Investigations on Coherence of Active Control of Traffic Noise Transmission Through an Open Window into a Rectangular Room in High-Rise Buildings

Jiping Zhang
Zhejiang Research and Design Institute of Environmental Protection, Hangzhou 310007, China
E-mail: jpzhang@mail.hz.zj.cn

A method for theoretically calculating the coherence between sound pressure inside a rectangular room in a high-rise building and that outside the open window of the room is proposed. The traffic noise transmitted into a room is generally dominated by low-frequency components, to which active noise control (ANC) technology may find an application. However, good coherence between reference and error signals is essential for effective noise reduction and should be checked first. Based on traffic noise prediction methods, wave theory, and mode coupling theory, the results of this paper enable one to determine the potentials and limitations of ANC used to reduce such a transmission. Experimental coherence results are shown for two similar, empty rectangular rooms located on the 17th and 30th floors of a 34 floor high-rise building. The calculated results with the proposed method are generally in good agreement with the experimental results and demonstrate the usefulness of the method for predicting the coherence.

Key words: coherence, road traffic noise, active noise control, local area/space/zone

1. INTRODUCTION

Traffic noise is one of the major environmental problems in urban societies. In China, with the development of the economy and society, and with the implementation of the noise law and a series of standards for environmental noise control, urban noise pollution has changed mainly from industry in 1980's to traffic noise nowadays. Meanwhile, the numbers of high-rise buildings in modern cities are increasing. For instance, in Shanghai, the number of high-rise buildings higher than 24 meters is about 3000 now. Therefore, traffic noise pollution is more than just an issue of ground propagation, given the number of high rise buildings and the high population densities they create. It was reported that there were 65% complaints about traffic noise in the all environmental noise problems in 2001 in Beijing City, and many of them were from the residents living in the high-rise buildings along the city's main roads. So it is important and practical to investigate traffic noise propagating and both the control methods outside as well as inside high-rise buildings.

Sound barriers and window insulation are commonly used for traffic noise control but these techniques are mainly effective at the middle and high frequencies. Much of the high-frequency noise reaching a high-rise building will be absorbed by the air, leaving the lower-frequency components. Sometimes, due to resonance in a room, the low-frequency traffic noise transmitted into a room can become severe because the wavelength is of the order of the room dimensions.[1] Active noise control is now recognized as an important technology for reduction of the low-frequency noise. Therefore, it is worth studying the feasibility of active noise control technology for control of the low-frequency traffic noise transmitted into a room, especially in a high-rise building.

According to the comfortable-living criteria of rooms in architectural acoustics, two cases should be considered, a room with an open window and a room with a closed window. Therefore, active control of noise transmission into a room is also divided into two such situations.

In the case of a closed window, we have active control of noise transmission into a sealed or closed acoustic enclosure. Considerable research on this subject has been reported in the literature. Earlier research focused on the average performance of the sound transmission through a rectangular panel or window backed by a rectangular room, where the transient behavior was not considered (for instance, see Refs. [2] and [3]). Current research interest on active control of interior noise is focused on enclosures with flexible boundaries, because there is a real need to control low-frequency noise in lightweight systems such as aircraft and vehicles.[4] The glass of a closed window can be approximated as a flexible boundary. An empty, rectangular room with a closed window is better modelled as a panel with a back cavity. Much previous work can be applied directly to analyze the problem (e.g., the work of Pan et al.,[5,6] Snyder,[7] Kim and Brennan,[8] and Sampath and Balachamdran[9]). However, only a little attention has been paid to the active control of noise transmission into a building.

In the case of an open window, it is much more difficult to control traffic noise. Duhamel and Sergent have presented the concept of active traffic noise control in Ref. [10]. However, their work was mainly concerned with active control of the outdoor noise created by an incoherent line source. Although their latest investigation was extended to the numerical calculation of the pressure crossing an aperture in a rigid plane (set in free space) to simulate the noise entering a room through an open window, the diffraction of the aperture is much different than that of a real window on the wall of a room with a closed door. Martin presented a strategy[11] to reduce traffic noise by actively controlling the deterministic and slowly varying noise radiated by a moving source such as an airplane taking off, a train, or a car, but only in the open air. Kropp and Berillen proposed a theoretical model to investigate the acoustic performance of a building balcony in the low- and middle-frequency range just used for determining optimal balcony design,[12,13] where full opening front wall was used simply instead of a true opening balcony. There still exists a gap between the prediction of traffic noise transmitting into an open window room and its active control, since the complexity of the physical system may limit the reduction.

In controlling actively the noise transmitted through an open window into a room, global control should be considered as nearly impossible. Finding local zones of quiet is a more possible and applicable strategy, even though local control may cause an increase of noise level in areas away from the error sensors. Since the traffic noise reaching at the receiver is broadband (random) in the low-frequency range, just using a simple feedback algorithm will be not enough and the quiet zone could be small and unstable because of the time delay in the devices. Because a reference sensor can be easily located outside the room, e.g., below the windowsill, the sound transmission mechanisms suggest a feedforward strategy. The benefits of this placement might more effectively reduce the positive feedback from the reflections of the walls or surfaces and the secondary sources in the room toward the reference sensor. The coherence between signals measured by all the reference and error sensors will conversely influence or determine the control performance. A method to compensate for the weakness of the above algorithm is to use a combined or hybrid feedback and feedforward control,[14,15] but more information at a very limited number of sensors has to be obtained. Nevertheless, once the feedforward strategy is used in the transmission control, the coherence between signals passing through the open window and at the receiver will become an important issue to be studied.

The work in this paper intends to fill, in part, this gap. First, though, the coherence between the error signal inside the room and the reference signal outside the window should be investigated, if a feedforward control strategy is to be adopted. This function determines the feasibility of noise reduction. In this paper the work of Duhamel and Sergent is extended by developing a theoretical method for calculating the coherence for an empty rectangular room in a high-rise building, including the interaction of a fully open window. Experimental verification of the method is given and numerical examples are presented that demonstrate the coherence of the system.

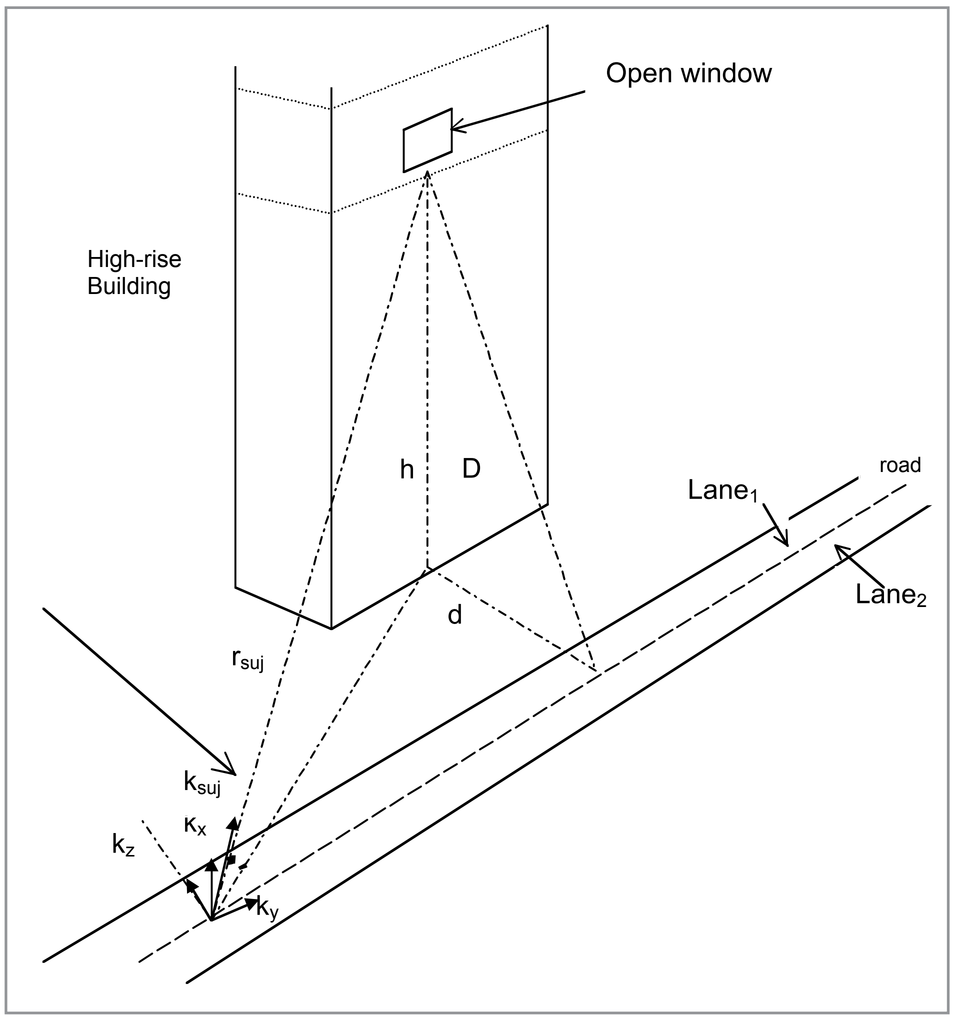


Figure. 1. Sketch of a high-rise building at a traffic road.

II. THEORY

A. TRAFFIC SOUND PRESSURE ON THE BUILDING FAÇADE

A high-rise building at a traffic road is shown in Figure 1. The following assumptions are adopted: there are no other obstacles between the building and the road; the road in front of the building has two vehicles lanes, the traffic flow through each lane has identical averaged speed v, for three types of vehicles, including automobiles, heavy vehicles (including buses and trucks), and motorcycles, with the vehicles flow for the road being N per second.

Any one vehicle can be represented by a monopole sound source moving along the road close to the earth's surface when the observation point is far away from it. Therefore the sound pressure due to a vehicle at a reception position can be expressed in the frequency domain.

The vehicles moving on the road are described by the addition of the monopole sound sources which are uncorrelated with each other, so the sound pressure on the high-rise building façade from the road can be calculated from the source strength related to the surface vibrating velocity of the vehicles, the characteristics of the air, and the reflection coefficient of ground. The sound pressure is assumed to be affected only by the vehicles in a time interval when the vehicles are not far away from the high-rise building.

B. THEORETICAL MODEL OF SOUND TRANSMISSION INTO A HIGH-RISE BUILDING

A room with an open window on the façade of a high-rise building can be modelled as a partially open rectangular cavity in a rigid baffle, as shown in Figure 2. The sound level inside the room depends on the size of the window, the acoustical absorptive characteristics of the walls surfaces, and the room dimensions. Above the Schröder frequency, the sound field will be diffuse. At low frequencies, the sound pressure has distinct resonance peaks. For frequencies of interest below 100 Hz, the wavelength will be greater than 3.4m, comparable with the dimensions of the room, taken as about $3\times3\times4$ m^3.

As shown in Figure 2, the room cavity has an open window. The sound pressure inside the room is described by the classic wave equation with the boundary conditions of the room and on the front open window shown in Figure 2.

The solution for the sound pressure inside the room can be got under the following assumptions are adopted: p_{in}, p_{re}, and p_{rad} represent the sound pressure of the incident and reflected traffic noise field and the radiated sound field at the open window, respectively, and $ps = p_{in} + p_{re}$. Parameters $v_{in}z$, $v_{re}z$, and vsz represent the velocities due to the incident and reflected traffic noise ($vsz = v_{in}z + v_{re}z$) and the velocity of the radiated sound field ($v_{re} = vsz$) in the room where $z = 0$.

Because the façade of the high-rise building is modelled as a baffle, the sound pressure propagates from each vehicle on the road to the cavity, as shown in Figure 1. Applying a Taylor expansion to the far field of the sound pressure from traffic flow, we obtain the sound pressure ps.

The sound radiation from the open window back into the free space can be calculated using the Rayleigh integral as if there was a virtual radiating surface on the rigid baffle.

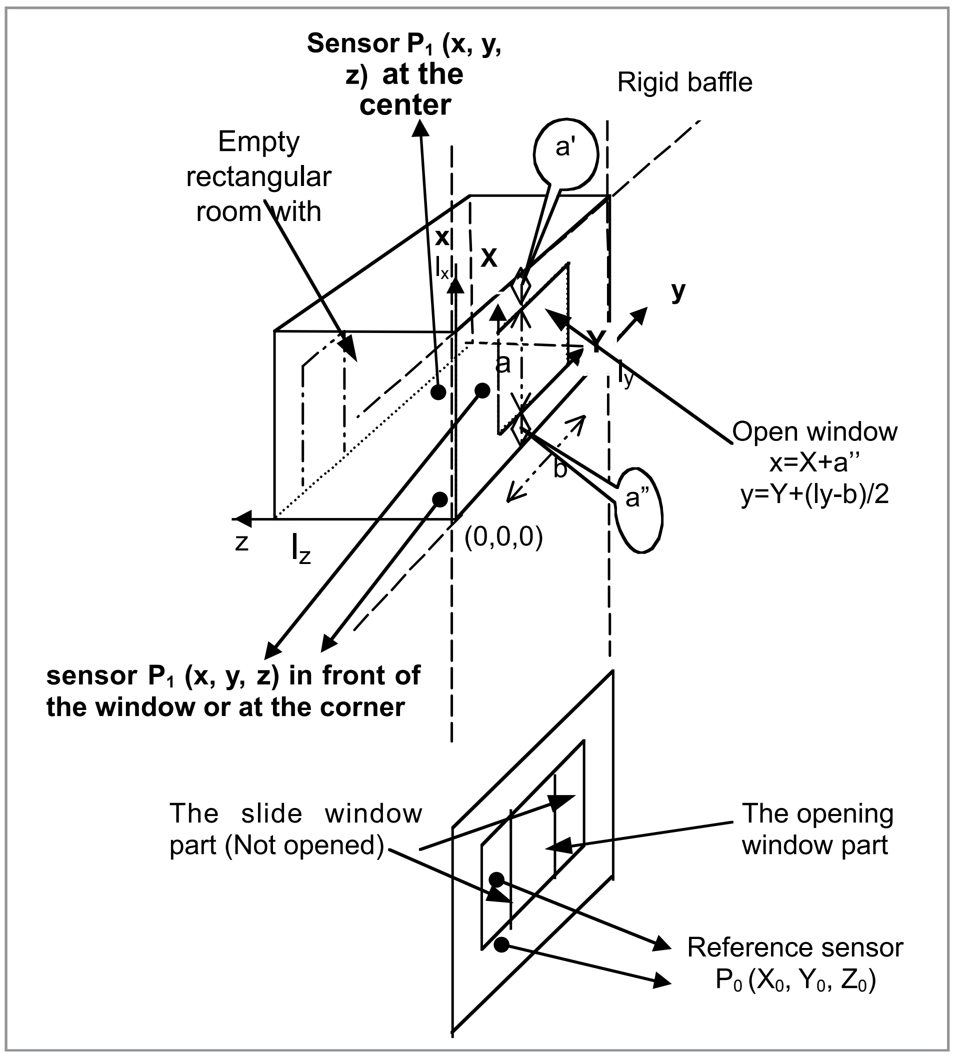


Figure 2. Sketch of the open window room with coordinates, parameters, and sensor locations.

Therefore, the complete sound field solution for the traffic noise transmission into a room in a high-rise building is obtained, but the noise strength of the transient traffic flowing must be known in advance.

C. COHERENCE BETWEEN THE SOUND PRESSURE INSIDE THE ROOM AND THAT OUTSIDE THE WINDOW

The open window can be treated as a virtual surface sound reradiator. An assumed reference sensor is placed outside the window, where the impact of sound reflection toward the sensor is negligible if it is properly located or directed. The autocorrelation sequence of sound pressure at the sensor can be calculated by using *ps* and assuming the monopole sound sources uncorrelated each other. Locating the reference sensor at (X_0, Y_0, Z_0), then the autocorrelation sequence of sound pressure at any point inside the rectangular room in the high-rise building can be calculated. Locating the error sensor at (x, y, z), where the noise from the road is considered to be cancelled in the near field or locally, then the cross-correlation sequence of the sound pressure between the error sensor and the reference sensor can be calculated by assuming.

The coherence can be expressed using the independent relationship or the orthogonal conditions that any two-vehicle noise sources are uncorrelated with each other. The coherence calculation can successfully be greatly simplified because of the removal of the impact items from the road traffic, which also implies that the averaged coherence is mainly determined by the locations of the room, the window, and the road.

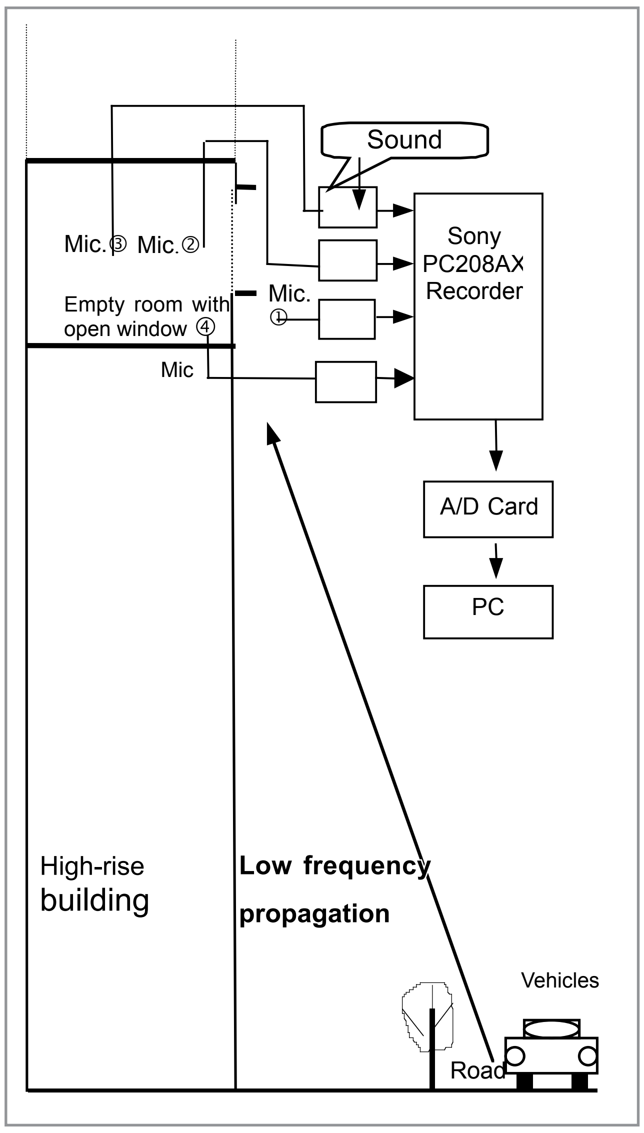


Figure 3. The schematic of an experiment for investigating the coherence of traffic noise.

III. EXPERIMENTS

To verify experimentally the present theoretical method, we require the simultaneous measurement of sound pressures inside the test room in a high-rise building and outside the open window room. Two similar, empty rectangular rooms were chosen, located on the 17th floor (Room 1704) and the 30th floor (Room 3004) in a 34 floor high-rise building. The building is the central one of ten new, empty buildings named Yeuliang Wan Square, located on the north side of Coacheng Men Road in Nanjing City, China. Except for vehicle traffic noise from the road, there is no obvious noise transmitted into the rooms of the building.

Between the building and the road, there is grassland and no other obstacles, and the distance d between the building and the road is 168 m. The two rooms studied have a slide window centered on the south wall of the rooms facing the road, and a door on the north backwall of the rooms. During the measurements, the doors of the rooms were closed and the slide windows were fully opened, as shown in Figure 2.

The measurements were carried out between 14:00 and 18:00, when the traffic flows on Coacheng Men Road were 1300-1950 vehicles/h. During each measurement period of five minutes, the traffic flow numbers were obtained.

A schematic of the measurement system is shown in Figure 3. An eight-channel digital recorder was used for simultaneously recording the road sound pressure signals inside the room and those outside the open window room. The frequency bandwidth of the recorder is 5 kHz at normal speed and 10 kHz at double speed. One reference sensor was set at a position of outside the open window, locating at $P_0(X_0, Y_0, Z_0)$, and the other two to three sensors were arranged inside the room for measuring sound pressure separately at the positions of $P_1(Xi, Yi, Zi)$ ($i = 1, 2,$ or 3), typically representing the different receivers, one outside the opening window, one at the center of the room, and one in front of the open window inside the room, or in the corner of the room. A Brüel & Kjaer measurement amplifier was connected between the reference sensor and the recorder. B&K precision sound level meters were used to measure pressures at the center sensor, the front sensor, and the corner sensor inside the room.

After the one-site measurements, the instruments were moved back to the laboratory at Nanjing University. Using an A/D card attached to the recorder, the recorded signals (on a DAT cassette) were transmitted into a personal computer as digital time series data. They were then used to evaluate the expressions for the coherence in the frequency domain according to the coherence definition.[17]

All the sensor locations were listed in site. After the experiments, these parameters were used to compute the coherence between the reference sensor location $P_0(X_0, Y_0, Z_0)$ and the error sensor location $P_1(xi, yi, zi)$ using the proposed theoretical coherence calculation method. In the calculation, the thickness of the window and the walls were assumed to be the same.

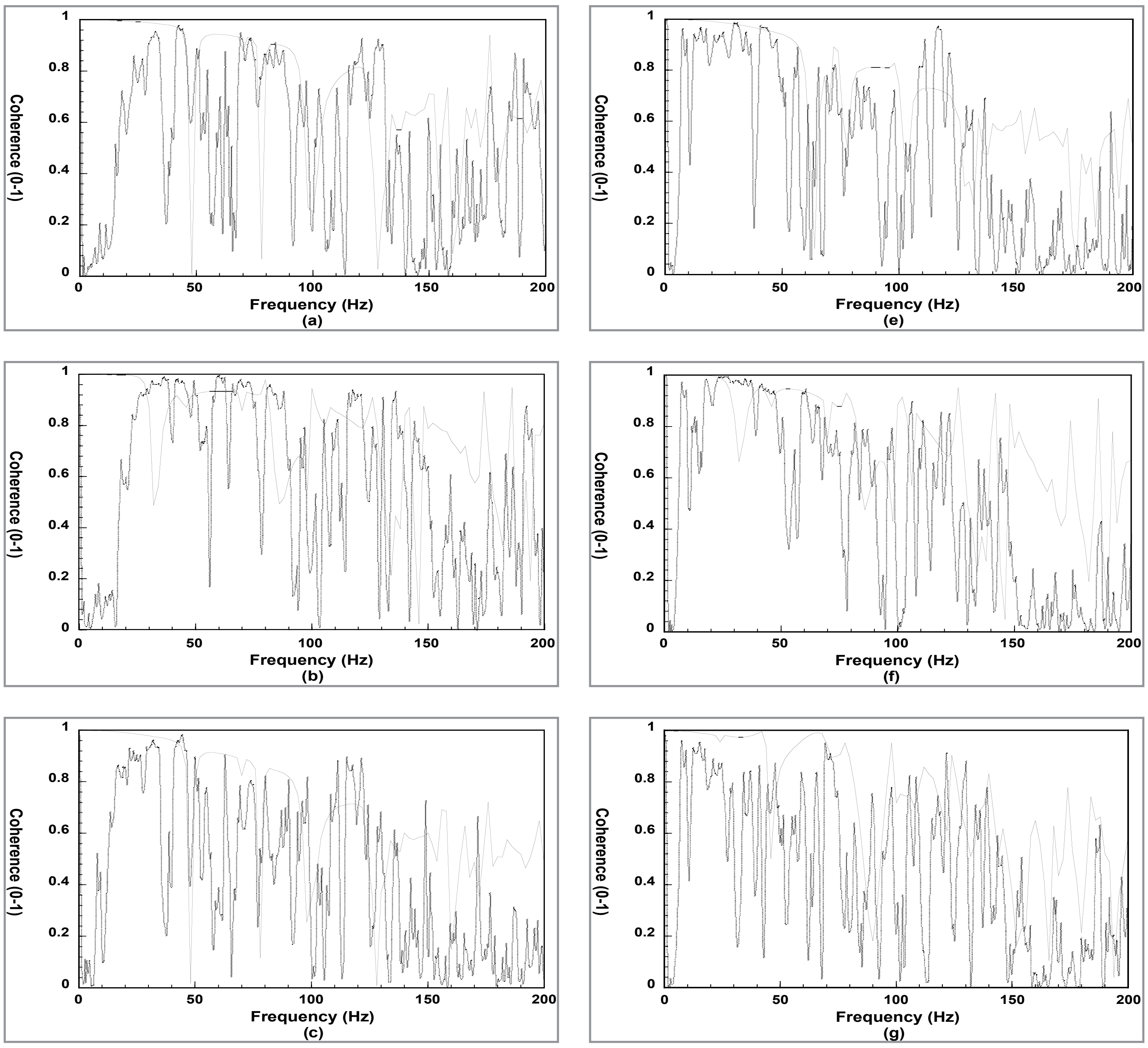
The room dimensions in the x and y directions[18] were approximated as a case between a short duct with one end sealed and a small rectangular room with the door and window closed, but not completely the same as the sound propagating in the duct or in the room because of the open window at the other end or the wall.

The calculated and experimental coherence results are shown in Figures 4(a)-(g). The figure shows that the coherences calculated using the proposed method are generally in good agreement with the experimental results.

It can be seen in Figure 4 that the calculated coherence values tend to be a little larger than the experimental values. This is likely due to the simplifications and approximations in the theoretical calculation method. For example, in the real measurement situation, vehicles on the road would move at a varying speed and the noise strength of any one vehicle would also vary – this is not included in the proposed method. Other background noise, such as stochastic horn sounds from the vehicles (mainly lower-frequency components) can cause the sound pressure values to give poor coherence between the reference sensor and the error sensor. In addition, the difference in thickness of the open window, the closed door, and the walls has not been considered and the open window boundary has been treated as a rigid baffle. Finally, sound absorption has not been included in this calculation. In general, it is believed that the errors are not serious and that acceptable values of coherence are predicted at lower frequencies.

As can be anticipated, the calculated values at low frequencies below 20-50 Hz approach unity. The experimental coherence curves at these low frequencies are low because of the limitations of the sound level meters.

The above comparisons demonstrate the usefulness of the proposed method for predicting coherence. It will be of assistance in determining the physical limitations for the implementation of active traffic noise control in high-rise buildings.



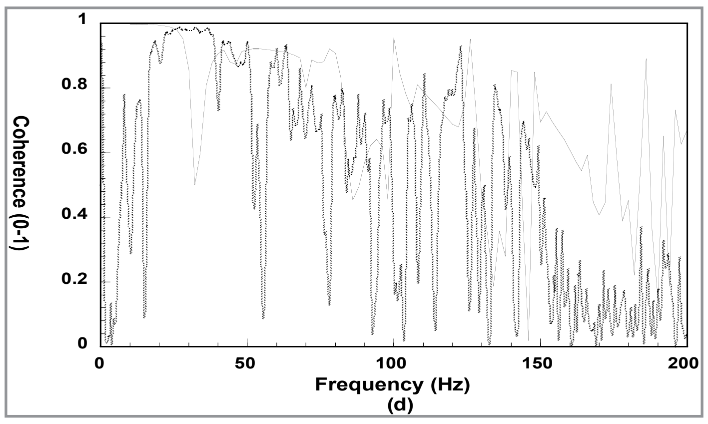


Figure 4. *(a)-(g); A comparison between the calculated coherence value curves and the experimental ones (— calculation; --- experiment).*

(a) *On the 17th floor, P_1 in the front of the room, P_0 below the windowsill; traffic flow is 1848 vehicles/hour.*

(b) *On the 17th floor, P_1 in the front of the room window, P_0 below the windowsill; traffic flow is 1848 vehicles/hour..*

(c) *On the 17th floor, P_1 at the center of the room, P_0 above the slide not open window part; traffic flow is 1920 vehicles/hour.*

(d) *On the 17th floor, P_1 in the front of the room window, P_0 above the slide not open window part; traffic flow is 1920 vehicles/hour.*

(e) *On the 30th floor, P_1 at the center of the room, P_0 above the slide not open window part; traffic flow is 1365 vehicles/hour.*

(f) *On the 30th floor, P_1 in the front of the room window, P_0 above the slide not open window part; traffic flow is 1365 vehicles/hour.*

(g) *On the 30th floor, P_1 at the corner of the room, P_0 above the slide not open window part; traffic flow is 1365 vehicles/hour.*

IV. NUMERICAL EXAMPLE CALCUALTION, PREDICTION, AND THEIR DISCUSSIONS

In this section, coherence functions are calculated for a hypothetical room. The room has the size of a typical living room with an open window, centered in the y direction, and the height of the windowsill is 0.9 m. The room is on the 20th floor with a height h of 53 m. The distance d between the road and the building is 200 m. The vehicle speed v, on the road is assumed to be 40 km/h. A reference point outside the window was chosen at $P_0(X = -0.2$ m, $Y = 0.0$ m, $Z = -0.1$ m), and the two receiver (observation) points inside the room were selected at $P_1(x = 0.7$ m, $y = 3.0$ m, $z = 2.0$ m), which could be a reasonable location for placing a bed, or $P_1(x = lx/2$ m, $y = ly/2$ m, $z = lz/2$ m), which is at the center of the room. The coherence functions of P_1 to P_0 were calculated for frequencies below 200 Hz. The road segment impacting the sound pressure at the receivers was chosen with length of time as 300 s.

The numerical results are shown in Figure 5. From this figure, we can see the tendency of the coherence curves. As expected, the coherence at very low frequencies approaches unity, although the results below 20 Hz have little relevance to human hearing. When the location of receiving point $P_1(x, y, z)$ is changed, the coherence result is also different because of the phenomena of stationary waves.

In Figure 5, one coherence curve has been produced assuming that the vehicle speed v is identically zero. The results approaches 1.00 for all frequencies. It can be expected that the coherence for fixed (mot moving) monopoles on the road is 1.00, so this calculation provides a check on the validity of the proposed theory.

When the dimensions of the open window are chosen at 1.0 × 0.7, 1.0 × 1.4, or 1.4 × 0.7 m^2, with $P_1(x = 0.7$ m, $y = 3.0$ m, $z = 2.0$ m), the coherence curves shown in Figure 6 are obtained. The figure indicates that the dimension of the open window affects the shape of the coherence curves.

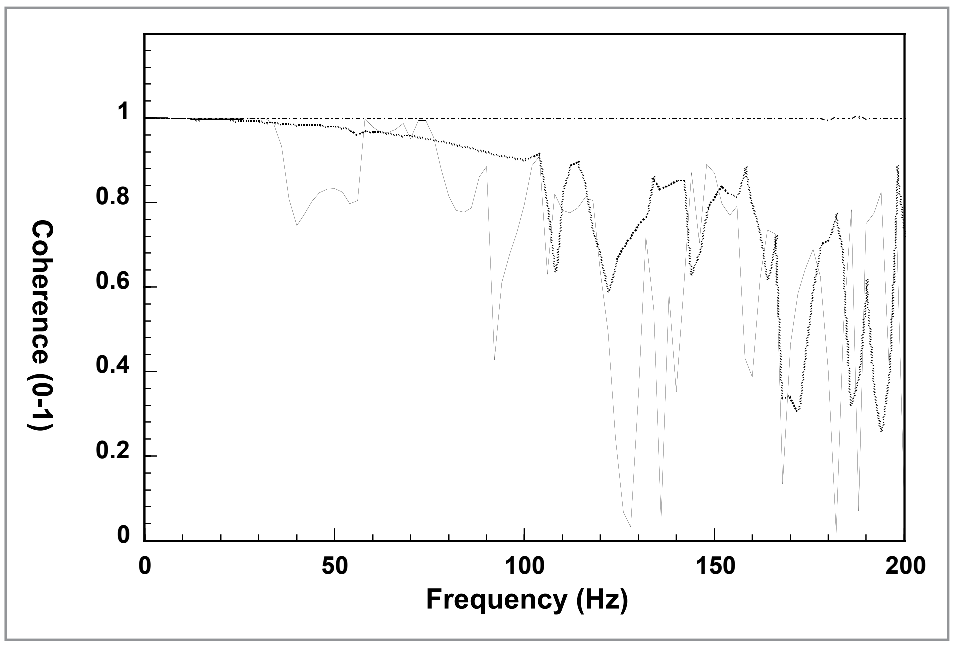


Figure 5. Calculated coherence curves of the numerical examples. Legend: —, v=40 Km/h, P_1 (x=0.7 m, y=3.0 m, z=2.0 m)/P_0 (X=-0.2 m, Y=0.0 mz =-0.1 m); ---, v=40 Km/h, P_1 (x=lx/2 m, y=ly/2 m, z=lz/2 m)/P_0 (X=-0.2 m, Y=0.0 m, Z=-0.1 m); --·--, v=0 Km/h, P_1 (x=0.7 m, y=3.0 m, z=2.0 m)/P_0 (X=0.1 m).

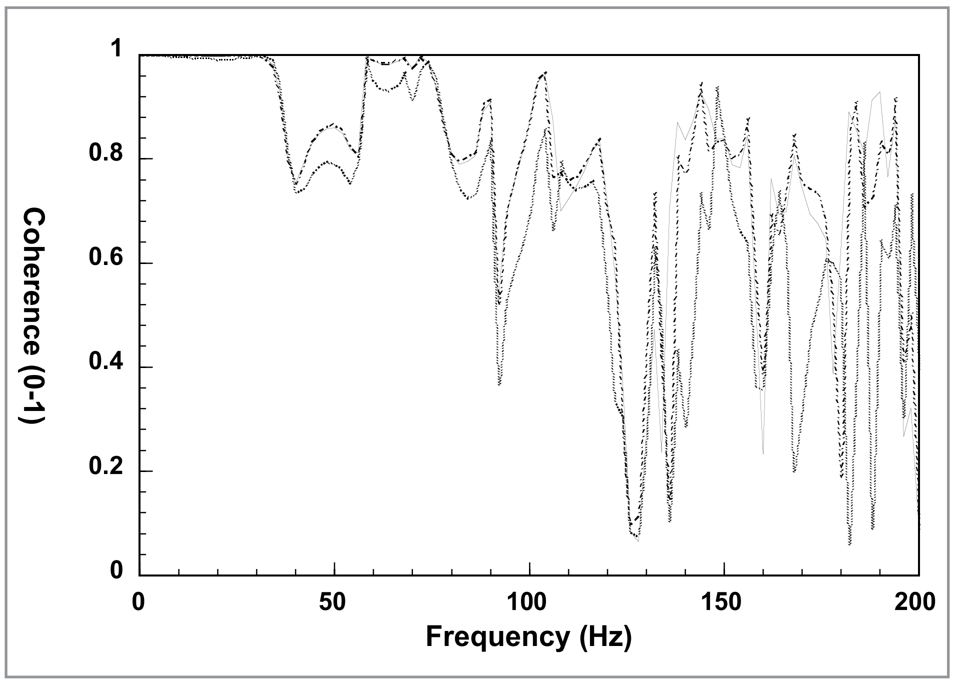


Figure 6. Coherence curves of the numerical example with changes of a and b; P_1 (x=0.7 m, y=0.3 m, z=2.0 m)/P_0 (X=-0.2 m, Y=-0.175 m, Z=-0.1 m). Legend: — z=1.0, b=0.7; ---, a=1.0, b=1.5; --·--, a=1.4, b=0.7.

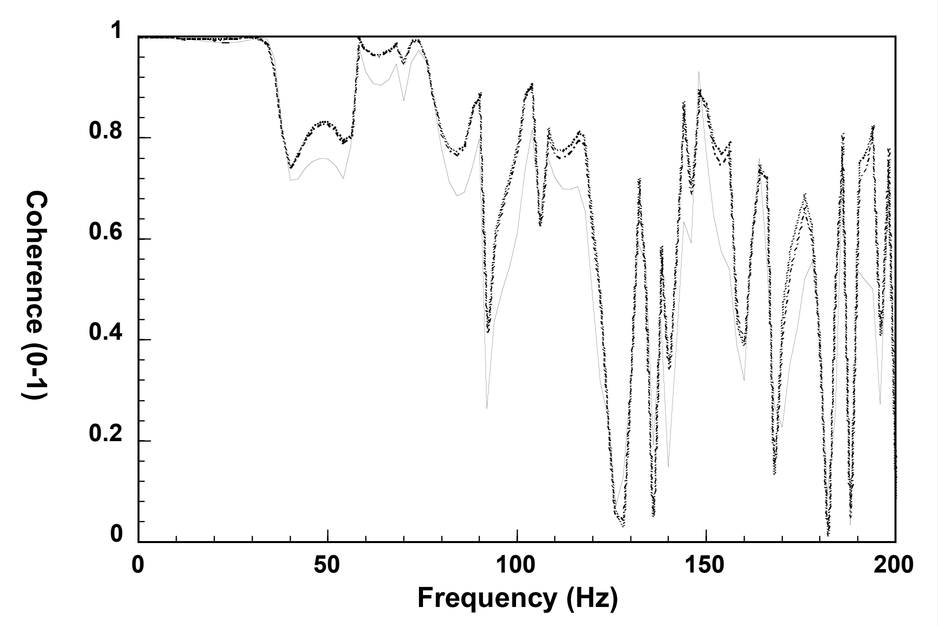


Figure 7. *Coherence curves of the numerical example with changes of P_0 locations when P_1 (x=0.7 m, y=3.0 m. z=2.0 m) and a×b=1.4×1.4 m^2. Legend: —, P_0 (X=0.700, Y=-0.175, Z=-0.100); ---, P_0 (X=-0.200, Y=0.000, Z=-0.100); --·--, P_0 (X=0.700, Y=0.175, Z=-0.100).*

When the location point $P_0(X, Y, Z)$ was changed, the coherence results also changed Figure 7 shows the curves for $P_0(X = 0.700, Y = -0.175, Z = -0.100)$, $P_0(X = 0.700, Y = +0.175, Z = -0.100)$, and $P_0(X = -0.200, Y = 0.000, Z = -0.100)$, all with $P_1(x = 0.7 \text{ m}, y = 3.0 \text{ m}, z = 2.0 \text{ m})$.

Similar calculations were performed to determine the effect of distant roads, high building floors, and different vehicles speeds. The coherence functions were nearly independent of the height h of the room above ground, the distance d between the road and the building, and the vehicle moving speed v on the road. Although these parameters have little impact on the far field coherence properties, they do have an important effect on the spectrum of moving vehicles in the frequency domain. Therefore, with larger parameters h and d, a smaller v, i.e. a room a very tall building with the road far away, the sound of the road traffic noise outside the open window and inside the room are dominated by very low frequencies, so such situations satisfy the conditions for a high coherence.

From Figures 5-7, we find that the coherent curves may be the best candidate for a feedforward control strategy at very low frequencies, at least below 150 Hz. At higher frequencies, more than one reference sensor would need to be considered. It should be noted that the effect of A weighting for sound pressure has not been included in the calculations of the coherence functions.

V. CONCLUSIONS

The sound field in a rectangular room caused by road traffic noise was investigated in this paper, using wave theory, modal analysis, and a traffic noise model. A method for predicting the coherence between the sound pressure inside a rectangular room in a high-rise building and that outside the open window of the room was derived theoretically. Finally, the coherence functions were calculated and verified by experiment. The experiments show that the calculated results with the proposed calculation method are generally in good agreement with the experimental results.

The new method has some distinct advantages over existing ones for such a noise transmission system. First, a room with an open window has been studied rather than using the front or end wall fully opened to approximate a real open window. Second, the calculated coherence results show that all of the items related to every one of vehicles do not appear with the orthogonality on a road, which has made the theoretical calculations for the coherence possible. And third, this work has focused on the low-frequency traffic noise far away from a road, so damping and absorption were not considered for simplicity. If the impact of damping and absorption is added, it is easy to expand the calculation of the middle- or higher-frequency range, which could lead to a meaningful extension to the method of prediction of traffic noise from outdoor to indoor

Because of the complexity of wave theory, the proposed method or idea is mainly used for a rectangular or a regular room. Consequently, with this approach, we can make some preliminary qualitative predictions concerning the potential and limitations of applying active noise control technology to the open window room in high-rise buildings. For a room of arbitrary shape, other methods such as FEM, BEM, or experimental measurement should be considered, but it may then be difficult to get a physical insight.

ACKNOWLEDGMENTS

The work was supported by the Environmental Protection Agency in Zhejiang province as a science and technology project numbered 9809 and by the State Key Lab of Modem Acoustics at Nanjing University as an opening scientific research project numbered 9906 (listed in time turn).

REFERENCES

[1] M. Nieemas, "Vibration and noise in dwellings generated by traffic," *Proceedings on Inter-Noise 97*, Budapest, Hungary, 25-27 August 1997, pp. 555-558.

[2] R. W Guy, "The steady state transmission of sound at normal and oblique incidence through a thin panel backed by a rectangular room – a multimodal analysis," *Acustica*, Vol. 43, pp. 295-304 (1979).

[3] T. Kihlman, "Sound radiation into a rectangular room – applications to airborne sound transmission in buildings," *Acustica*, Vol. 18, pp. 11-20 (1967).

[4] C H. Hansen and B. S. Cazzolato, "Recent advance in the active control of interior noise," presented at *The 6th International Congress on Sound and Vibration*, 1999, pp. 1-43.

[5] J. Pan and D. Bies, "The effect of fluid-structural coupling on sound waves in an enclosure-theoretical part, experimental part," *J. Acoust. Soc. Am.*, Vol. 87, pp. 691-717 (1990).

[6] J. Pan, C. H. Hansen, and D. A. Bies, "Active control of noise transmission through a panel into a cavity: I. Analytical study, II. Experimental study, III. Effect of the actuator location," *J. Acoust. Soc. Am.*, Vol. 87, pp. 2098-2108 ~1990, Vol. 90, pp. 1488-1501 (1991).

[7] S. D. Snyder, "The design of systems to control actively periodic sound transmission into enclosed spaces. Part I: Analytical models; Part II: Mechanisms and trends," *J. Sound Vib.*, Vol. 170, pp. 433-472 (1994).

[8] S. M. Kim and M. J. Brennan, "A comparative study of feedforward control of harmonic and random sound transmission into an acoustic enclosure," *J. Sound Vib.*, Vol. 226, pp. 549-571 (1999).

[9] A. Sampath and B. Balachamdran, "Active noise control of an incoherent line source," *J. Sound Vib.*, Vol. 212, pp. 141-164 (1998).

[11]V. Martin, "Active control of moving sound source radiation-numerical modeling in the space-frequency and space-time domains," *J. Sound Vib.*, Vol. 228, pp. 477-509 (1999).

[12]W. Kropp and J. Berillon, "A theoretical model to investigate the acoustic performance of building facades in the low and middle frequency range," *Acustica*, Vol. 84, pp. 681-688 (1998).

[13]T. Kihlman and W. Wropp, "The influence of room resonance on the propagation of traffic noise into small rooms," *Proceedings of Inter-Noise '98*, Christchurch, NZ, 16-18 November, I-INCE Classification No. 31, 1998, pp. 391-394.

[14]S. M. Kuo and D. Vijayan, "Hybrid active noise control," in *Proceedings of the International Conference on Signal Processing Applications & Technology*, 1994, pp. 1272-1277.

[15]W. K. Tseng B. Rafaely, and S. J. Elliott, "Combined feedback feedforward active control of sound in a room," *J. Acoust. Soc. Am.*, Vol. 104, pp. 3417-3425 (1998).

[16]Sony Company, *PC208AX Instrumentation Cassette Recorder Digital Operation Manual*, 1st ed. (revised 3, 1996. 10).

[17]J. S. Bendat and A. G. Piersol, *Engineering Applications of Correlation and Spectral Analysis* (Wiley-Interscience, New York, 1980).

[18]D. Gonghuan, Z. Zheming, and G. Xioufeng, *Basic Acoustics*, 2nd ed. (Nanjing University, Nanjing, 2001), Chap. 5 (in Chinese).

RADICAL AVIATION TAX PLANS PROPOSED

Radical aviation tax plans that would raise air fares in Britain have been proposed by a key transport advisory body. An international agreement on airspace congestion charging was one of the proposals put forward by the British Commission for Integrated Transport (CfIT). If adopted, the proposals would introduced tough noise, congestion and pollution charges on airlines, with these charges passed on to passengers. But the commission added that further work would be necessary to fully understand aviation costs and to assess "the impact of our recommendations on passenger demand and airport expansion options." In its report, the commission said that airlines were responsible for far more pollution than they were held accountable for. It believes that airlines' responsibilities should be extended to congested runways and airspace, local environment, health effects, greenhouse gases and land blight.

Among its proposals were:

- Noise charges or tradable noise permits should be introduced – based on time of arrival and departure.
- Land remaining vacant because of noise nuisance should be included in external costs.
- The impact of flights on local habitats should be monitored and influence flight path trajectory.

FRUITS OF TECHNOLOGY

An area of housing, close to Hartsfield Airport, Atlanta, was progressively bought up by the airport in the 1970s and 1980s, as the airport's noise made the area uninhabitable. But now, in what is thought to be the first scheme of its kind, new building is to begin. The area is habitable again because aircraft are quieter now than they were twenty of thirty years ago, and noise insulation techniques and equipment are better.

AIR HORNS BANNED

The Kerala High Court on 3 September banned use of air horns and directed police and transport authorities to "effectively" curb noise pollution being caused by them. Justice A K Basheer ordered that no vehicle shall be permitted to use air horns. The Court had directed the State Government also to take measures for the reduction of noise pollution, including that caused by vehicular movements. The Court was of the view that appropriate action shall be taken to implement the mandate contained in the Noise Pollution (Regulation and Control) Rules 2000. It felt that environment pollution was one of the biggest and most menacing hazards to human existence. The Court justified the prosecution against stage carriage operators for using air horns, under the Motor Vehicles Act. The Court repelled the contention of stage carriage operators to the effect that air horns were not an extra or additional device but an integral part of the air brake system fitted in the transport vehicle. The directions were issued while dismissing a writ petition of Bus Operators Association.