impact of the traffic on the nearby highway[2]. ITST2 computes, on the basis of the traffic flow parameters for each vehicle class, such as the number of vehicles per hour and their average speed, the overall dBA-level at each receiver.

The Data-Base of reference levels L_o (max dBA-level measured at a distance of 15 m during the passby of each vehicle) was gathered along an Italian highway; at present, there are three vehicle classes (cars, medium and heavy trucks), as in the original U.S. model, but their height as well as their emission equations have been modified on the basis of Italian data.

In the ITST2 model the sound propagation is considered as being affected by:

- the geometry of the "source-receiver system", being the source one of the linear segments into which the highway is divided;
- the "alpha" and the "shielding" factors, taking into account respectively the attenuation due to the vegetation and the interference with the ground (alpha) and the presence of shielding elements, if any (shielding);
- the presence of natural or man-made barrier (the attenuation is computed following the Kurze-Anderson approach).

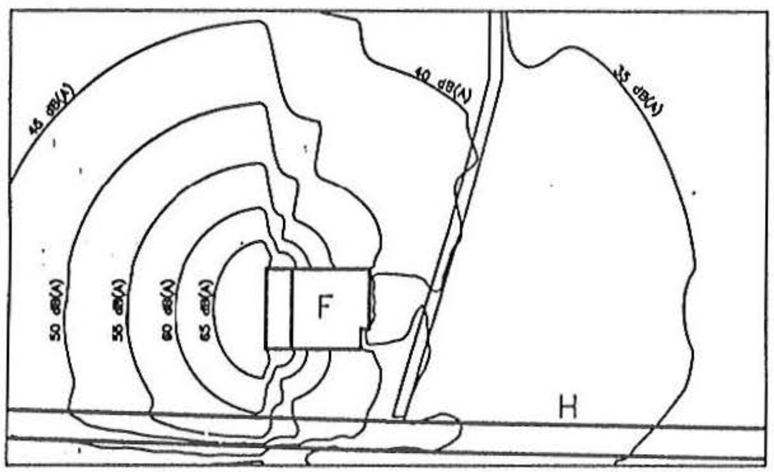

Fig. 5 - Contour noise levels emitted by the stone-work with noise control techniques

Previous investigations show that ITST2 fits well at short distances (up to 100 m) at regular sites, that is with flat or uniformly sloping terrain; it should still be improved as regards the representation of more complex sites and the interference of sound waves with the ground which strongly affects long range propagation.

By comparing measured and theoretical dBA-levels, input parameters of ITST2 have been adjusted in order to have a good representation of the real traffic noise emission. As for the noise emitted by the factory, on the basis of our acoustical design it was supposed that the noise should mostly be emitted by the main doors and the roof, so these were the items modelled as sets of point sources.

The contour levels resulting from the factory in normal operating conditions are displayed in fig. 5; fig. 6 refers to highway and factory noise.

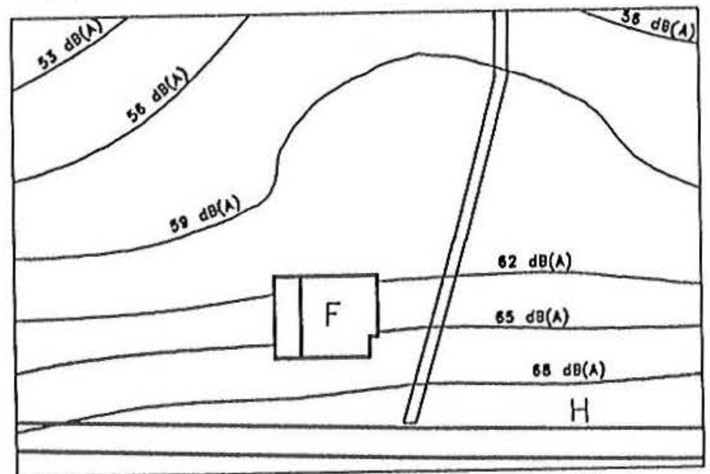

Fig. 6 - Contour noise levels emitted by the stone-work with noise control techniques and the highway

4. CONCLUSIVE REMARKS

The procedure followed proved to be effective as a predictive tool for Environmental Impact Statement. Still, some algorithms should be improved, namely:

a) the sound attenuation due to the interference of sound waves with the ground is computed, according to the Van der Pool equation, on the basis of a single paremeter of the ground, the flow resistivity σ [rayls] and taking into account only the first reflection[3]. In the reality, terrains are much more complex and it is incorrect to estimate the ground interference effects by considering a simple reflection; thus the attenuation computed by the program needs often to be someway smoothed in order to be more representative of the real situation;

b) the barrier attenuation, computed as suggested by Kurze-Anderson, is not always correct, since it does not take into account the shape of the barrier, the ground cover at each side of the barrier[4], the lateral edges diffraction;

c) the program suits better a "long-distance" E.I.S.; however, it can be successfully applied also at shorter distances provided that an array of point sources, instead of linear and plane sources, is used to model the real noise sources;

d) the atmospheric absorption at high frequencies is such that the predicted levels are much lower than real ones in this frequency range. The existence of background noise sources (even if not distinguishable) should therefore be considered in order to reach a better approximation in the whole frequency range;

e) the directivity of each source is now computed according to the related international standard, from sound pressure levels measured at many locations all around the source; yet, for some type of noise emetting elements (i.e. windows), this computation could be more easily accomplished by applying a relationship derived from experimental data[5].

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THE INFLUENCE OF SHAPES AND DEVELOPMENTS OF TOWN SETTLMENTS ON THE ACOUSTIC QUALITY OF URBAN AREAS

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Specific character of architect's work forces him to take a complex view at an urban establishment being designed.

Apart from usefulness and aesthetics of urban settlements being designed, the architect should take into consideration a number of factors decisive about the quality of the created environment what is linked with separate branches of science of the requiring a specialized study.

A choice of an optimum establishment requires some compromise from the architect. In order to weight which of the factors decisive about the quality of a designed urban settlement is more essential, the architect should be given a possibility of evaluating himself at first, leaving the rest of the details to specialists.

Treating noise as one of these factors the task was to test whether it was possible to evaluate the whole urban settlements, typical for the trends in the world architecture and separate those urban elements which are decisive about the acoustic quality of a given settlement.

The investigations have been held as model ones using the optical method for the most typical shapes of urban interiors, characteristc for the trends in world's town-planning. Out of the study available and newly designed settlements the conclusion is that main elements varying the interiors but likely to have some influence on the acoustic quality are:

- proportions between the open space of settlement and height of adjacent buildings,
- shape of settlement,
- kind of development /continous or dispersed/.

Selecting most typical settlements two types of housing estates have been distinguished: the "nest" type /fig. 1/, which has the shape of a square with equal sides of undeveloped area /a=b/ and the "street" type, having the shape of a rectangle with the following proportions of height of development to the open space: a=2h to a=5h.

The urban interiors with the proportion a=5h, preferable because of illumination, have been found optimal from the point of view of acoustics. For the interiors with these proportions the study has been made on the influence of every