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EFFECTIVENESS OF NOISE BARRIERS TILTED TOWARDS THE TRAFFIC WAY OVER BRIDGES

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Abstract

Traffic noise over bridges and its impacts can be substantially reduced with road side barriers. A single barrier erected on one side of a bridge way can often provide the most effective solution. A single barrier may not always be sufficient, particularly in urban sittings. In these cases, barriers may be necessary on both sides of the bridge. This paper presents a study of the effectiveness of barriers tilted towards the traffic way with different angles and shapes to reduce the effect of the reflected sound waves from the second barrier. The insertion loss was determined at many points distributed horizontally and vertically behind the barrier.

1. INTRODUCTION

Many papers studied the change in sound levels experienced when a barrier was inserted into the acoustic propagation path. The performance of different barrier design is amenable to investigation by acoustical scale modeling.

In 1979 R. N. Foss [1], described an accurate method for calculating the attenuation effect of two cascaded thin screens on the sound from a point source. The formula was derived empirically from data obtained from model experiments at 5kHz and 10kHz.

Christopher W. Menge (1980) presented studies of the effectiveness of barriers sloped away from a highway [2]. Studies have suggested that noise barrier faces sloped away from a highway could eliminate or reduce the reverberant build up of sound energy that occurs between parallel barriers. Poor performance was obtained when the barriers were vertical (0 degrees). As the barriers were sloped back, however, the insertion loss increased to a maximum at 10 degrees of slope and dropped to lower values at greater angles.

In 1985, D. A. Huchins et al [3], investigated barriers insertion loss as a function of frequency in a parallel configuration. Inclined barriers, showed higher overall insertion loss than the upright barrier, and differences in detail were observed arising from the direction of inclination.

In 1995, G. R. Watts [4], carried out many tests on several different parallel barrier configurations to assess, I) the magnitude of the degradations in screening performance produced by parallel barriers under full scale controlled conditions and II) to identify barrier designs which could reduce this problem.

In 1997 D.C. Hothersall and S.A.Tomlinson [5], studied the effects of the high vehicles on the performance of noise barriers. It has been suggested that $\theta = 10°$ is a suitable angle to adopt for parallel barriers in many situations to reduce reflected sound to an insignificant level at typical source and receiver positions.

The effectiveness of a barrier depends on how well it diffracts and absorbs the noise. A high performance barrier has negligible noise transmission and reflection. This is controlled by its sound insulation and absorption. [6].

2. SCALE MODEL TEST

The scale model was made of wood covered with polished plywood to ensure a totally reflective surface was provided.

Scale ratio of 1:4 was chosen for the barrier dimensions. The height of the model was 50 cm, which corresponds to two meters in real barrier. The scale model was designed to be used on one side or on both sides of the roadway performance at angles of 0, 10, 12.5, 15, 17.5, 20, 22.5 and 25 degrees inwards from vertical. Barriers configurations are illustrated in figure 1.

3. MEASUREMENT PROCEDURE

The sound pressure level measurements were carried out to determine the optimum design of the many barrier configurations examined. The microphone was positioned behind the barrier, at four measuring levels of heights 12.5, 25, 37.5, and 50 cm from the ground which correspond to 0.5, 1.0, 1.5 and 2 meters height of the real barrier.

Measurements were carried out also at distances of 12.5, 25, 37.5, 50, 62.5, 75, 87.5, 100, 112.5 and 125 cm outside from the barrier which correspond to 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5 and 5 meters from the real barrier.

The used sound source was positioned in ground inside a hollow wooden box, without the upper side, of dimensions 50* 50 * 60 cm. The measurements were carried out at frequency range from 400 - 10000 Hz, that is corresponding to 100-2500 Hz in real barrier.

4. RESULTS AND DISCUSSION

4.1 The effect of the tilt angle of the single barrier on traffic IL:

The relation between the traffic insertion loss (IL) value and microphone position behind barriers of different tilt angles, and at height; 12.5, 25, 37.5 and 50 cm is represented in figures 2, 3, 4 &5 respectively.

Figure 2 shows that the IL values at the first microphone position, at each barrier tilt angle, is relatively high because the microphone in that position is completely shielded from the source. Then IL value decreases with increasing the distance from the barrier. That was expected due to the less shielding rate of the microphone. At each microphone position the IL decreases with increasing the tilt angle. This can be attributed to that, with increasing the tilt angle, the barrier elevation, and consequently its IL decreases.

Figure 3 shows that the IL values just behind the barrier, for all the tilt angles, are high due to the completely shielded zone. At the next positions, mainly up to the fifth microphone position, the IL decreases as getting far from the barrier. This can be attributed to the decrease in the shielding rate at that region. After the fifth microphone position, where the microphone lies out of the shielding zone, the IL value becomes almost constant for each barrier tilt angle. The figure shows also that at any microphone position the IL value decreases with increasing the barrier tilt angle. This is attributed to the relation between the elevation of the barrier and its tilt angle.

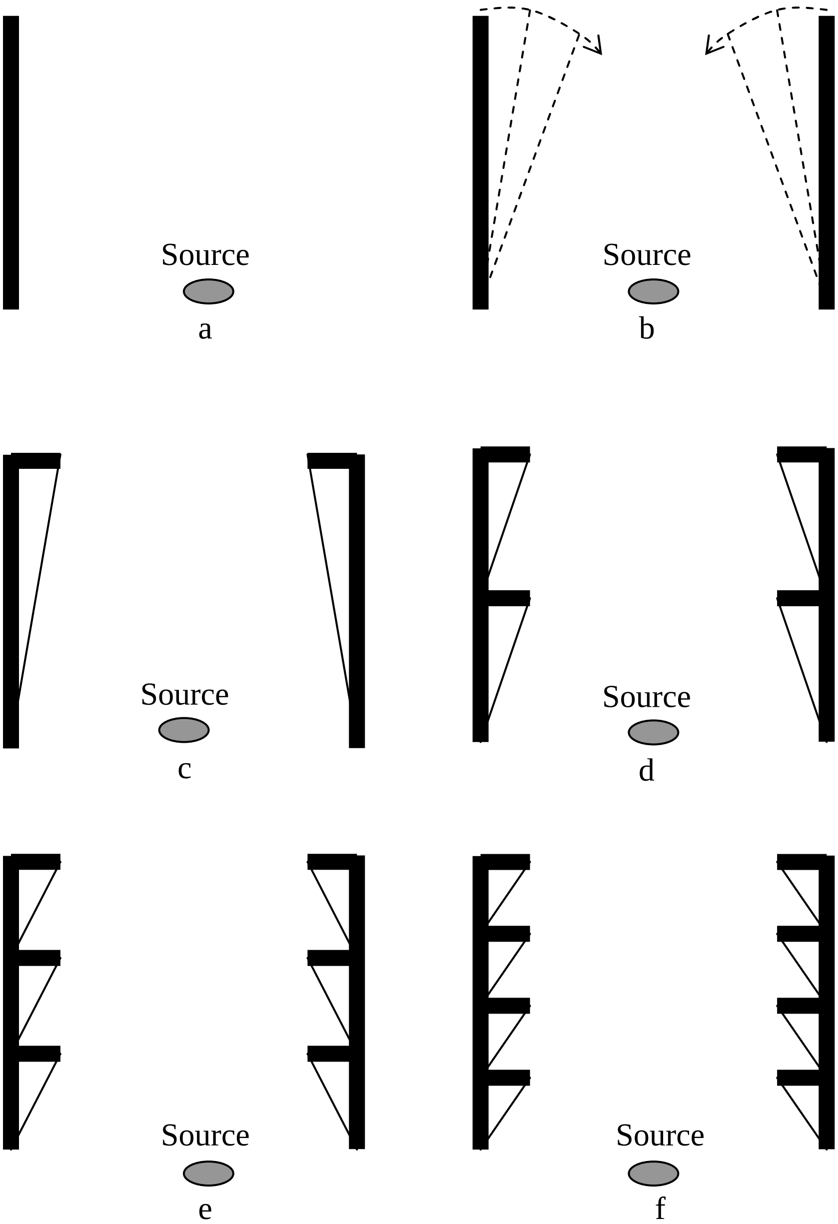

Figure 1. Different shapes for barriers designs. a: single barrier, b: parallel barriers with tilted angles, c, d, e and f: different shapes for single and parallel barriers.

Figure 4 shows that with increasing the barrier tilt angle the IL value decreases. The increase of the tilt angle from 0 degree to 25 degree corresponds a decrease in IL value of less than 2dB. The figure shows also that, at that measuring level, the IL value does not affected with the distance from the barrier. This means that, at that measuring level, the effect of the shielding rate on the IL value near the barrier is equal to the effect of the distance on the IL far from the barrier.

Figure 5 shows that, at that measuring level, with increasing the barrier tilt angle from 0 degree to 25 degree the IL value decreases in the range of 1.5dB. The figure shows also that at that level, where the shielding rate is minimum the IL value is minimum just behind the barrier and it increases with increasing the distance from the source to receiver.

Figures 2, 3, 4, and 5 show that the highest values of IL are corresponding to barriers tilt angle of zero degree. This means that in the case of single barrier, tilting it towards the traffic way has unfavorable effect on the IL for any of the four measuring levels.

4.2 The effect of the tilt angle of the two barriers on traffic IL

The relation between the insertion loss (IL) value and microphone position behind barriers of different tilt angles, and at height; 12.5, 25, 37.5 and 50 cm is represented in figures 6, 7, 8 & 9 respectively.

The feature of figure 6 is similar to that of figure 2, i.e. the effect of barrier tilt angle and microphone position from the barrier or from the ground are a like for both cases (one or two barriers). The only difference is that; the IL values in the case of two barriers is slightly less than the corresponding values in the case of one barrier. This difference is attributed to the reflected sound from the second barrier. The figure also shows that at that measuring level the IL value, at any microphone position, decreases with increasing the tilt angle of the two barriers, i.e. a negative benefit occurs on increasing the tilt angle.

Figure 7 does not show any distinguish between the 8 curves. For all the tilt angles used, the IL values decreases gradually by increasing the distance from the barrier.

Figure 8 shows that near the barrier, the IL value is small due to the diminished effect of the shielding zone at that level. The figure shows also increase in the IL value with increasing the distance from the barrier i.e. the distance from the source.

Figure 9 shows that near the barrier the IL value is minimum due to the vanished effect of the barrier at that level. The figure shows also increase in the IL value with increasing the distance from the barrier i.e. the distance from the source.

Figure 8 and 9 show also that the most effective tilt angle is that of 17.5 degree, where the IL values are the highest value with respect to the other tilt angles.

4.3 The effect of noise barrier consists of identical tilted parts on traffic IL

The above studies showed that: 1) tilting a single barrier, at any angle, towards the traffic way does not improve the IL of the barrier. 2) tilting double barrier towards the traffic way improves the IL only when the tilt angle is equal to 17.5 degree, and the microphone is at the third or fourth measuring levels. So to study the effect of noise barrier consisting of identical tilted parts, two identical barriers each of them consists of one or two or three or four panels are used. Each of these panels was tilted towards the way at angle of 17.5 degree (see Fig.1). The two barriers model were erected on both sides of the bridge. The SPL measurements were carried out behind one of the barrier at 10 different distances from it, and at the upper two levels (37.5 and 50 cm) from the ground. The relation between the obtained IL values and microphone positions for the four double barriers, at the two levels are represented in figures 10 &11. The figures show that the best IL improvement is achieved by using two barriers each of them consists of two tilted panels.

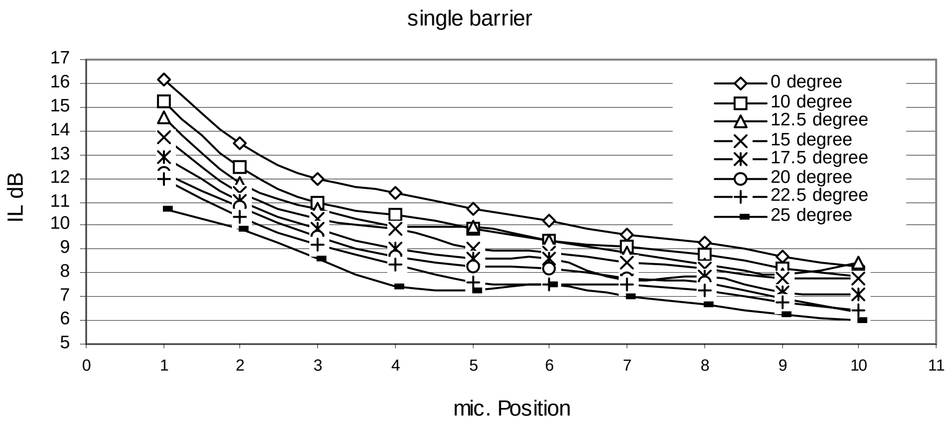

Figure 2. The relation between IL and Mic. position at 12.5 cm height from the ground for 8 tilt angles.

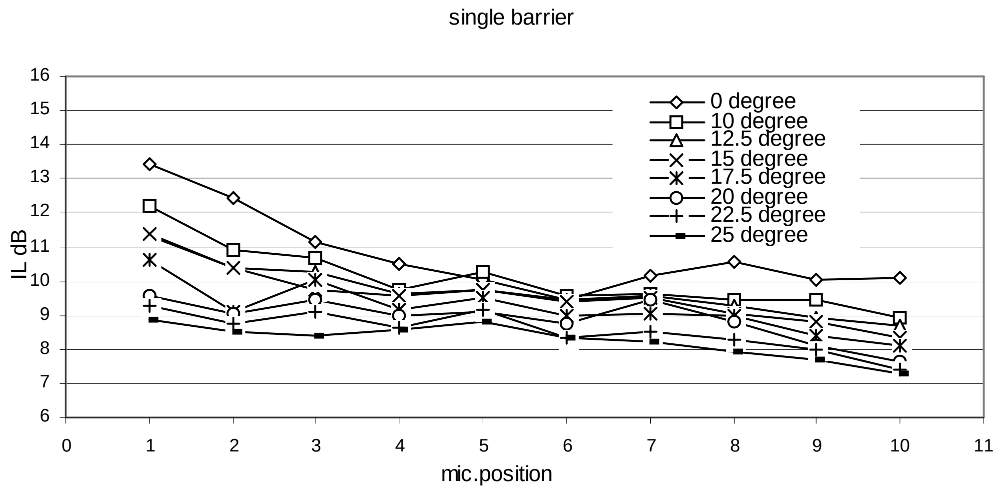

Figure 3. The relation between IL and Mic. position at 25 cm height from the ground for 8 tilt angles.

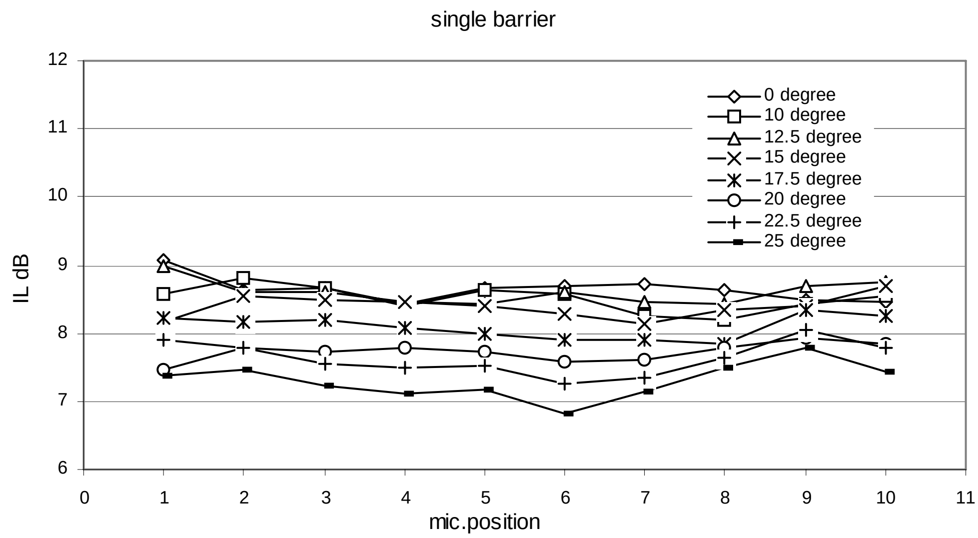

Figure 4. The relation between IL and Mic. position at 37.5 cm height from the ground for 8 tilt angles.

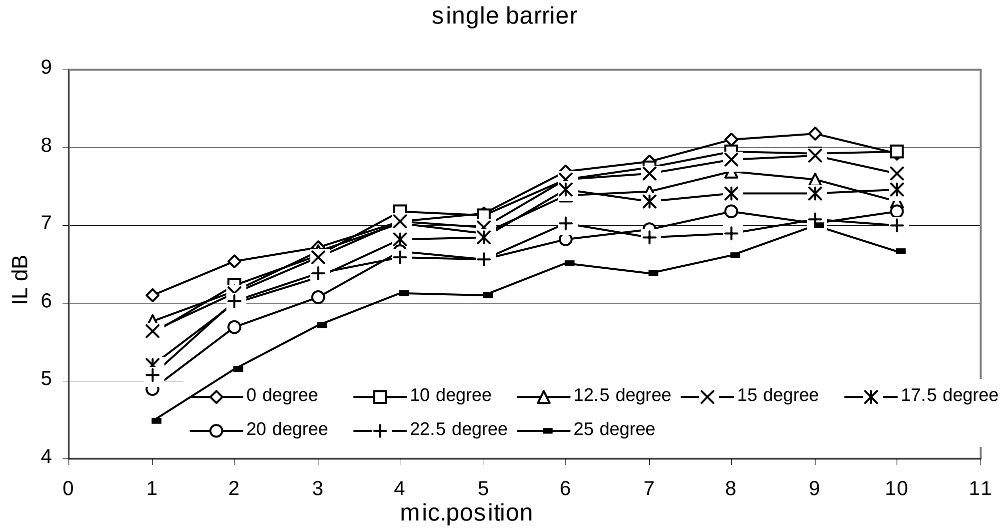

Figure 5. The relation between IL and Mic. position at 50 cm height from the ground for 8 tilt angles.

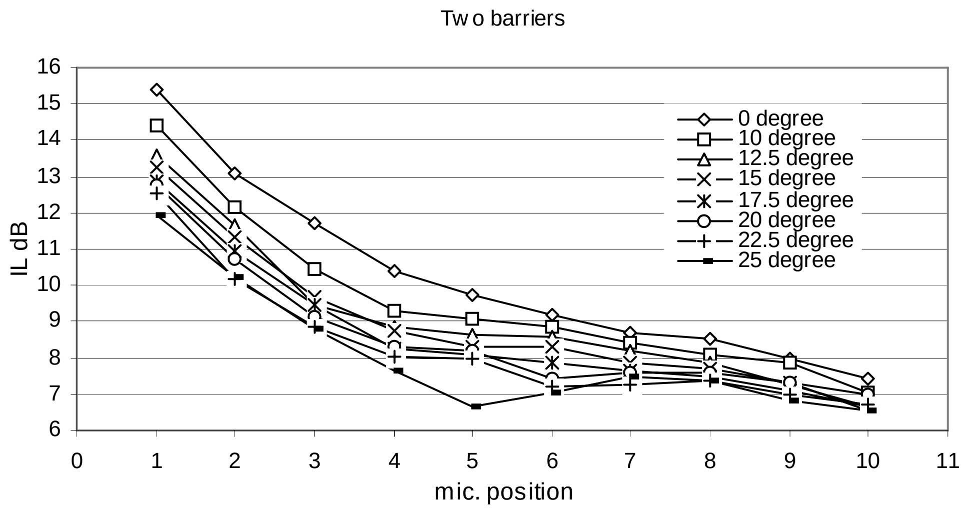

Figure 6. The relation between IL and Mic. position at 12.5 cm height from the ground for 8 tilt angles.

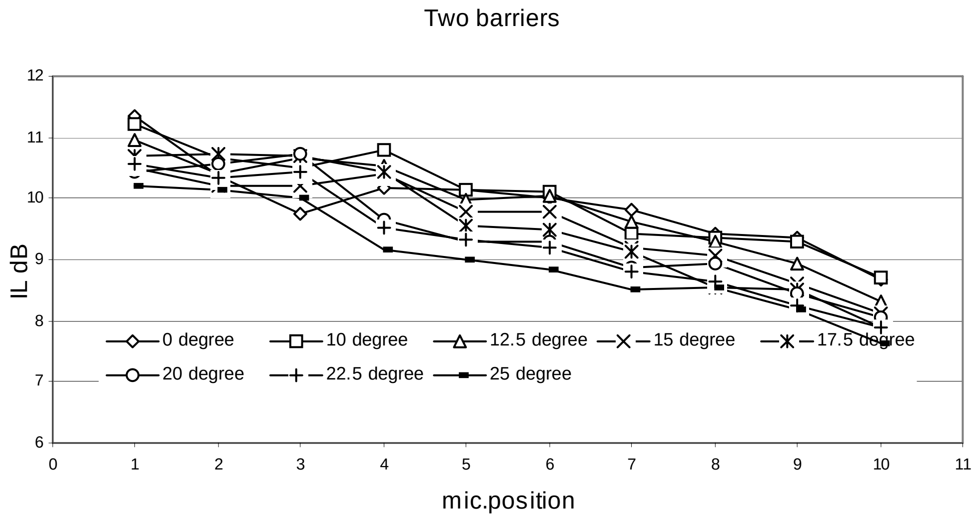

Figure 7. The relation between IL and Mic. position at 25 cm height from the ground for 8 tilt angles.

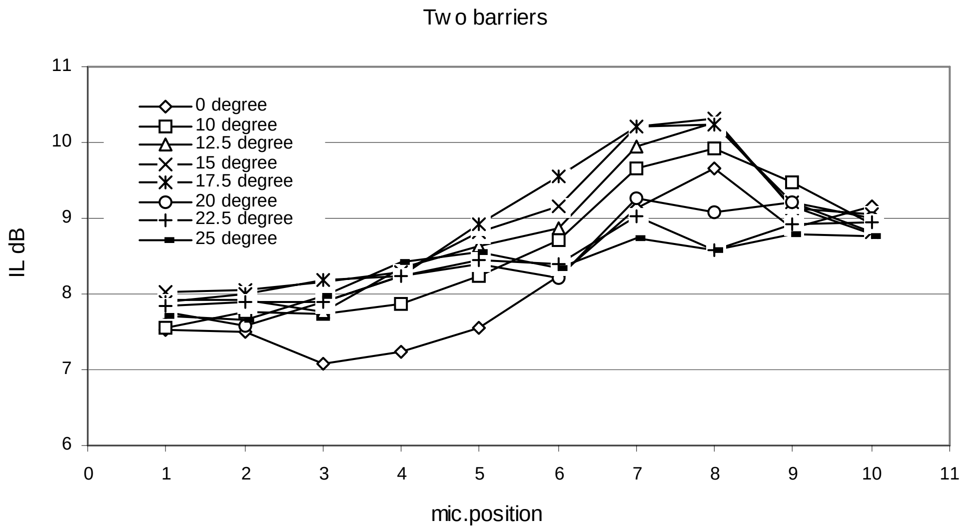

Figure 8. The relation between IL and Mic. position at 37.5 cm height from the ground for 8 tilt angles.

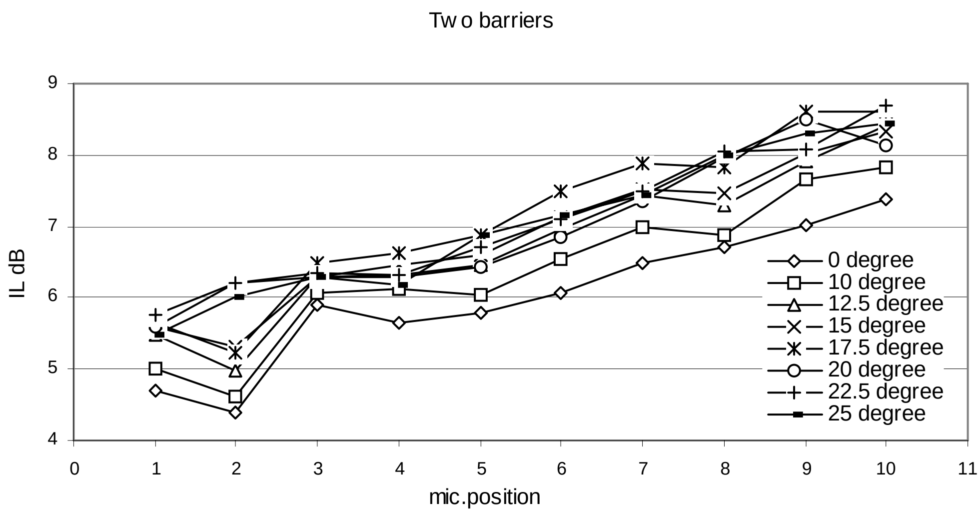

Figure 9. The relation between IL and Mic. position at 50 cm height from the ground for 8 tilt angles.

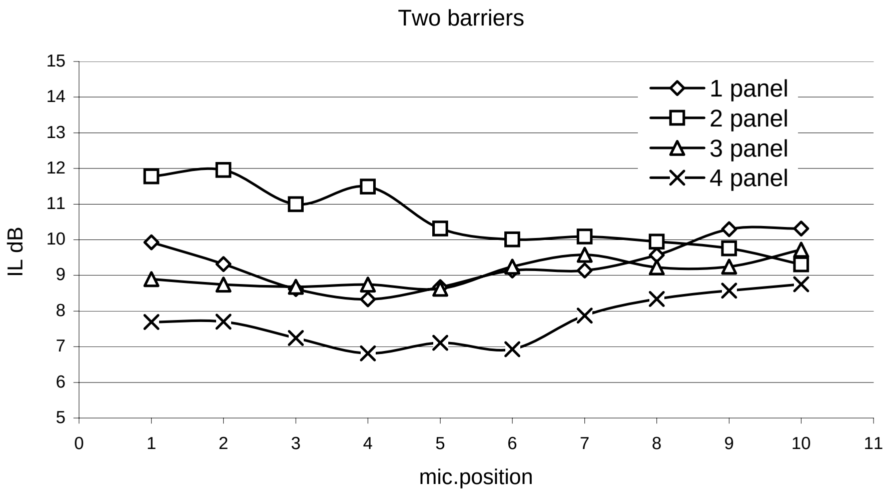

Figure 10. The relation between IL and Mic. position at 37.5 cm height from the ground for 4 barriers with different panels.

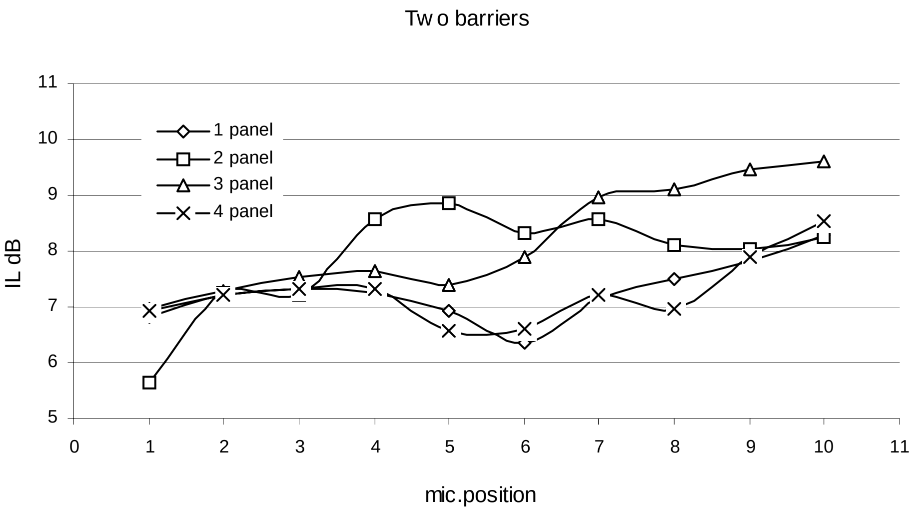

Figure 11. The relation between IL and Mic. position at 50 cm height from the ground for 4 barriers with different panels.

6. CONCLUSIONS

In case of using single barrier, the insertion loss (IL) at any point behind the barrier decreases with increasing the barrier tilt angle, this is due to the decrease of barrier elevation with increasing its tilt angle and consequently the insertion loss decreases. On the other hand, the insertion loss value becomes higher behind barrier as the receiver situation becomes nearer to the barrier or to the ground, this is due to the effect of shielding zone near the barrier or near the ground.

When using two parallel barriers, the insertion loss (IL) value is slightly less than the corresponding values in case of using single barrier, this is because of the presence of many reflections of sound wave from the two barriers. For the two parallel barriers, the best insertion loss achieved by using two barriers each of them consisted of two tilted panels.

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