A shaped shielding in office block environment

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***Abstract*— The increase of wireless systems in big cities has brought its consequences. In Buenos Aires, for instance, many FM broadcasting transmitting antennas are installed on top of high buildings. Some of these are only office buildings, but some others have also apartments. In general, the main FM broadcast stations have very high power transmitters, with powers beyond 20kW and arrays of antennas with 6 or more cross-field elements.**

This situation becomes more complex when the top of the building houses many radiation systems and when the electromagnetic field levels existing within the offices or the apartments on the top floor surpass the limits established in the Non-Ionizing Radiation national protection guidelines or cause electromagnetic interference problems. When there is no possibility for decreasing the transmitters' power, a proper shielding can be the solution to attenuate these field levels below the guidelines limits.

This paper compares the performance of two different shieldings designed to attenuate field levels in the top floor of "Tower MOP", in Buenos Aires, by examining their simulated and measured results.

Keywords-shielding; antennas; protection; guidelines.

I. INTRODUCTION

One of the highest buildings in Buenos Aires downtown is the "Tower MOP" "Fig.1", which has 24 floors and is located in a favorable site for broadcast services to cover downtown area. In fact, its top houses two over–the–air T.V transmitting stations and an important F.M broadcast station "Fig.2".

Figure1. Tower Mop

Figure 2. FM Broadcast antenna (right) and TV antenna (left), on top of Tower MOP.

In 2007, in a periodic Non-Ionizing Radiation (NIR) measurement performed at the top of the building and inside the offices of the top floor, there were found, within these offices, some Electric and Magnetic field values that exceeded NIR limits, all nearby the FM antenna; suggesting that the main contribution to the total electromagnetic field was provided by that source. Aware of this situation, building authorities asked a group of professionals to find a solution for this problem.
The clear target was to attenuate field values below the guidelines limits without transmit power modifications.

II. FIRST STEP: SIMULATION

As the center of the FM array is only 30 meters up from the offices, which implies a near field condition with a complex field distribution, the electromagnetic shielding design had to be supported on software simulation tools that could take into account some of the real environmental obstacles and materials. For this task, "WIPL-D Professional" was used. Because the main contributor to the total field was the FM array, only this antenna was simulated along with a part of the top floor roof where the offices were located, "Fig.3", and the Electric field (E) values were obtained for a diagonal line along "**y**" axis, 2 meters below the roof, which are shown in "Fig.6".

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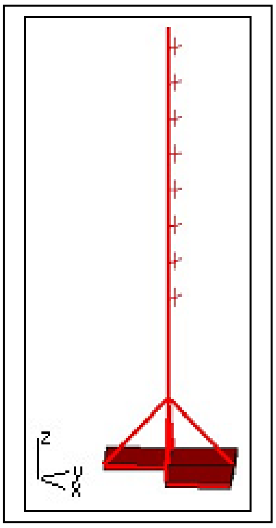

Figure 3. Design of the FM antenna and part of the top floor roof.

In a general case, a good starting point for attenuating the electromagnetic field is to suggest a planar surface of high conductivity [5] like the one simulated in “Fig.4” and which results are shown in “Fig.6”.

After simulating the planar surface with good results, we proposed a wedged shape shielding, “Fig.5”, expecting to reflect a part of the vertical component of the cross-polarized field and thus getting better attenuation. According to the simulation results, shown in “Fig.6”, the wedged shape provided slightly better performance. Therefore, regarding that the model did not completely take into account the real environment, it was known that in situ measurements could somehow differ from the results so far obtained.

III. MAKING AND TESTING A PROTOTYPE

As real problems must be solved in real environments, after finishing the simulation with satisfactory results, the next step was to perform a real test under real conditions. For easy mounting, a prototype with light wooden slats and woven wire mesh was made. Before starting to mount the prototype on the roof, several measurements were performed inside the offices for later comparison.

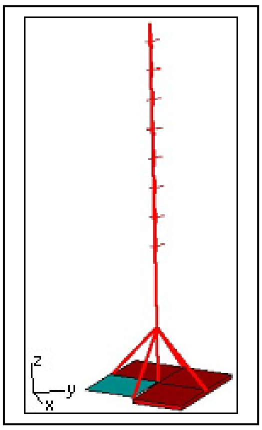

Figure 4. Design of the planar shielding.

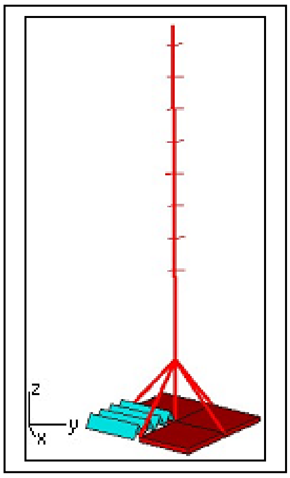

Figure 5. Design of the wedge-shaped shielding.

Another problem to analyse was the situation of the ground system [7]. Unable to simulate the building ground structure because its geometry was unknown, the shielding performance, grounded and ungrounded, was tested in situ, connecting the shielding structure to one of the steel strips from the concrete in the roof.

The best attenuation performance for both fields was found with the high conductive wedged structure with no ground connections (floating). When connected, the currents induced in the metal structure of the building radiate and increase the electromagnetic field inside the offices.

In “Fig.7”, the real size structure of one wedged cell is shown. The complete structure has four of these cells to cover the roof area of the target offices.

IV. THE NIR PROBLEM

The worries of the citizens about NIR produced by transmitting antennas are not new, even more in big cities, where the amount of antennas from a wide communication services (mobile, data links, FM Broadcasting, TV and others) is considerable.

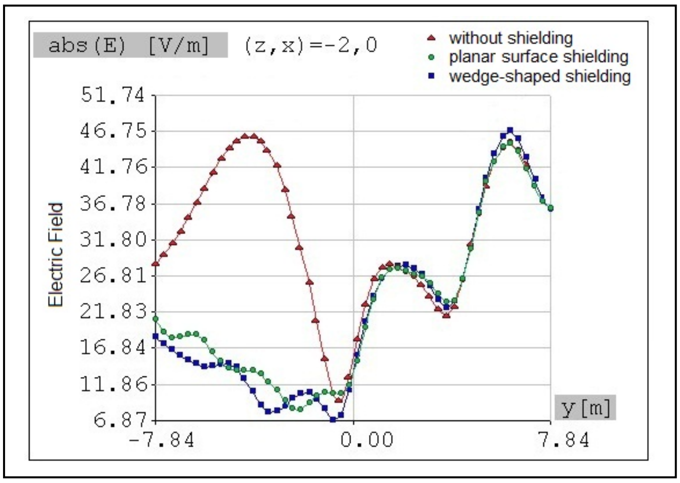

Figure 6. Electric field values, E, simulated for the surface without shielding, with planar shielding and wedge-shaped shielding.

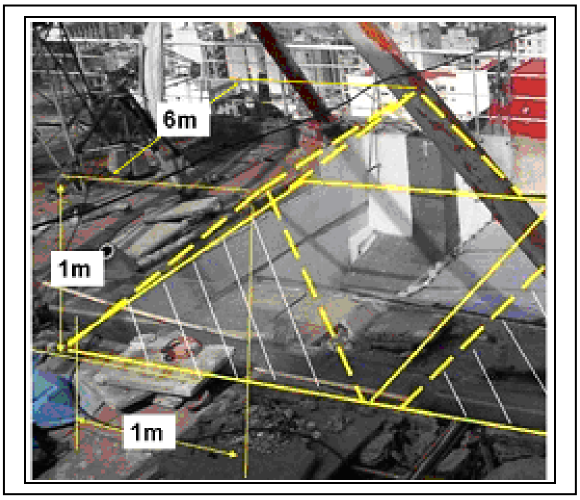

Figure 7. Real size structure of one wedged cell.

When the public demand reached the local government authorities, the first logical step was to promote a big measurement campaign; it meant to trace a radiation map of the city.

Buenos Aires City has a surface area of 203 km^2, 3 million inhabitants and about 700 mobile phone base stations between macro and micro cells, and more than 40 FM broadcast stations.

Day by day, it is becoming more frequent that some people living or working nearby a radiating antenna ask for some information about its potential risks.

Argentina's got guidelines and protocols to verify the level of NIR [2]. The exposure limits guidelines are the same that the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the World Health Organization (WHO) recommend.

For this case, we had to consider the lowest limit for the Electric field, E=27.5V/m for general public. Even though people that can be found in the offices of "Tower MOP" are workers, they fit into this category for NIR guidelines because, in general, they don't know anything about electromagnetic field precautions and they don't have any control over the emission sources.

However, when NIR worries are installed among workers or neighbors nearby any antenna, the best shielding is not enough.

V. THE FINAL RESULTS

The final structure was then isolated from ground, regarding the loss in attenuation efficiency measured when connecting the structure to the ground system. The results of in situ measurements are shown in "Table. I".

According to these results, the slight difference between the planar shielding and the wedge-shaped shielding, obtained with the software simulation tool, became more important in real situation, where the planar shielding was not efficient enough to attenuate the Electric field value below the limit.

TABLE I. IN SITU REAL MEASUREMENTS

Field Measured	**Maximum Field Values According to Different Shielding Conditions**			
	Without Shielding	***Planar Shielding***	***Wedge-Shaped Shielding***	***ICNIRP Limits***
E (V/m)	51	30	< 5	27.5
H (A/m)	0.1	No data[a]	0.017	0.073

a: **H** field was not measured in this case because the **E** field was already exceeded.

As supposed, this could have happened because not enough parts of the environment were taken into account during the simulation process, but it was helpful for time optimization and the objective could be successfully accomplished. Further studies should be carried out in order to identify the main cause of the difference between simulation and measurement results.

For the final structure, our mechanical team took into account some typical weather-proof like aspects as corrosion, rigidity, electrical conductivity and wind resistance. The final structure is illustrated in "Fig.8".

VI. CONCLUSIONS

- High power transmitters, with frequencies below UHF, may cause some NIR or Electromagnetic interference (EMI) problems when located in urban areas.
- When is impossible to decrease the transmit power, shaped shielding can be a solution for certain closed environments.
- The materials used for the shielding and the shielding shape must be thought regarding the geometric field conditions, frequency and power in the area of interest.

Figure 8. Final shielding structure.

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