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RAILWAY NOICE IN URBAN AREA: A REAL CASE STUDY IN CATANIA CITY.

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Abstract

To find suitable tool able to characterize in acoustical way a particular area of city crossed by railway, which adds its noise impact to that one caused by road traffic, people carried out a research aimed at evaluation of noisiness resulting from railway, crossing Catania city and called "Circumetnea", to the aim to evaluate also the consequences on health of exposed inhabitants with reference to acoustical safety limits fixed by Decree of President of Italian Republic (DPR) 18.11.1998 n°459.

The paper wants to show:

- the method and the procedures adopted in research;
- the test of a software, forecasting the features of railway noise in the investigated zones, to know if it can be really used as valuable tool in this particular case of urban environment;
- the results of research with reference to acoustical impact produced when railway crosses areas of city with intensive building.

METHOD AND PROCEDURES OF RESEARCH

The research has been carried out by following steps:

- Choice of urban areas with high density of buildings and crossed by railway (Fig.1).
- Characterization of railway traffic: by the information coming from Circumetnea management, people has been able to know the kinds of trains and the number of daily runs crossing the investigated area.
- Forecasting of railway noise by MITHRA code.

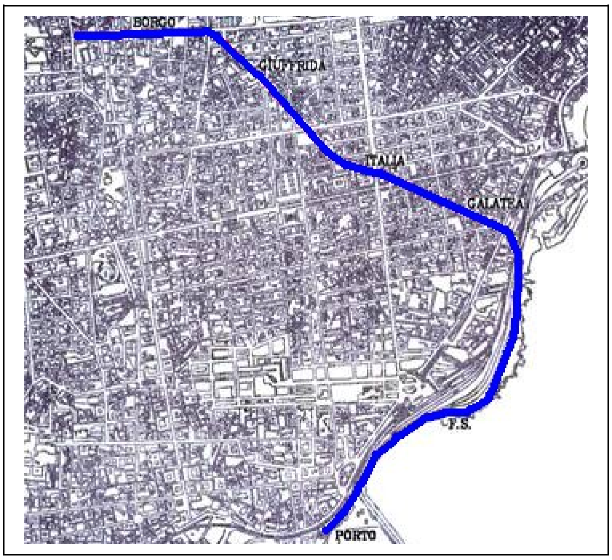

Figure 1 – Urban areas crossed by railway

To forecast acoustical climate of investigated area, people used the MITHRA software [1], built by Centre For The Science And Technology Of Buildings (CSTB) of Grenoble, following a procedure organized in several part, as follows:
a – Three-dimensional computerized construction of orography of investigated area complete of buildings and various obstacles tosound diffusion.
b – Acquisition of meteoclimatic parameters (T, ϕ, wind velocity) registered by public environmental steady station located in investigated area.
c – Characterization of surfaces both of delimitation of fixed obstacles and ground to noise diffusion by means of sound absorption and/or reflection coefficients.
d – Choosing of characteristics of noise source in function both of length and composition of each train.
In the choices people took in account the railway noise is characterized by noise levels suddenly increasing during phase of approach of train to the receptors and vice versa (Fig. 2).

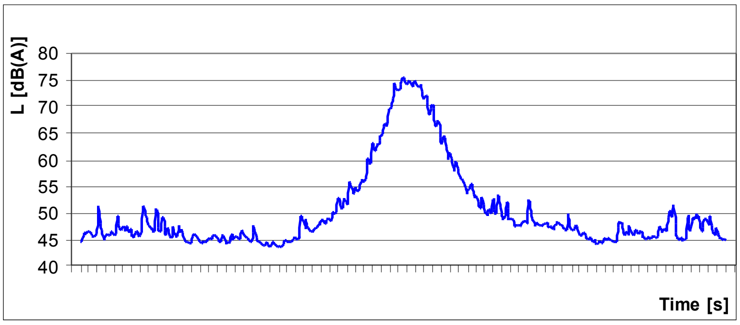

Figure 2 – Temporal evolution of railway noise

People took in account too railway noise is function of velocity of transit, kind of train and features of unballasted permanent way (superstructure).
On the basis of previous consideration people used following formulas:

- the variation of sound power in function of train velocity, given by [2]

$$Lw = L_0 + 30\log\left(\frac{v}{v_0}\right) \; [dB] \qquad (1)$$

v_0 = reference velocity *[km/h]*
L_0 = reference level measured at 25,00 m far from rail with $v=v_0$
- the equivalent continuous level, coming from DPR n°459 of 18.11.1998, given by [3]

$$L_{Aeq,\,TR} = 10\log\left[\sum_{i=1}^{n} 10^{0.1\left(L_{AE}\right)_i}\right] - k \quad [dB] \qquad (2)$$

TR = time period of reference (daily or night)
n = number of transit in TR period
k = 47,6 dB(A) in day period (from 6:00 in the morning to 22:00 in the evening)
k = 44,6 dB(A) in night period (from 22:00 in the evening to 6:00 in the morning)

KIND OF RAILWAY

The Circumetnea is that line linking up Catania city with some other town in Etna area (Fig. 3).

Figure 3 – Circumetnea railway

The superstructure in investigated zone shows rails type 36 UNI and sleepers durmast (Quercus sessiliflora) rested on ballast layer. The locomotives are kind ADE 21/25 (Fig. 4) and RAL 64 (Fig. 5), both working respectively with diesel and electric engine.
Commercial velocity of this line is 35 km/h, whilst the biggest one is 60 km/h.

Figure 4 – Locomotive kind ADE

Figure 5 – Locomotive kind RAL

EXPERIMENTAL TESTS

During the whole period of use of railway trade (from 6:00 in the morning to 22:00 in the evening) and during two weeks, people measured Leq by phonometric equipments in three different receptors Ri (Fig. 6):

- R1 point: d= 1,00 m from facade of "Sammartino Pardo" school and h= 4,00 m from ground;
- R2 point: d= 7,50 m from rails and h= 1,50 m from ground in free field condition (absence of obstacles to sound diffusion);
- R3 point: d= 1,00 m from facade of one building and h= 4,00 m from ground.

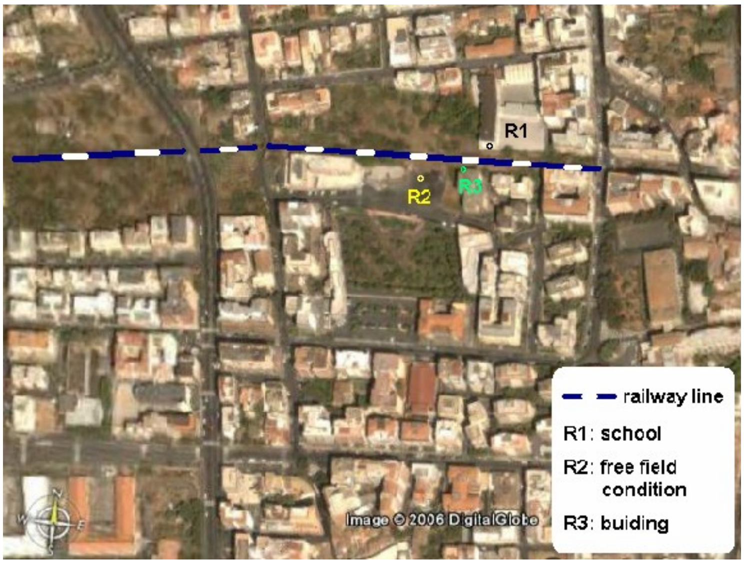

Figure 6 – Investigated area

The equipment used by people to measure has been an Real Team Analyser Norsonic AS 118, class I and one calibrator class I too. Phonometer has been planned in the way to let the identification for each travelling train both of L_{AFmax} *"maximum sound* *level"* (Fig. 7) and L_{AE} *"sound exposure level"* (Fig. 8).

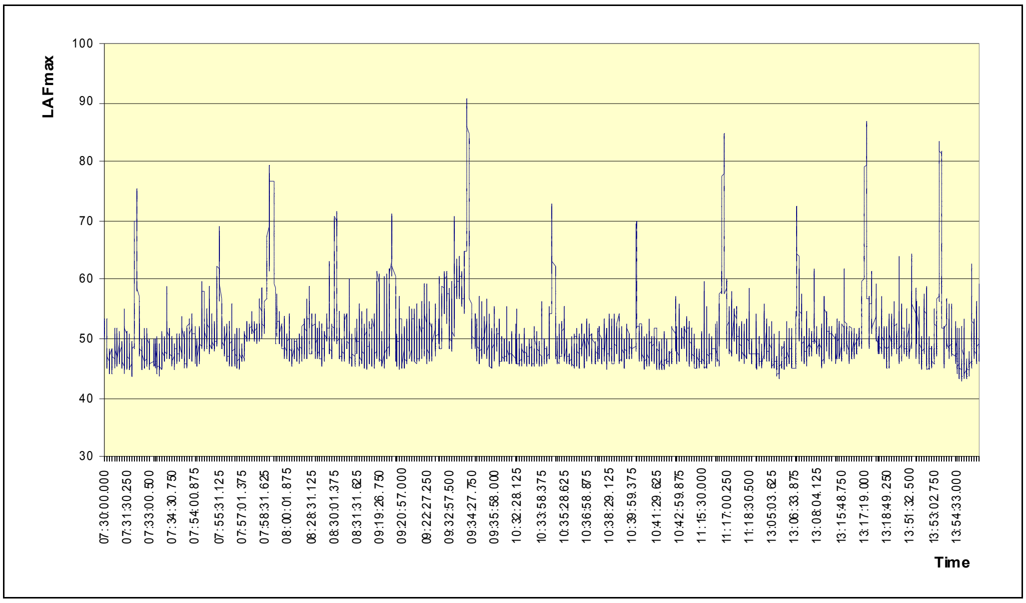

Figure 7 – Temporal evolution of maximum sound level

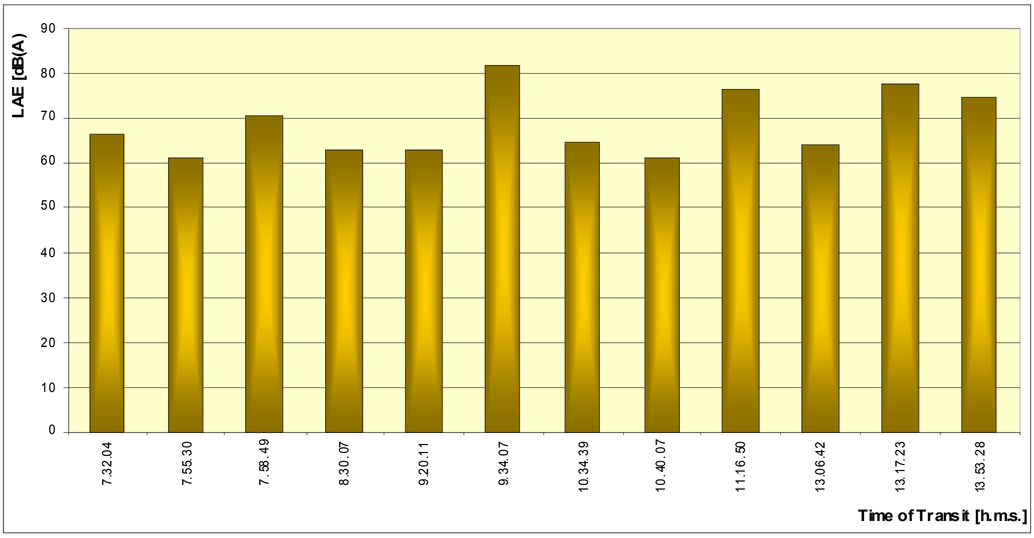

Figure 8 – sound exposure level values for each travelling train

RESULTS

Table 1 shows the trend of L_{AE} and L_{AFmax} in function of trains in transit along the line.

Table 1 – Characteristics of categories of train in transit along the line

TRAIN	NUMBER OF TRANSITS	L_{AE} dB(A)	$L_{AF\ MAX}$ dB(A)
1	11	62,6	71,4
2	9	66,5	75,5
3	3	≤ 75,0	≤ 84,1
4	6	>75,0	> 84,1

Table 2 shows spectrum of emission of each category of locomotive.

Table 2 – Spectrum of emission of locomotive

CATEGORY	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
1	**93,6**	**88,6**	**86,5**	**82,5**	**78,1**	**77,1**
2	**97,9**	**93,8**	**90,5**	**85,0**	**82,0**	**80,9**
3	**93,4**	**91,0**	**92,2**	**92,8**	**86,3**	**87,9**
4	**103,7**	**99,8**	**101,5**	**103,6**	**94,0**	**90,5**

Table 3 shows the octave band spectrum of global sound power.

Table 3 – Spectrum of global sound power

LW/m	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
59,6 dB(A)/m	**29,1**	**59,1**	**55,1**	**55,7**	**57,2**	**48,2**	**45,6**	**15,6**

Figures 9-10-11-12 shows some maps of trend of isophones in investigated areas both in horizontal and vertical section at different heights from ground.

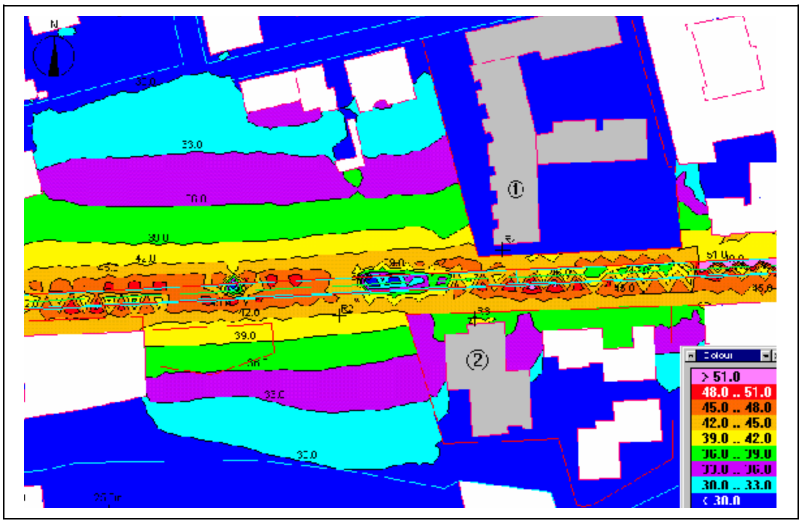

Figure 9 – Horizontal map of isophones at height of 1,80 m from ground

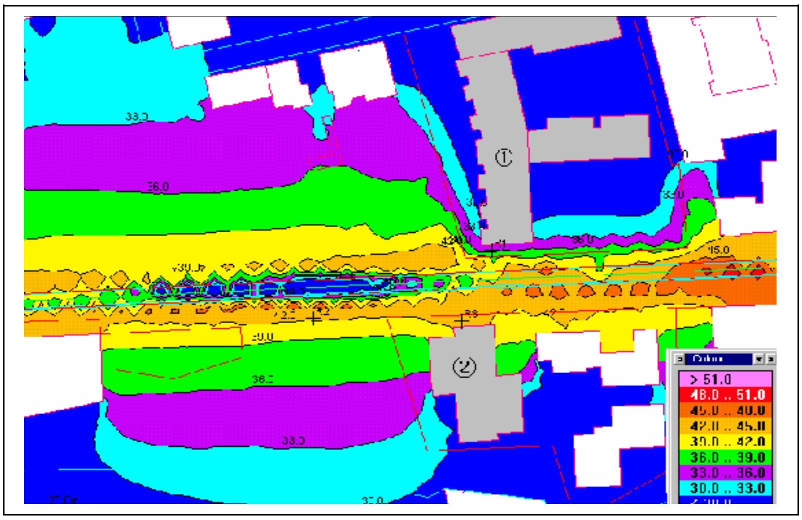

Figure 10 – Horizontal map of isophones at height of 4,00 m from ground

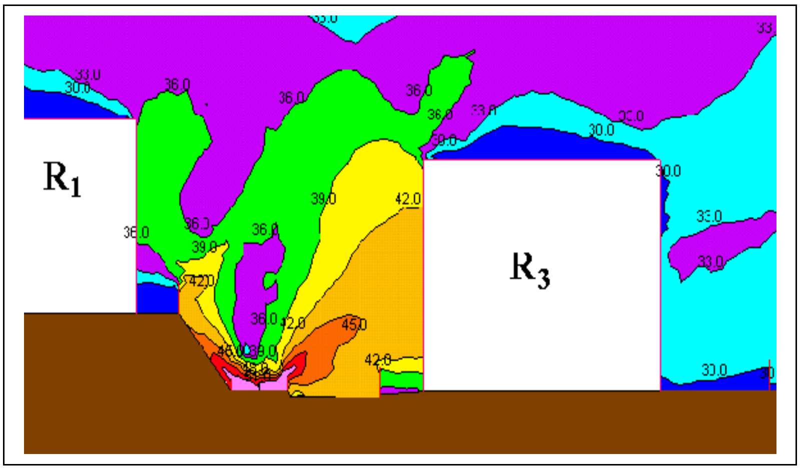

Figure 11 – Vertical map of isophones

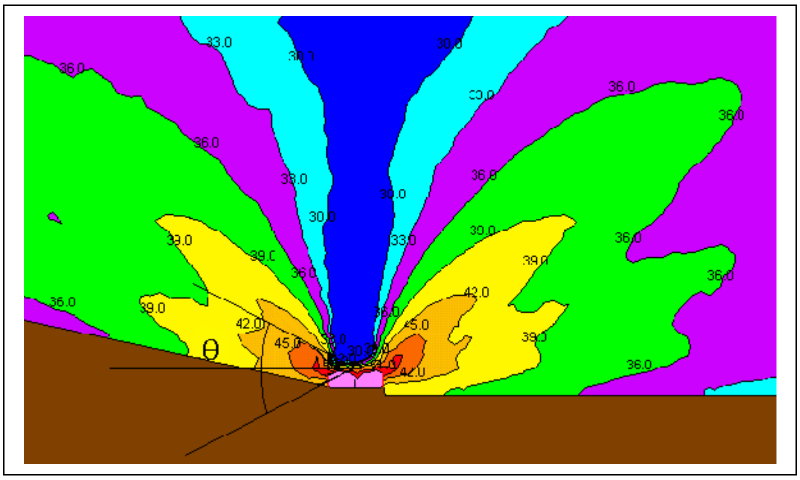

Figure 12 – Vertical map of isophones in free field condition

Table 4 shows data regarding comparison between values of Leq_{TR} coming from measurements in situ and that ones fixed by Decree for that typologies urban areas.

Table 4 – Values of Leq_{TR} coming from measurements and limits fixed by DPR n° 459

RECEPTORS	VALUES MEASUREMENTS dB(A)		LIMITS FIXED BY DPR 459 dB(A)
	AVERAGE	DIFFERENCE	
R1 - school "Sammartino Pardo"	36,9	± 1,1	50,0
R2 - free field condition	41,7	± 1,3	70,0
R3 - building	37,5	± 0,9	70,0

Table 5 shows data regarding comparison between values of measured Leq and that ones forecasted by MITHRA code.

Table 5 – Values of Leq coming from measurements and forecasting values

RECEPTORS	Leq MEASURED dB(A)	Leq FORECASTED dB(A)	Δ dB(A)
R1 - school "Sammartino Pardo"	36,9	36,8	**0,1**
R2 - free field condition	41,7	40,8	**0,9**
R3 - building	37,5	36,6	**0,9**

CONCLUSIONS

- By analysis of data coming from table 4 it is possible to affirm that sound levels of investigated area observe that ones fixed by regulations (DPR n°459).
- By analysis of data coming from table 1 it is possible to notice that both trains n°3 and n°4 are much more noisier than that one of n°2 and n°1.
- By analysis of data coming from table 5 it is possible to affirm that MITHRA code is a tool quite able to forecast the acoustical climate also originate by railway noise in urban inhabited area. In fact in all tested situation the difference between forecasted data and that ones measured is quite less than 1,00 dB(A).
- The results coming from research can be utilized both as tool to evaluate sound levels in correspondence of sound receptors situated in the zones of pertinence and to build isophone maps in all area adjoining railway line ables to evaluate noise impact in the cases of change of the route of rails or in the case of development of service.

REFERENCES

[1] 01dB-Stell USER MANUAL MITHRA.

[2] D. Howard, "Acoustics and Psychoacoustics", BUTTERWORTH HEINEMANN.

[3] DPR n°459 del 18.11.98.