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ACOUSTIC ENCLOSURE DESIGN FOR A COOLING SYSTEM

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ABSTRACT
The air-cooled water chiller performing for a commercial building is placed at the garden of the building, very close to neighborhood dwellings. The system operates depending on the needs, in a non-predictable regime and it became a nuisance to the neighborhood, especially in summer time. Measurements held while the system was on showed that, noise created by the cooling system was high enough to be clearly perceptible and disturbing. An acoustic enclosure is designed in order to reduce the sound propagation, however as fans need air circulation, a semi-close structure was inevitable. The enclosure consists of concrete panel elements on a metal frame construction. To avoid noise increase due to internal reflections, interior of the enclosure is covered with synthetic grass. Measurements repeated after the treatment has shown that required reduction values are held.

1 - INTRODUCTION

Outdoor mechanical building equipment such as generators and air conditioning machinery, keeps on being a serious noise nuisance for the buildings they are serving but much more for the neighborhood buildings. Those types of building equipment are generally placed at appropriate locations such as roofs or backyards, where they will be out of sight of the buildings they are used for. The need and habit of using those sort of equipment is relatively new in developing countries, so the regulations of some countries such as Turkey, lack specifications on this subject, causing conscious or unconscious negligence. In a lot of cases it is not possible to say that noise is taken as a criteria at the selection and placement of those equipment. Therefore, they generally cause noise problem for neighborhood buildings, especially when different building types such as commercial and residential buildings are situated closely. As a result, a lot of complaint came from the inhabitants of the nearby buildings of such equipment, within the last years.

This paper presents a specific solution to a noise problem caused by a cooling system placed at the garden of a commercial building, in Ankara, Turkey. The problem is examined and observed in-situ and noise sources affecting the situation are determined. There could be different solutions such as, replacement of the equipment with a less noisy one, reinforcement of the sound insulation of the residential building or displacement of the unit to a more appropriate place, however usage of a sound enclosure surrounding the unit has been preferred. An acoustic enclosure is designed in order to provide sufficient reduction, with a semi-open structure allowing air circulation.

2 - ASSESSMENT OF NOISE ENVIRONMENT AND MEASUREMENTS

The commercial building is located at the corner of a main street and a secondary road. Although the secondary road has got relatively few circulation, main street has heavy traffic especially during day-time. Buildings adjacent to the main street shadow the road noise partially, however as the buildings are detached, all the buildings at the second line are also highly affected from the noise of the main street.

The air-cooled water chiller unit, which is the cause of noise disturbance for the neighborhood, is placed at the backyard of the commercial building. It has got 4 fans of 1,65 kW, and the nominal cooling capacity is 233,7 kW. Sound pressure levels of the unit are given as in Table 1, by the manufacturer.

Sound pressure level at 1 m from the unit in free field								
63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dBA
71,0	71,0	72,0	69,5	67,0	63,5	59,0	53,0	72,0

Table 1: Sound pressure levels of the unit.

The system operates depending on the needs, in a non-predictable regime, namely intermittently and at different condition (sometimes 2, sometimes 4 fans functions). It became a nuisance for the neighborhood, especially in summer time; nearby inhabitants complain about the unpredictability of the noise, besides the high levels. The system operates only during working days and hours. As can be seen from Figure 1, distances between neighborhood buildings are small, therefore reflections from the hard surfaces of the buildings cause a certain amount of noise increase. The building, which is mostly affected is of course, the dwelling (shown as R in Figure 1), just behind the commercial building.

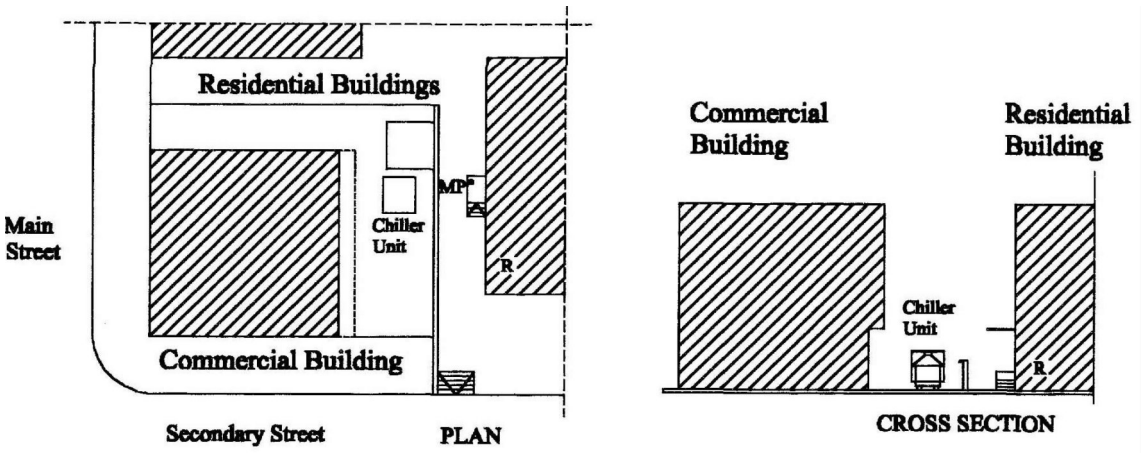

Figure 1: Location of the buildings and measurement point (MP).

Measurements are done according to the Noise Control Regulation (of Turkey) in Leq dBA. Statistical levels are also measured. Bruel&Kjaer Precision Integrating Sound Level Meter (Type 2236), was used. Measurements are held on the point shown as "MP" in Figure 1. First of all, background noise is measured, then for two situation of the units operation, namely 2 and 4 fans working together, source noise has been measured. Results are shown in Table 2.

Measurement situation	Sound pressure levels dBA					
	Leq	L10	L50	L90	MaxL	MinL
Background noise	65,7	65,5	58,5	53,5	90,5	51,0
2 fans operating	67,9	69,5	67,0	64,5	88,1	58,0
4 fans operating	71,4	72,5	71,0	69,5	80,5	66,4

Table 2: Background and source noise levels.

According to the "Guideline values for community noise" of WHO, limit of the permissible level is 55 Leq dBA for outdoor, whereas Turkish regulation permissible levels for that zone is 65 Leq dBA. Although the difference between the values are too high, it is clear that the noise environment of the zone is out of the acceptable levels, even without the noise of the chiller. However, it is also obvious that, operation of the equipment creates a perceptible difference that causes annoyance.

3 - DESIGN OF THE ENCLOSURE

At the design of the enclosure, the target was to reduce the noise of the equipment below the background noise, in this case. The main difficulty was the closeness of the unit to the buildings. On the other hand openings that should be left to allow the air circulation, would diminish the effectiveness of the enclosure. The low frequency components of the unit cause also an important problem.
The enclosure is designed as constituting of 24 mm concrete panel elements having 30 kg/m^2 mass per unit area and a STC of 35 (value provided by the manufacturer), over a metal frame construction. Openings

are left at the top of the fans, however in order to shield the noise, panels have been lengthened and fortified with side barriers (Figure 2). A slope is given to the lengthened panels used over the openings, in order to decrease the sound energy propagating towards the residential building. However it is obvious that this detail will provide a limited benefit for low frequency components.
To provide absorption, synthetic grass (used for football fields) are chosen; this material is of course not designed for sound absorption, however its physical structure seems to be appropriate to absorb sounds of high and middle frequency range. Use of synthetic grass has also an obvious benefit because of the resistance of the material to the open-air conditions. Walls of the enclosure have been covered with two sort of synthetic grass, one with short and dense leaves and the other with long and sparse leaves to unable the absorption of different frequency ranges. Those two types of synthetic grass sheets have been screwed in place as bands of 50 cm. Reflective facade of the building is also covered with this material in order to decrease reflections.
Detail of the enclosure construction is given at Figure 3. The grid system's outside surface is covered with another panel, lighter then the other one.

4 - EVALUATION AFTER PRECAUTIONS

Measurements are repeated after the construction of the enclosure. Table 3 shows Leq dBA and statistical levels, measured at outdoor (at the position of the first measurement) and at indoor (at the 3rd floor).
It is clear that levels are not below 55 Leq dBA level required by WHO, for outdoor. However taking into consideration traffic noise level which is already over this limit, it is not feasible to decrease the level below the background noise. Noise of the chiller unit is only 0,3 dB over the background noise, for the measurement situation; taking into consideration the fluctuations of both sources and the closeness of the levels, it can be accepted that, noise of the unit does not affect the background level. WHO's recommendation for dwelling indoors is 55 Leq dBA, whereas Turkish Noise Control Regulation's limit for living spaces of dwellings in towns is 60 Leq dBA. Measurements held at the mostly affected space of the building show that levels are clearly below from both of them, although an increase of 1,5 dB is determined while the unit is operating.
On the other hand, same evaluations can not be done for L90 and MinL levels, where there is still a clear increase caused by the unit, going up to 11 dB, although a decrease of 4 dB is detected, compared to the initial situation.

Measurement situation	Sound pressure levels dBA					
	Leq	L10	L50	L90	MaxL	MinL
Background noise (outdoor)	**65,4**	64,0	58,0	53,5	83,7	51,0
4 fans operating (outdoor)	**65,7**	65,0	65,0	64,5	70,8	62,5
Background noise (indoor)	**44,1**	47,0	43,0	38,5	52,8	33,4
4 fans operating (indoor)	**45,6**	47,0	45,5	44,5	53,0	42,7

Table 3: Background and source noise levels.

The efficiency of the enclosure depends on the openings left to provide air circulation, however measured levels show that limits given in regulations are held, although ideal condition is not reached for outdoor.

5 - CONCLUSION

Noise caused by mechanical building equipment is one of the sources of annoyance for the people living in neighborhood buildings. In order to reduce the unwanted effects of those sort of outdoor mechanical equipment, regulations should be more evident and strict.
In this case, high noise of the environment and high level of regulations limits, helped the solution. Outdoor and indoor noise levels are shown to be within the acceptable levels given in regulations, after the implementation of the enclosure. Levels are within the limits of regulations, however people living in the area can still be disturbed from the unit's noise. This fact can be explained by the difference detected at L90 and MinL. As a conclusion it could be said that, not only the limit values but also noise indicators used in regulations, still need to be justified, in order to show better correlation with people's responses.

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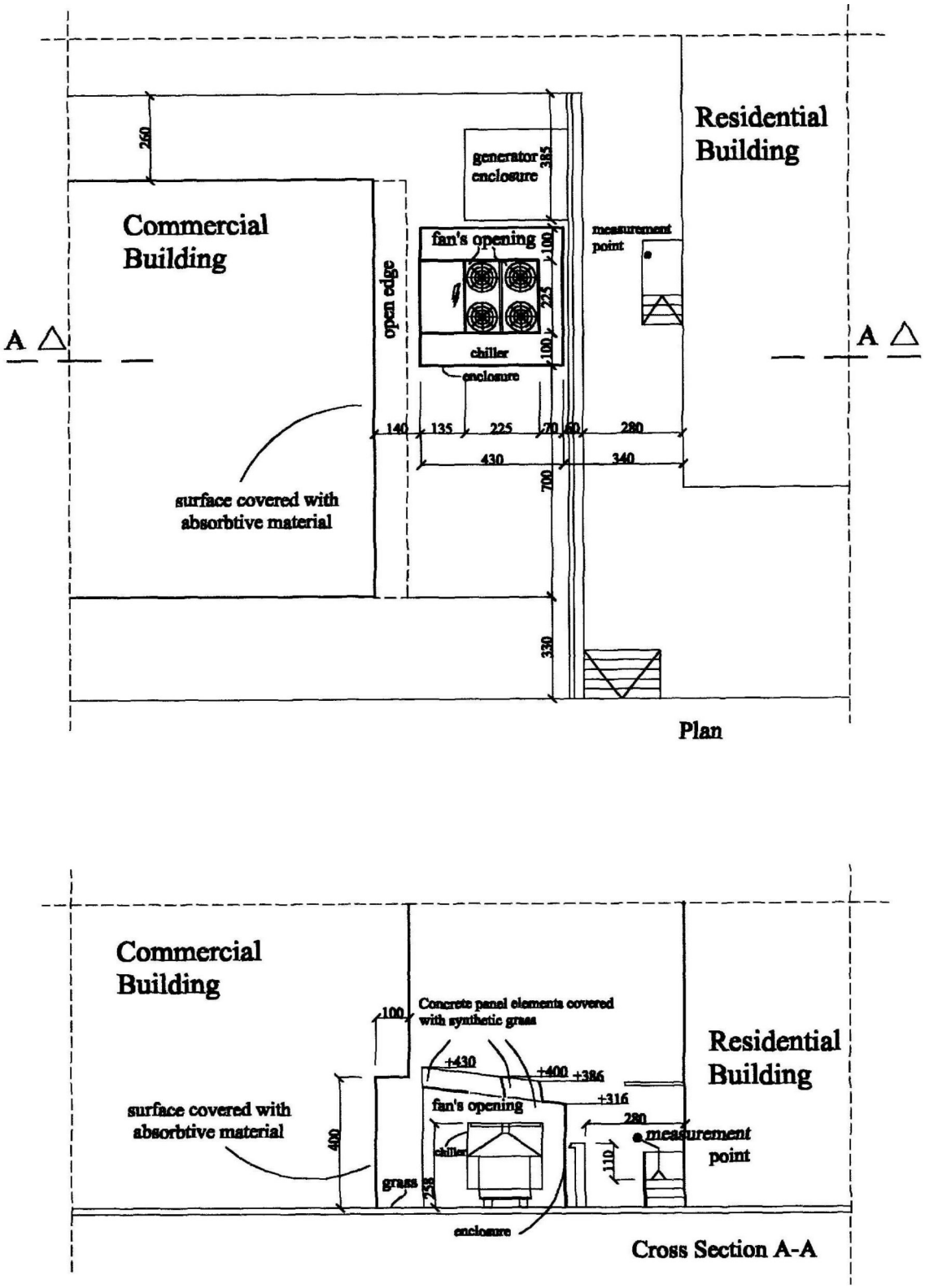

Figure 2: Plan and section of the enclosure.

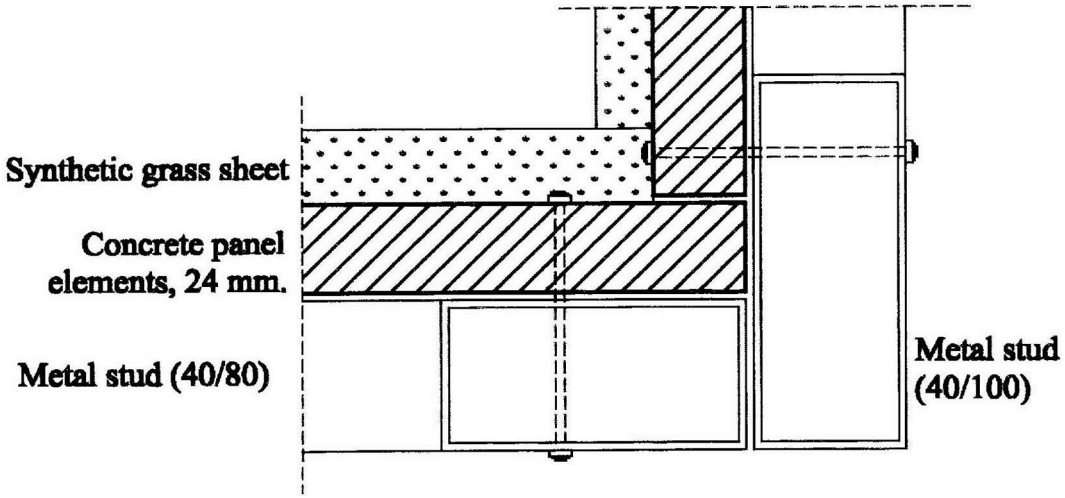

Figure 3: Detail from the enclosure.