NOISE/NEWS INTERNATIONAL

Volume 11, Number 3
2003 September

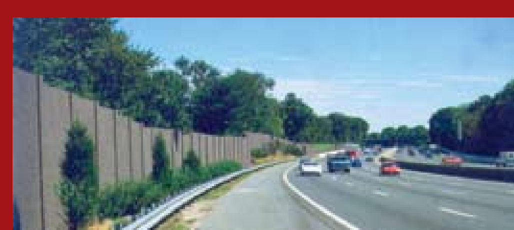
A quarterly news magazine with an Internet supplement published by I-INCE and INCE/USA

NOISE-CON 2004
Announcement and
Call for Papers

INTER-NOISE 2004
Announcement and
Call for Papers

Member Society Profile
Acoustical Society of Finland

Highway Traffic Noise Barriers in the U.S.
Construction Trends and Cost Analysis



First Announcement:
ACTIVE 04
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NOISE/NEWS INTERNATIONAL

Volume 11, Number 3 — 2003 September

Features

Departments

Cover Photos:

Baltimore Inner Harbor • Photo Credit: Richard Nowitz
Courtesy of Baltimore Area Convention and Visitors Association

The Czech Technical University-venue for INTER-NOISE 2004, Prague, Czech Republic
Courtesy of INTER-NOISE 2004 Conference Organizers

Noise Barrier Photo
Courtesy of Kenneth Polcak

A quarterly news magazine with an Internet supplement published by I-INCE and INCE/USA

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NOISE/NEWS INTERNATIONAL

The printed version of Noise/News International (NNI) and its Internet supplement are published jointly by the International Institute of Noise Control Engineering (I-INCE) and the Institute of Noise Control Engineering of the USA (INCE/USA).

I-INCE

The International Institute of Noise Control Engineering (I-INCE) is a worldwide consortium of societies concerned with noise control and acoustics. I-INCE, chartered in Zürich, Switzerland, is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering, and, with the Institute of Noise Control Engineering of the USA, publishes this quarterly magazine and its Internet supplement. I-INCE has an active program of technical initiatives, which are described in the Internet supplement to NNI. I-INCE currently has 46 Member Societies in 39 countries.

INCE/USA

The Institute of Noise Control Engineering of the USA (INCE/USA) is a non-profit professional organization incorporated in Washington, D.C., USA. The primary purpose of the Institute is to promote engineering solutions to environmental noise problems. INCE/USA publishes the technical journal, *Noise Control Engineering Journal*, and, with I-INCE publishes this quarterly magazine and its Internet supplement. INCE/USA sponsors the NOISE-CON series of national conferences on noise control engineering and the INTER-NOISE Congress when it is held in North America. INCE/USA Members are professionals in the field of noise control engineering, and many offer consulting services in noise control. Any persons interested in noise control may become an Associate of INCE/USA and receive both this magazine and *Noise Control Engineering Journal.*

NNI Internet Supplement

www.noisenewsinternational.net

- Links to the home pages of I-INCE and INCE/USA
- Abstracts of feature articles in the printed version
- Directory of the Member Societies of I-INCE with links, where available, to the Member Society Profiles and home pages
- Links to I-INCE Technical Initiatives
- Calendar of meetings related to noise—worldwide
- Links, where available, to NNI advertisers
- Links to news related to the development of standards
- Link to an article "Surf the 'Net for News on Noise," which contains links to noise-related sites—worldwide

The Development of Noise Policies

The urgent need for effective noise policies has been the subject of several sessions at our INTER-NOISE Congresses. Numerous examples have been given of the lack of policies, or how existing policies have not been effective in reducing noise problems.

Much of the explanation for this failure is that noise as an environmental problem has a number of unique features. Noise policies—to be effective—cannot easily be copied from other environmental fields. The incentives to develop noise policies are also less than for many other agents in our environment.

Environmental noise is the result of the diffuse emissions from an enormous number of sources. We are all both emitters of noise and victims of the noisy environment. Through our daily activities, we share the responsibility for the noisy world and—and, to a somewhat lesser degree, we jointly suffer from its effects.

Practically all machines are at least 20-30 dB too noisy; if all machines emitted 20-30 dB less sound we would have very few noise problems. But there are, in general, no known solutions to achieve such a noise reduction on machines; the well-designed product typically has an acoustic efficiency of 10^{-7}. We do not know how to reduce this efficiency to 10^{-9} or 10^{-10}. If at all possible, it will probably demand a couple of hundred years of research and development to achieve this. The noise problem cannot be solved—only a little decreased—through emission legislation.

Noise has a number of adverse effects on our health. But it causes no blood in the streets and the relationship between noise and serious health problems are very indirect and therefore almost impossible to prove scientifically.

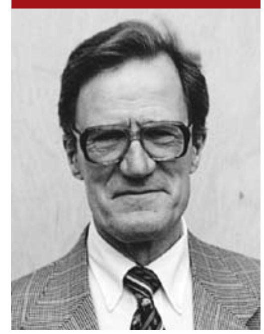
Noise does not endanger nature or affect natural resources. It has no known effect on nature such as ozone layer depletion or climate change, although there may be a few issues related to biodiversity.

Noise is normally not a serious problem for affluent persons because they usually have had the resources to remove themselves from unsatisfactory acoustic environments. This decreases their understanding of the problem and thereby their incentive to act.

However, the political problem is worse than that. Political actions or decisions on noise issues seldom result in any noticable effect for the victims within one election period for the politicians. Five to ten election periods are needed because the low cost measures to reduce noise demand long-term programs, which have to be run with continuity and determination, and which may produce very low effects in the beginning of any program. Also, for some of these optional measures it may be necessary to intervene in the present freedom to use noisy equipment wherever and whenever people like. Reasonable measures to reduce noise problems may include restrictions in this freedom.

These special features of noise create obstacles in our actions for noise policies. But the need for effective policies is obvious; such high fractions of the population suffer from the effects of noise that much more than hitherto has to be done.

I-INCE has two Technical Study Groups, (TSGs), working on noise policies. TSG 5, Global noise policy, intends to present a comprehensive draft report in time for INTER-NOISE 2004 in Prague. It will be an important basis for the discussions planned for the Prague congress and the further initiatives that should be taken.



Tor Kihlman

2003 President, International INCE

Noise Barriers Revisited

George Maling

Pan-American Editor

Regular readers of *NNI* will notice that several of the usual departments in the back of this issue are missing. There are two reasons for this. First, INCE/USA is attempting to keep *NNI* within a budget that allows for about 40 pages in each issue, and, second, there is a long article on the status of noise barriers in the USA that seems to me to be very important and of interest to many readers.

The data in Appendix A of the feature indicate that, as of 1998, 1.9 billion U.S. dollars (1998 dollars) were spent to construct 2610 linear km of barriers—for an average cost of about 731 USD per meter. The detailed State-by-State analysis in the article shows that there can be very wide variations in this cost, and identifies a number of factors that contribute to this variation.

In the President's Column in this issue, Tor Kihlman discusses noise policy and the difficulties that exist in attempting to create and implement noise policies. The material in this feature article is an excellent summary of how noise policy related to noise barriers has evolved in the U.S.A.

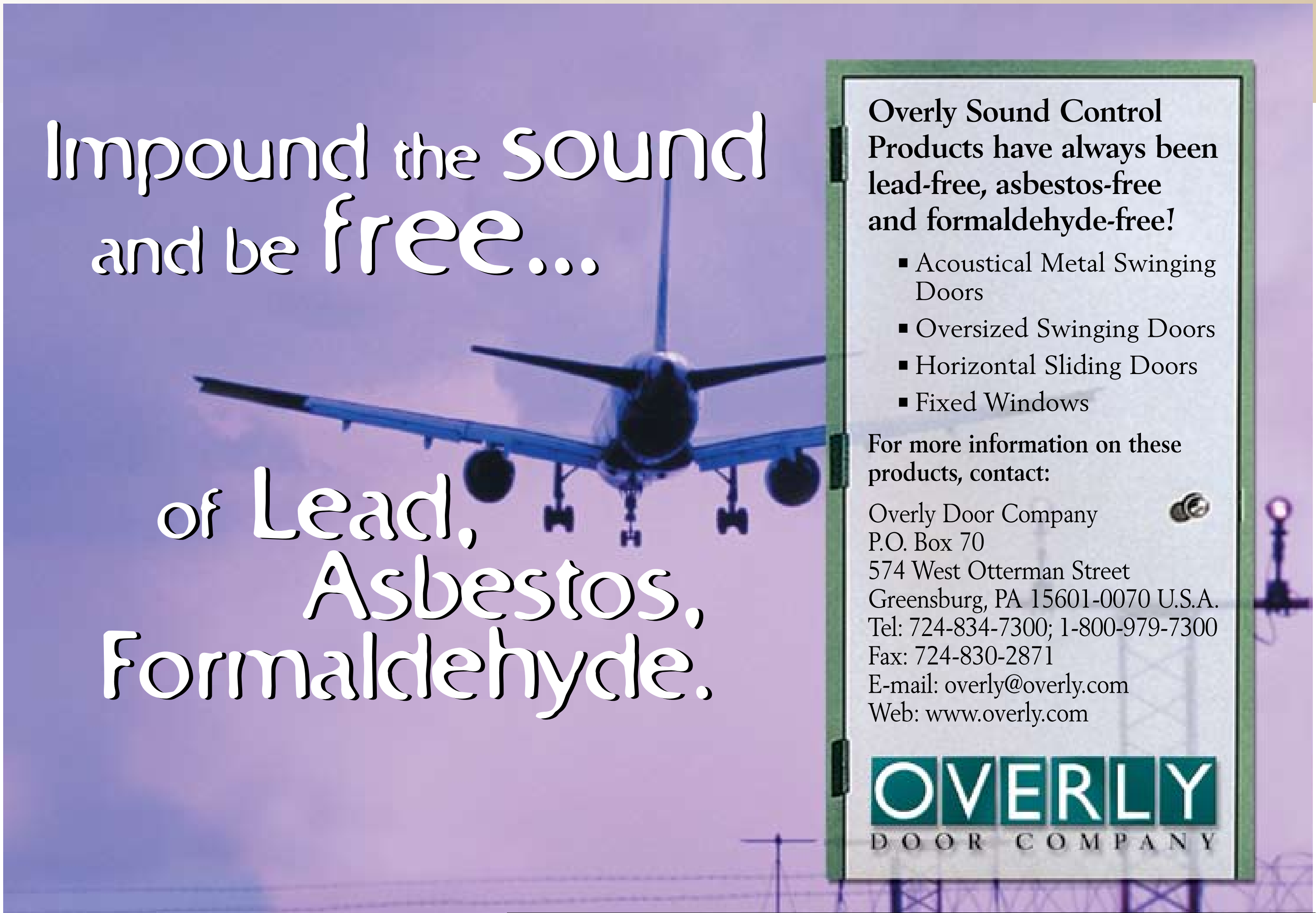
The International INCE report on a technical assessment of the effectiveness of noise barriers—published in this magazine in 1999—provides a wealth of information on the noise reduction available from barriers. Together, these articles should be useful for analyzing costs and benefits, but it is likely that the results of such an analysis will show that both costs and benefits vary over a very wide range.

Another point is the total cost of noise barriers. I doubt if anything like 1.9 billion USD has been spent on noise reduction of any source—with the possible exception of aircraft noise. I don't know how much money is being spent on tire/road noise research (both tires and road surfaces), but it seems to me that this work is of vital importance. It may lead to lower costs, and provide benefits to many persons who don't now live behind noise barriers.

All of our usual departments will appear in the December issue—as will summaries of three meetings held this summer: NOISE-CON 03, INTER-NOISE 03, and the 2003 Fan Noise Symposium. All three meetings were very successful. NOISE-CON 03 attracted 270 registrants as well as accompanying persons and the exhibitors listed in the product news department of this issue. The announcement of the availability of the conference CD-ROM is on the inside back cover of this issue, and proceedings information is also posted on the INCE/USA home page, http://www.inceusa.org.

INTER-NOISE 03 drew 832 registrants; exhibitors and accompanying persons brought the total attendance to well over 1000 persons. The specialist Fan Noise Symposium was an International INCE symposium, and drew 307 attendees from 28 countries. The proceedings of these two meetings are available from the conference organizers (see the June issue of this magazine). More details will be presented in *NNI* in December.

Finally, I would like to welcome Gordon Ebbitt to the *NNI* staff as Feature Editor. I am very grateful for his assistance, and we will begin to see the results of his work in early 2004.



Available from the INCE/USA Page at the Atlas Bookstore

- **The NOISE-CON 2003 Proceedings on CD-ROM.** This CD also contains ALL of the NOISE-CON Proceedings beginning in 1996 as well as the SQS 98 Proceedings.
- **The INTER-NOISE 2002 Proceedings on CD-ROM.** This CD also contains the Proceedings of SQS 2002.
- **The INTER-NOISE 99 Proceedings on CD-ROM.** This CD also contains the Proceedings of ACTIVE 99.
- **Noise and Vibration Control**
  Edited by Leo L. Beranek.
  This classic text on noise and vibration control is very widely used throughout the world. The book is divided into three parts: the basics of noise control (including measurement methods, acoustical materials, and sound propagation), application of these principles to reducing noise from sources, and criteria for noise control.
- **Noise Control in Buildings**
  Edited by Cyril M. Harris.
  Noise Control in Buildings features contributions by leading authorities on noise control, and contains a very complete set of data on the properties of acoustical materials and on the sound insulation of walls and floor/ceiling constructions. This wealth of technical information provides an invaluable resource for the professional as well as the non-professional.

http://www.atlasbooks.com/marktplc/00726.htm

The Acoustical Society of Finland

The history of the Acoustical Society of Finland dates back to a meeting held in the offices of the Finnish Broadcasting Corporation on 1942 August 25. At this meeting, a committee was appointed to study the need for a society to promote acoustical research in Finland and, if the need was demonstrated, to draft the bylaws for an acoustical society. Although it was wartime, the committee considered that acoustics was an area in which there should be activity within Finland. The bylaws were accepted at the first general meeting of the new Sound Technical Society on 1943 March 29. The Society is the oldest one of the Nordic acoustical societies.

The present name of the society was adopted in 1970. The purposes of the Acoustical Society of Finland are to provide a forum for professionals interested in acoustics and to promote research and education in all fields of acoustics. To achieve these objectives, the Society:

- Arranges meetings, courses, lectures, and exhibitions,
- promotes research activities and distributes professional literature,
- supports publication, consultative and similar activities, and
- develops acoustical terminology in Finnish.

One of the first actions to promote research was taken in 1943 October. Upon the recommendation of the Society, an acoustics laboratory was established at the Technical Research Center of Finland. A second initiative along the same lines was taken in 1947. An acoustics laboratory was established at the Helsinki University of Technology.

One concrete way in which the Society has promoted domestic acoustical research has been through small grants to undergraduate and graduate students, for example, to cover their travel expenses to international conferences.

The Society has been a member of I-INCE (since 1980), FASE (1979), EAA [European Acoustics Association] (1992), ICA (1953), and NAS [Nordic Acoustical Society)](1955).

During a typical year, the Society will host two general meetings, plus a half-dozen or so afternoon or evening meetings with lectures or discussions presented by members or international visitors. Since 1982, a Day of Acoustics has been held annually. The first foreign visitor was Per Brüel 1944. In 1983, Dr. Brüel was made an honorary member of the Society.

The joint meetings of the Nordic societies have been held for more than 40 years—every second year with one of the Nordic member societies acting as host. Recently the Baltic countries were welcomed to join the tradition, and the name has been expanded to Baltic-Nordic Acoustics Meeting. The Acoustical Society of Finland is responsible for the meeting to be held in Marienhamn, Aland next year during the period 2004 June 8-10. The official conference language is English. Further information can be obtained from the BNAM Secretariat via e-mail: bnam046@acoustics.hut.fi or from the Internet: www.acoustics.hut.fi/asf/bnam04.

The current president of the Society is Heikki T. Tuominen. He works as consultant at the Finnish Acoustics Centre Ltd., and can be reached directly by e-mail address: heikki.tuominen@akusti.com.

This is the 43rd in a series of articles on the Member Societies of International INCE. This is an update of the profile that appeared in the 1995 December issue of this magazine.—Ed.

Reduced INCE/USA Membership Fees

What a Deal!

For individuals who become new members or associates of INCE/USA in 2004, there is a reduced membership fee. See the membership application on pages 111-112 of this issue.

NOISE-CON 2004

NOISE-CON 04/TRB A1F04 Summer Meeting and Exposition

Announcement and Call for Papers

Submission of Abstracts - 5 March 04

Submission of Papers - 16 April 04

Reservations for Hotel and Tours - 11 June 04

Overview

The Institute of Noise Control Engineering of the USA (INCE/USA) holds a meeting every year. NOISE-CON 04 will be the 20th in the series of national conferences. The Transportation-Related Noise Committee of the Transportation Research Board (A1F04) holds meetings each summer.

This year, INCE/USA and A1F04 will be meeting together at the Wyndham Inner Harbor Hotel in Baltimore, Maryland, on 12–14 July 2004. This joint NOISE-CON 04/TRB A1F04 meeting will consist of technical sessions on all aspects of noise control engineering with an emphasis on transportation noise; receptions and socials, including a dinner cruise of the Baltimore Harbor; and an exposition of measurement instrumentation and noise and vibration control products.

Conference proceedings will be published on a CD-ROM that will be part of the package received at the conference by each attendee. Submission of papers for INCE technical sessions will be required. It will be left as an option for participants from TRB A1F04 to submit a paper for publication in the conference proceedings.

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cbb2@psu.edu

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Ames, IA 50011-2153
(515) 294-6142
ibo@inceusa.org

Technical Sessions

Technical papers are welcome in all aspects of noise control engineering and transportation noise. In addition, special sessions are being organized in the following areas:

Transportation Noise

- Materials and treatments for controlling surface transportation noise
- Railroad and urban transit noise
- Community exposure to airport noise
- Aircraft interior noise and airport personnel noise exposure
- Tire-pavement interaction noise—Long-term effects
- Noise metrics for transportation noise
- Railroad noise—Community standards and predictive technologies
- Active control for transportation noise
- Highway and commercial construction noise
- Isolation of building structures from transportation systems

Analysis and Measurements

- Statistical energy analyses in noise control
- Characterization of structure-borne noise source
- Fan noise
- Information technology product and component noise—New measurement and design techniques
- Modeling and measurement of noise from sources

Vendor Products

- Noise control products
- Computational capabilities and limitations—General purpose and building acoustics
- Instrumentation capabilities and limitations

Policies and Metrics

- Loudness standards and low frequency noise
- Facilitating public input in the community noise decision-making process
- Effectiveness and enforcement of noise policies and regulations
- Standards related to noise exposure and measurements
- Information technology product and component noise—Targets, requirements, and labels

2004

Invitation to Submit Abstract of Papers

Abstract Due Date
5 March 2004

Address for Abstract Submission
ibo@ince.org
or
NOISE-CON 04 Secretariat
INCE/USA Business Office
212 Marston Hall
Iowa State University
Ames IA 50011-2153

Instructions for Preparation of Abstracts

PAPER TITLE BOLD UPPER CASE LETTERS (20 words maximum)
First author's name, address, telephone number, Fax, and e-mail for correspondence

Additional authors' names and addresses (if any)

Text of the Abstract: An abstract of not more than 200 words is required for each paper, whether invited or contributed. Abstracts longer than 200 words will be edited or truncated. For abstracts submitted by postal mail, the text of the abstract should be double spaced. The abstract should include **(1)** a brief description of the problem being addressed, **(2)** why the problem is important, and **(3)** a brief description of the approach to and contribution of the work to be presented in the paper. There should be no special characters or equations in the abstract.

INCE/USA Subject Classification: Follows the abstract text. The Subject Classification numbers are given on the last page of this announcement.

Exposition Venue

This conference will be held in the Wyndham Inner Harbor Hotel located in the heart of downtown Baltimore, just a short walk from many restaurants and most of Baltimore's main attractions. Baltimore is served by Baltimore/Washington International (BWI) Airport, which is approximately 10 miles from the Wyndham Hotel. Taxi fares to the Wyndham are approximately $18, and the BWI SuperShuttle approximately $11. Baltimore is within a five-hour drive of most of the major northeast cities such as Washington D.C., New York, Philadelphia, Pittsburgh, and State College, Pennsylvania.

Baltimore is currently undergoing a second renaissance, with the city anticipating $1 billion in new development. The Inner Harbor, which is five blocks from the Wyndham, is the home of the National Aquarium, Maryland Science Center, and the Constellation, as well as many shops and restaurants. Included in the conference fee is a dinner cruise through the Inner Harbor and surrounding areas. Just minutes from the hotel are Little Italy, historic Fells Point, and the Can Company, a collection of historic buildings featuring a wide variety of shops and restaurants. The Light Rail, which can take you to Camden Yards and Meyerhoff Symphony Hall in the Cultural Center, is only a few blocks from the Wyndham. For more information on Baltimore, visit the Web site: www.baltimore.org.

Reply Coupon

Please complete this form and submit to the NOISE-CON 04 Conference Secretariat, INCE/USA Business Office, 212 Marston Hall, Iowa State University, Ames, IA 50011-2153. Form can be faxed to (515) 294-3528.

☐ Prof.
☐ Dr.
☐ Mr.
☐ Mrs.

Family Name ______________________ First Name ______________________

Institute/Organization ____

Postal Address ______________________ Fax ______________________

Telephone ______________________ E-mail ______________________

Position ____

☐ I am interested in attending NOISE-CON 2004.
☐ I am interested in presenting a technical paper.
☐ Please send me information on the equipment exposition.
☐ I would like to organize a special session for NOISE-CON 2004.

INCE/USA and I-INCE

Classification of Subjects in Noise Control Engineering

General
00 General
01 International INCE
02 International INCE *(continued)*
03 International INCE *(continued)*
04 International INCE *(continued)*
05 Publications *(other than technical articles)*
06 History and philosophy
07 Education
08 Noise programs
09 Definitions and descriptors

Emission: Noise Sources *(noise generation and control)*
10 General
11 Noise-generating devices *(including components and subassemblies)*
12 Stationary noise sources *(noise generation and control)*
13 Moving noise sources including aircraft *(noise generation and control)*
14 Specialized industrial machinery and equipment

Physical Phenomena
20 General
21 Physical mechanisms of noise generation
22 Natural sources of noise
23 Propagation, transmission, & scattering of sound *(general wave equation)*
24 Sound propagation in the atmosphere
25 Sound propagation in enclosed spaces
26 Sound propagation in ducts

Noise Control Elements *(for path noise control)*
30 General
31 Barriers and screens, shielding
32 Enclosures for noise sources
33 Sound isolating elements *(including panels, partitions, and curtains)*
34 Filters, mufflers, silencers, and resonators *(conventional types)*
35 Absorptive materials
36 Hearing protective devices
37 Noise attenuation and transmission in ducts
38 Special treatments *(including active noise control)*

Vibration and Shock: Generation, Transmission, Isolation, and Reduction
40 General
41 Characteristics of sources of vibration and shock
42 Vibrating surfaces and structures *(beams, plates, shells)*
43 Propagation in structures *(solid-borne noise)*
44 Balancing of rotating and reciprocating machines
45 Reduction of impact forces; shock isolation and absorption
46 Vibration isolators and attenuators
47 Vibration-clamping materials and structures
48 Vibration generators, shake tables
49 Effects of vibration and mechanical shock *(on man, on structures)*

Immission: Physical Aspects of Environmental Noise *(multiple sources and multiple paths)*
50 General
51 Building noise control
52 Community noise control
53 In-plant noise control
54 Shipboard and offshore platform noise control
55 Outdoor plant noise control design and construction
56 Noise surveys

Immission: Effects of Noise
60 General
61 Perception of sound
62 Physiological effects
63 Psychological effects
64 Effects of noise on physical structures
65 Effects of noise on domesticated and wild animals
66 Sociological effects; community reaction to noise
67 Economic effects
68 Environmental impact statements
69 Criteria and rating of noise

Analysis
70 General
71 Instruments for noise and vibration measurements
72 Measurement techniques
73 Test facilities *(design and qualification)*
74 Signal processing
75 Analytical methods
76 Modeling, prediction, and simulation
77 Sampling and quality control procedures
78 Audiometry, dosimetry, and hearing measurements
79 Psychoacoustical evaluations and testing

Requirements
80 General
81 Standards
82 Federal government legislation and regulations
83 State and local legislation and regulations
84 Other legislation and regulations
85 Ordinances, including zoning requirements
86 Building codes
87 Specifications
88 Auditing, enforcement, and certification
89 Labeling

Second Announcement and Call for Papers

Czech Acoustical Society
The International Institute of Noise Control Engineering

inter.noise 2004

Prague • Czech Republic • August 22–25

Dear Colleagues,

On behalf of the organizer of INTER-NOISE 2004, the Czech Acoustical Society, and the International Institute of Noise Control Engineering, we would like to invite you to present a paper or simply to participate in INTER-NOISE 2004, the International Congress and Exposition on Noise Control Engineering. This congress will be the 33rd in a series of international congresses. As in previous years, the congress is open to all innovative contributions from a variety of topics in noise control engineering. The theme for the Congress is as broad as possible to cover all interesting aspects - “Progress in Noise Control for the 21st Century”.

The organizing committee has taken great pains to arrange an outstanding technical program and exhibition. The congress will be held at the campus of the Czech Technical University. The buildings of the Faculty of Electrical Engineering and the Faculty of Mechanical Engineering offer all of the facilities necessary for a congress of this size.

In addition, the main congress hotels are within easy walking distance. Last but not least, we should like to invite you to city of Prague. If this is your first visit to this city, you will be surprised by its architectural beauty and new-found dynamism. We are sure you will enjoy INTER-NOISE 2004 in Prague, both professionally and socially.

Josef Novák, President of the Congress
Tor Kihlman, President of I-INCE

Congress Venue

INTER-NOISE 2004 will take place at the Czech Technical University, Faculty of Electrical Engineering in Prague. The university campus is situated in the district of Dejvice, in the western part of the city and close to some of Prague’s largest hotels. The congress venue can be reached from the airport within 30 minutes by taxi or by bus. Prague is also easily accessible by car and by train.

Official Partners of Inter-Noise 2004

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Call for Technical Contributions

Papers related to the technical areas listed below are especially welcome for presentation at the **INTER-NOISE 2004** Congress, but technical papers in all areas of noise control may be submitted for inclusion in the technical program. Abstracts must be submitted in the format enclosed with this announcement. The deadline for the receipt of the abstract is January 30, 2004. Information as to the papers' acceptance will be sent to the authors on February 29, 2004. Manuscripts for publication in the Conference proceedings are due on April 30, 2004.

Manuscripts must be prepared according to the format described on the Congress home page http://www.internoise2004.cz Final manuscripts must be submitted in PDF format by April 30, 2004. All registrants for **INTER-NOISE 2004** will receive a printed booklet containing all abstracts, the final technical program, and a CD that will include all INTER-NOISE 2004 papers. The Conference organizers reserve the right to schedule papers for the appropriate sessions and appropriate format (poster sessions versus oral presentation in technical sessions).

Format for Submission of Abstracts

Abstracts can be only submitted through the registration contained in the Congress home page http://www.internoise2004.cz. Please have the following information prepared for submitting an abstract via the web:

I. Paper title (20 words maximum)
II. I-INCE Classification of subjects (use detailed classification of subjects at http://www.internoise2004.cz
III. First author's name, address (including country), telephone number, fax, end email (essential) for correspondence
IV. Additional authors' names and addresses (if any)
V. Indicate specific type of paper
   – Invited paper
   – Contributed Paper
   – Paper for poster session
VI. Text of the abstract, not exceeding 250 words
   The text should include:
   – A brief description of the problem being addressed
   – Importance of the problem
   – Method of the development used for problem solving
   – Original contribution of the work
   – Conclusions

Address any questions and notes to:
Inter-Noise 2004 Congress Secretariat
Technická 2
166 27 Praha 6
Czech Republic

or e-mail to:
internoise2004@fel.cvut.cz
tel.: +420 224 352 310
fax: +420 224 355 433

INTER-NOISE 2004 Exposition

An exposition of acoustical equipment, materials, software, and other products for noise and vibration control, measurement and diagnosis, will be organized in the **INTER-NOISE 2004** Exposition. All companies active in the field are welcome to participate in the exposition.

General Topics

- Noise sources
- Machinery noise
- Noise propagation
- Noise control methods and materials
- Active noise and vibration control
- Structure borne noise
- Vibrations (vibrating surfaces and structures, isolation and damping)
- Noise in buildings
- Transportation noise (air, road, rail and marine vehicles)
- Traffic noise
- Sound quality
- Effect of noise on man and society
- Environmental noise
- Community noise
- Instrumentation and techniques for noise measurement and analysis
- Modeling, prediction and simulation
- Regulations and legislations
- Costs and benefits

Prague

The capital city of the Czech Republic, Prague is again assuming its historical role as a cosmopolitan urban crossroads for creative figures of all nations and fields of activity. The explosion of activity released in the return of freedom to the arts, commerce, and even science has shown Prague to be well on its way to matching its past glories with concrete present achievement. With its unmatched legacy of architectural styles, from Romanesque, Gothic, Renaissance, Baroque, and Art Nouveau through Cubism and Functionalism, the urban fabric of Prague might appear to be a living architectural guide illustrated with the finest examples of each style. Add to this the exceptional range of museums, galleries, theatrical and concert venues, and one would be tempted never to stray outside the city. Nevertheless, the immediate surroundings of Prague, whether the landscapes of forests and hills or the famous castles are themselves as fascinating as the city itself, and almost as easily accessible. Congress participants and accompanying persons will have opportunity to take part in following activities organized during and after the congress:

- **Social Program**
  Opening ceremony with concert
  Welcome party
  Congress dinner
  Closing ceremony and reception

- **Sightseeing Tours in Prague in the time of the congress:**
  Prague City, Prague Castle, History in the Architecture,
  King Charles IV Medieval City,
  Jewish Town, Prague by Night

- **Sightseeing Trips in Bohemia after the congress:**
  Antonín Dvořák's memorials to the north of Prague,
  Karlstein and Konopiště castles, Karlovy Vary spa and
  Pilsen

- **Sightseeing Trips in Central Europe after the congress:**
  Austrian Salzkammer (Linz, Salzburg),
  Central Europe capital cities (Vienna, Budapest,
  Bratislava)

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Highway Traffic Noise Barriers in the U.S.—Construction Trends and Cost Analysis

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Introduction

For a number of years, the U.S. Department of Transportation (DOT) and the Federal Highway Administration (FHWA) have been compiling data on highway traffic noise barriers constructed in the U.S. in an effort to identify trends and to measure and document progress of the States in addressing the issue of highway traffic noise impact on communities. As part of this effort, FHWA's Office of Natural Environment issues a call on a triennial basis to all the fifty States, the District of Columbia, and the Commonwealth of Puerto Rico for updates and summaries of local/state-level noise barrier construction activity that has occurred in the last three-year period. FHWA then compiles and analyzes the data into a running list of noise barriers for each State/jurisdiction and publishes two documents. The first report summarizes the individual project or barrier-related costs and other physical characteristics for all noise barriers constructed by each State/jurisdiction to date. As part of the overall document, the actual listing of all barriers as reported by each State is also included. The second document provides some statistical analysis of the data to identify general *national* trends pertaining to highway traffic noise barrier construction. One key factor to note in the FHWA data compilation is that the data are reported based upon each State's own criteria, practices, and procedures. There is *no* universally applied method or guidance for reporting cost and other barrier data from State to State. In the determination of costs associated with noise barriers, every State has its own criteria and factors for determining what is included in the reported cost of a noise barrier. For example, one State may use the overall bid cost for a project, while another may quote only the cost of the barrier material or "system" (i.e., posts, panels and foundations), while yet another State may include a combination of various cost elements. The methods for reporting data on the physical dimensions of the barriers are subject to somewhat less State-to-State variation; however, the overall accuracy of all the data is not fully verifiable. In addition, because some of the State running lists of barrier information may span a period of 20 years or more, there is a good chance that the individual State's methods or criteria for reporting costs and other data have not remained static or consistent over time. Therefore, in the absence of uniform guidance on reporting information on noise barrier construction, care must be exercised in all comparisons.

In this article, the goal is to examine the cost, trends and statistics limited to the top five to six most active States that have constructed noise barriers, and to expand upon the FHWA analysis of the State summary data to identify other trends. The latest available FHWA reports[1,2] dated 2000 April show that the top six States account for slightly more than 54% of the total linear kilometers and square meters of noise barriers constructed as of 1998 December 31. The top ten States accounted for 70% of the total linear kilometers and square meters.

Noise barrier costs, trends, and statistics are analyzed in this article.

Of particular interest and focus, is an assessment of potential "economy-of-scale" effects; i.e., the relationship of the noise barrier unit cost to the size (or length) of the noise barrier project. Each individual barrier listing for each State was compiled in a spreadsheet for analysis. It is theorized that with a relatively large project (considering both square meters and linear meters), barrier *unit cost* should be less than with a project involving smaller material quantities. In addition, certain other cost elements that are generally a part of every contract may be more significant to the overall cost (i.e., a higher percentage of the total cost) for a project involving smaller barrier quantities. The analysis examines trends found in the data from each State individually. In doing so, the results are less likely to be affected by the way in which barrier cost data are reported or which specific cost items are included in the cost— assuming, of course, that the data reporting is reasonably consistent within the overall State list. Whether each listing involves a single barrier section or multiple sections combined and listed as one composite project, the construction contract cost factors should carry over. Once again however, verification of the accuracy of the reported numbers is not possible, so the overall results should be considered in that light.

The data from the FHWA summary listing for each of the top five States (excluding California) will be discussed in detail. The reason for exclusion of California in this article is primarily due to the size and wide geographical diversity of the Golden State, and several rather unique conditions or circumstances that are absent or rare in the other top five States. A separate discussion of California as it relates to this study is included later in this article.

Finally, a closer examination of the specific elements that contribute to the cost of noise barriers is presented. Using several broader

research studies and a recent study of bid costs and cost trends undertaken by one of the top five States (to identify reasons for recent cost escalations), an effort was made to identify the most significant controlling factors in barrier costs. While the most recent study is State-specific, it is felt that the trends and factors identified can be reasonably applied on a more universal level— recognizing the collective influence of the known variables in the overall cost equation.

Background and Definitions

In any discussion of highway traffic noise barriers, there are several key terms that should be defined. A general understanding of the terminology will aid in placing some of the data and analysis in the proper context. In addition, a review of the historical background surrounding the highway traffic noise issue and the evolution of highway noise mitigation is also useful.

The requirements for noise barriers and noise abatement in general are defined in the regulations resulting from the passage of the National Environmental Policy Act (NEPA) in 1969. The NEPA process requires consideration of all potential environmental impacts (including noise) from proposed public works projects involving Federal funding. Subsequently, the passage of the Federal-Aid Highway Act of 1970 mandated the development of standards by FHWA for the mitigation of highway traffic noise. The very first noise regulation was promulgated in 1972 as Policy and Procedure Memorandum (PPM) 90-2. The first version of the current regulations was issued in May of 1976. Subsequent regulatory revisions and refinements and broader legislative actions have occurred over the years (e.g., the Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), and the National Highway System Designation Act of 1995). However, the major aspects of the regulations and the overall intent

About the Author

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Kenneth D. Polcak received his Bachelor's Degree in Civil Engineering in 1976 from the University of Maryland at College Park and shortly thereafter began his career with the Maryland State Highway Administration (MDSHA) in early 1977. Early on, he worked extensively in the establishment of the Type II Noise Abatement Program in Maryland, and was instrumental in the initial development of a statewide noise complaint and project tracking system for the noise program. He worked extensively on highway traffic noise studies, conducting noise measurements and analyzing noise abatement solutions, and developing barrier designs. He has also conducted several research studies on pavement noise.

For over twenty years, he has been involved with activities of the Transportation Research Board Committee A1F04 on Transportation-Related Noise & Vibration; from 1996 to 2002 he first served as Chair of the Highway Noise Subcommittee of A1F04, and most recently accepted appointment as Full Committee Chair in 2002. In addition, he has also served on several research synthesis expert panels for the National Cooperative Highway Research Program (NCHRP) that studied traffic noise barriers and pavement noise. He has also chaired another expert panel to develop guidelines for evaluating the performance of highway noise barriers under the auspices of the Civil Engineering Research Foundation (CERF) Highway Innovative Technology Evaluation Center (HITEC) for the American Society of Civil Engineers (ASCE).

He also served on the technical review panel for the development of the new FHWA traffic noise prediction model (TNM), and provided substantial field support in the development of new national Reference Energy Mean Emission Levels as part of TNM. In his current role with MDSHA he functions as a senior noise analyst for both planning and design projects.

governing the analysis and abatement of highway traffic noise have remained largely intact.

For the purposes of funding and to provide a measure of flexibility for the State transportation agencies, there are two "types" of noise barriers defined in the FHWA regulations. The major differences relate to 1) regulatory requirements, and 2) the circumstances under which each "type" of barrier would be constructed.

A "Type I" noise barrier is defined as a barrier built as part of a project which constructs a highway on a new location, or which involves the physical alteration of an existing highway that significantly changes the horizontal or vertical alignment, or increases the number of through-travel lanes. The noise barrier system and items directly associated with it (such as foundations, posts, special surface treatments or other aesthetics features, for example) are basically additional bid items in the overall highway construction contract. The regulations require *consideration* of Type I noise abatement (most often noise barriers) if noise impacts are identified. This alone, however, does not automatically guarantee noise barrier construction. The States establish specific criteria to judge whether a noise barrier would be "feasible and reasonable;" cost, of course, being a major consideration. Engineering feasibility, constructability, and other factors are also assessed. If a noise barrier is deemed "feasible and reasonable," then the barrier *must be included* as a part of the highway contract. Consideration of Type I noise barriers is not voluntary, but is a requirement as part of the NEPA process.

Type I and Type II noise barrier costs have to be treated differently.

A "Type II" noise barrier is one that is built along an existing highway or "retrofitted" to mitigate an existing noise problem (i.e., in response to citizen complaints). Unlike a Type I project scenario, no changes or improvements to the existing highway are involved in a Type II project. Type II barriers are only considered for communities that existed prior to the original construction of the highway, subject to the same "feasible and reasonable" assessment undertaken for Type I barriers. A separate contract is let just to provide noise abatement, thus the entire contract cost can reasonably be associated with a Type II project. Consideration of Type II noise barriers is purely *voluntary*. The mechanisms and basic criteria for considering Type II noise abatement are contained within the same FHWA regulations that govern Type I projects, however, to date, a majority of States have opted *not* to establish a Type II noise abatement program (twenty-two States have built at least one Type II barrier). Of the twenty-two however, the top ten States account for over 95% of all Type II barriers built—as of the end of 1998.

An important factor to note is that for either Type I or Type II projects, there can be more than one individual barrier in the same contract if several different and non-contiguous communities are involved, or if communities exist on both sides of the subject highway. If this is the case, when costs are reported they can be combined (along with the dimensional data such as area, etc.), or the information related to each barrier section can be listed separately. This can be important if cost reporting includes administrative or overhead costs. Appendix A is the actual FHWA document[1] upon which the data analysis for this article has been based (minus the actual barrier listing, which is over 60 pages). It is reprinted with the permission of the FHWA Office of Natural Environment. The construction trends analysis document[2], also reprinted by permission of the FHWA, is Appendix B. Both are included here for reference and to provide additional background and perspective on the Federal and State efforts in addressing the issue of highway traffic noise in the United States.

Initial Screening Assessment

In the process of developing the approach for the analysis of the State data, it was felt that an initial screening assessment should be undertaken to identify any conditions or factors that might place in context whatever additional trends were discovered. As stated earlier, in evaluating the data from the FHWA summary there was serious concern regarding the potential for inconsistency, non-uniformity, and data anomalies from known variables and sources of bias. The first decision made was that direct State-to-State comparisons should be avoided. A review of the listings of barriers for the top six States showed an extremely wide variation in the actual number of individual listings for each State, when considered in light of their ranking for total barrier area. Table 1 lists the top six States ranked by total area (m^2) built and compares the number of individual barrier listings. Also given is an average length of barrier per listing (each figure was derived by dividing each State's total linear kilometers by the total number of individual barrier listings).

Table 1 - State Ranking by Total Square Meters & Comparison of Listings

State	Ranking by Total Square Meters Built	Number of Barriers/ Projects in Listings	Average Length per Barrier/Project (km)
California	1	619	1.25
New Jersey	2	50	2.8
Virginia	3	256	0.6
Ohio	4	40	3.5
Maryland	5	71	1.4
New York	6	147	0.75

As stated earlier, there are two ways in which barrier data can be reported; either on an individual barrier basis, or on a project basis (in which a project may contain several individual barrier sections, and the overall cost and dimensional data is associated with more than one barrier). In essence, any data for a multiple barrier project listing is a composite figure. There appears to be clear evidence of this practice as illustrated by the diverse numbers of barrier listings shown in Table 1. The data indicate that, by the number of listings alone, California, Virginia, and New York, may be reporting barrier data primarily, or exclusively, on an individual barrier basis. For the remaining three States, some combined reporting of barrier data may be present. Some listings will include data totals that represent more than one barrier section, and others will be reporting data for individual barriers. There is also the potential for having a mixture of individually listed and multiple barrier listings in each State's list. Referring to Table 1 in the FHWA summary report[1] (presented as Appendix A), note that the top 5 states differ somewhat depending on whether one compares total barrier area or barrier length. This indicates that some states may, on average, be building taller barriers (hence more barrier area per linear meter). This trend appears to be evident in the construction trends document[2], Appendix B,which summarizes average height and average unit cost by State in Table 9.

For example, although Maryland ranks 8th based on linear kilometers completed, it ranks 5th based on total square meters. This appears to be linked to a higher (5.8 meter) average barrier height in Maryland, compared to both New York at 4.5 meters and Colorado at 3.2 meters.

Cost Trends Analysis

The following discussions offer some additional detailed analysis of the barrier data listings from the top six most active states, as shown in Table 1. Particular focus is placed on the potential for economies of scale; i.e., do larger overall projects yield lower unit costs, compared to smaller projects.

California

The first most obvious question one may ask is: "why is data from California not specifically analyzed and included as part of this study?" California has been the most active state in building noise barriers by far, having completed 777,160 meters (483 miles) of barriers since the early to mid 1970s. The summary listing for California contains data on over 600 individual barrier listings. In contrast, the next most active state (New Jersey) lists 50 barriers totaling 142,055 meters (88.3 miles). Hence, California could be a study unto itself, based on the volume of noise barrier work conducted to date.

Seismic requirements on structures (including noise barriers) are somewhat unique to California, especially compared with areas in the Eastern U.S. where the other top five States are located. Design requirements and criteria are, by definition, unique and incompatible with other States.

Another somewhat unique aspect of the noise barriers built in California is the type of material utilized. The vast majority of barrier projects involve masonry block construction. Only 15-17% of the listings involve material other than masonry block. In all the other top-five states, masonry construction is the exception, with pre-cast concrete the primary material used for noise barriers.

Finally, the huge geographical area that is California could introduce other non-uniformity factors in the form of potential regional variations in cost. The total land area of California is greater than that of all the other top-five States combined. It would seem that any analysis of California data should be done on a regional basis and compared with the State as a whole.

New Jersey

New Jersey ranks second behind California in total square meters of noise barrier completed as of the end of 1998. Figure 1 shows a comparison of the unit cost per square meter for each barrier listing, versus the corresponding length of barrier associated with each listing. This includes all projects and includes all material types. In Figure 2, the same comparison is made, but is limited to projects/barriers made of pre-cast concrete. A total of 50 listings were included in the FHWA summary, the majority of which were approximately 5000 meters or less. The smaller the length of the project, the wider the scatter in terms of the unit cost. The significant aspect of this data is that a relatively small number of listings result in a number two ranking nationwide—in terms of total barrier square meters completed.

Note in the analysis presented in Table 1, the average length of a barrier is 2.8 kilometers. Comparing this figure with the other states, it may be inferred that some listings may include data totals associated with more than one individual barrier.

The linear regression trend line in Fig. 1 shows that there does appear to be an "economy of scale" effect. Considering only the projects involving pre-cast concrete barriers (Fig. 2) the trend is similar though the scatter in the unit cost is overall somewhat less severe, as would be expected since only one material type is involved.

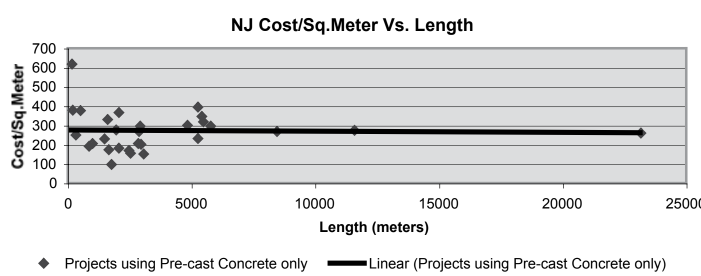


Figure 1

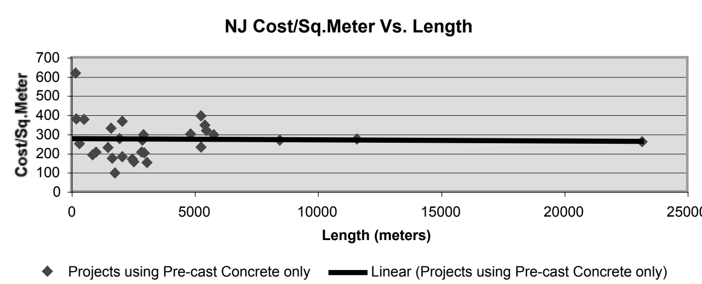


Figure 2

Virginia

In terms of total square meters of noise barrier completed as of the end of 1998, Virginia ranks third behind California. Figure 3 shows a graphical comparison of the unit cost per square meter for each barrier listing versus the corresponding length of barrier associated with each listing. This includes all projects and all material types. In Fig. 4, the same comparison is made, but is limited to projects/barriers made of pre-cast concrete. In contrast to the 50 listings for New Jersey, a total of 256 listings was included in the FHWA summary for Virginia. In contrast to New Jersey, nearly all the barrier listings involved linear dimensions of 2000 meters or less; the vast majority were approximately 1500 meters or less in length. As with the New Jersey data, the smaller the length of the project, the wider the scatter in terms of the unit cost.

More individual barrier listings suggest the likelihood that more single, individual barriers are included in the data provided to FHWA. In this case, contrary to the New Jersey data, a relatively large number of listings contribute to the number three ranking nationwide, in terms of total barrier square meters completed. The data in Table 1 show that the average length of a barrier is 0.6 kilometer. Comparison of this figure with the other states further supports the notion that the listings mostly include totals associated with a single barrier section.

The "economy-of-scale" analysis for the Virginia data is less definitive. In Fig. 3., the linear regression trend line shows virtually no relationship between size (i.e., length) and unit cost. In fact, considering only those projects involving pre-cast concrete barriers (Fig 4.) the trend is towards a modest increase in cost with barrier length. The reasons for this reverse trend are not apparent at this level of analysis; a much more detailed assessment of the data and the reporting methods and prevailing criteria are needed.

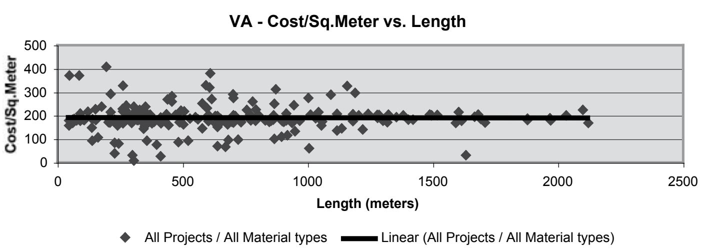
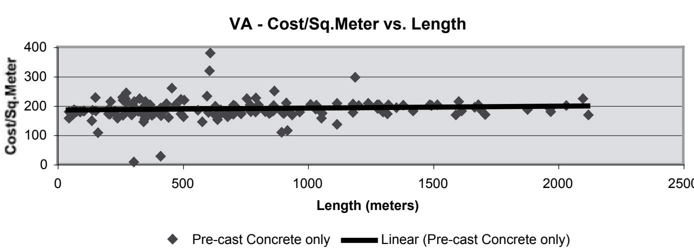


Figure 3



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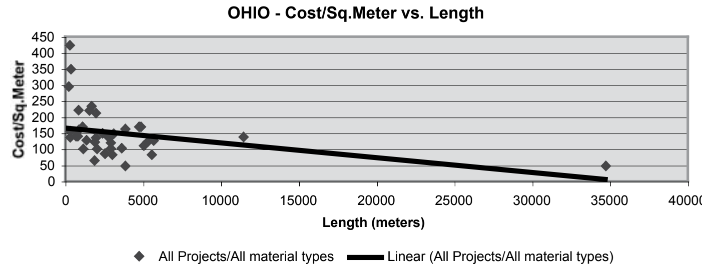

Figure 5

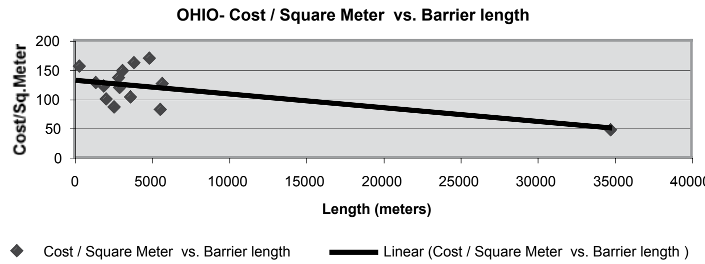

Figure 6

Ohio

Ohio ranks fourth behind California based on total area of noise barriers completed as of the end of 1998. Figure 5 shows a graphical comparison of the unit cost per square meter for each barrier listing, versus the corresponding length of barrier associated with each listing, and includes all material types. In Fig. 6, the same comparison is made, but is limited to projects/barriers made of pre-cast concrete. Similar to listings for New Jersey, the Ohio data includes a total of 40 listings in the FHWA summary. Compared with New Jersey, nearly all the barrier listings involved linear dimensions of 5000 meters or less in length. As with the New Jersey data, the smaller the length of the project, the wider the scatter in terms of the unit cost.

Fewer overall listings suggest that more of the listings may involve multiple barriers within the same listing. This is rather similar to the New Jersey data. The data in Table 1, show the average length of barrier for Ohio is 3.5 kilometer. Comparison of this figure with the other states further supports the notion that the Ohio listings include totals associated with multiple barrier sections.

According to the Ohio Department of Transportation[3], the cost items reported and included in the FHWA summary include costs for posts, panels, and foundations only. This would suggest some measure of consistency for inclusion of both Type I and Type II barriers, because other variable cost items are excluded.

The "economy-of-scale" analysis for the Ohio data is well defined. The linear regression trend line in Fig. 5 shows a strong correlation between the length to unit cost. For pre-cast concrete barriers, Fig. 6, the trend is similarly well defined.

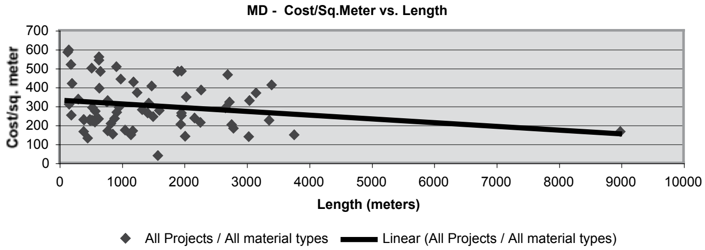

Figure 7

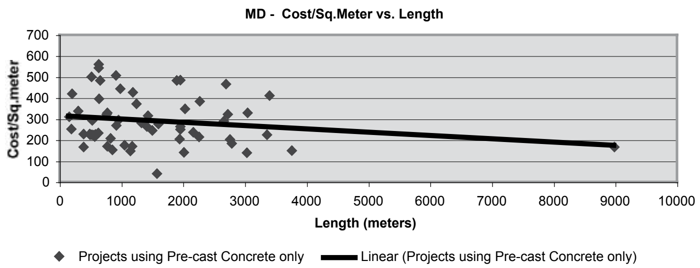

Figure 8

Maryland

Maryland ranks fifth behind California based on total square meters of noise barrier completed as of the end of 1998. Figure 7 shows a graphical comparison of the unit cost per square meter for each barrier listing, versus the corresponding length of barrier associated with each listing, and includes all material types. Figure 8 shows similar data, but is limited to projects/barriers made of pre-cast concrete. There is a total of 71 listings for Maryland in the FHWA summary. All of the listings involved barrier dimensions of less than 4000 meters in length. Unlike the New Jersey data, the scatter in the Maryland unit cost data is fairly consistent and less tied to the length of project.

In the overall listing, there is a mix of single barrier and multiple barrier entries, based on the author's knowledge of the State's practices. Table 1 shows that the average length of barrier for Maryland is 1.4 kilometer. This figure tends to fall in the middle of the range observed for the other States.

In the submission of data to FHWA for the triennial barrier update, the costs reported by the Maryland State Highway Administration (MD SHA) vary between Type I and Type II projects[4]. Total bid cost is generally reported for Type II projects since they are stand-alone contracts and the total costs associated with providing a Type II noise barrier are easily determined. For Type I projects however, only costs that can be directly related to the noise barriers are included in the FHWA summary (generally posts, panels, and foundations installed). This approach does not necessarily provide for complete consistency between Type I and Type II barrier costs, however, it can be argued that because other non-barrier items are associated with the larger Type I highway project, those costs would exist with or without noise barriers as a part of the contract and should not be attributed to the noise barrier. In a realistic accounting for cost associated with a Type II project, all contract items directly relate to the noise barrier construction and therefore should be included.

The "economy-of-scale" analysis for the Maryland data is well defined. The linear regression trend line in Fig. 7 shows a strong correlation between the project/barrier size or length to unit cost. Pre-cast concrete barriers, Fig. 8, show a similarly well defined trend.

New York

In terms of total square meters of noise barrier completed as of the end of 1998, New York ranks sixth behind California. Figure 9 shows a graphical comparison of the unit cost per square meter for each barrier listing, versus the corresponding length of barrier associated with each listing, including all material types. Figure 10 applies the same comparison, but is limited to projects/barriers made of pre-cast concrete, which comprise about 58% of all projects. A total of 147 listings is included in the FHWA summary for New York. Nearly all the barrier listings involved linear dimensions of 2000 meters or less. As was the trend in the New Jersey data, the smaller the length of the project, the wider the scatter in terms of the unit cost.

More individual barrier listings suggest that more single, individual barriers are included in the data provided to FHWA. The data in Table 1 show that the average length of barrier is 0.75 kilometer. Comparison of this figure to the other states further supports the notion that the listings include primarily totals associated with a single barrier section.

According to the New York State Department of Transportation[5] , cost items reported over the years in the FHWA summary vary widely. Some early cost figures were taken from environmental impact studies, while other subsequent cost reports were based on more detailed design data, engineering estimates or actual bid costs.

The "economy-of-scale" analysis for the New York State data is well defined, and is similar to the analysis of Ohio and Maryland data. The linear regression trend line in Fig. 9 shows a strong correlation between the project/barrier size or length to unit cost. For listings involving pre-cast concrete barriers only, Fig. 10, the trend is similarly well defined.

Sources of Data Inconsistency and Anomalies

As referenced in Appendix A, the FHWA summary listing of noise barrier construction, and the construction trends analysis, Appendix B, there is strong potential for non-uniformity and/or anomalies in the data supplied by the States regarding noise barrier construction. In general, the root cause lies with the different methods, criteria, and definitions of barrier information that each State highway agency utilizes— as reported by several of the highway agencies included in this evaluation.

The primary area for data anomalies is in the cost reporting. This can be linked to several aspects of cost determination; mostly differences in the items that are included in the overall barrier cost figure. Material costs such as posts, panels, and foundations are the universal baseline items defining cost. As reported in a recent bid analysis study[6] conducted for the MD SHA in early 2002, this "barrier system" cost constituted 64-69% of the total project cost, on average. Depending on the items included in a cost report, there could be as much as a 30-35% differential in the reported cost for a given noise barrier project, assuming, of course, the baseline cost items (posts, panels and foundations) as the reference point.

While barrier material costs represent the largest percentage of the total cost, other items required as part of the overall project may or may not be included, depending on the State and their definitions and criteria. These items can include, grading and excavation, drainage structures, utility work, maintenance of traffic or other traffic controls and safety measures such as guardrail, landscaping or other aesthetic treatments, and preliminary activities plus administrative or overhead costs. Absent specific guidance or criteria from FHWA, each State is free to determine the importance and relevance of all of these items and whether any or all should be part of the cost figure.

As stated earlier, cost definitions may also be different by virtue of the "type" of project. With a Type I barrier, there are a specific, limited number of cost items for the barrier system are readily identifiable; other cost items cannot be isolated or easily linked to the barrier, but rather are required as part of the overall highway project. Conversely, with a Type II barrier, all cost items can be linked directly to the barrier. The differential in overall cost between Type I and Type II noise barriers can therefore be substantial, and presents another source of variation or inconsistency.

Contributing Elements to Noise Barrier Costs

In addition to the efforts summarized in Appendix A, there have been several major efforts over the last several years to examine and document States' experiences with highway noise barriers[7] in terms of cost and other factors involving construction. For *all* of the cost elements associated with typical noise barrier construction to be successfully isolated, Type II projects offer the most reliable date for analysis. In Type II projects, bid items can be broken down into seven basic categories;

- **Preliminary.** This category includes such factors as mobilization costs, clearing and grubbing, field office set-up, and other preparatory activities that must occur before construction can commence.
- **Drainage.** This category includes all elements related to maintaining and facilitating drainage of the barrier site, including but not limited to inlets, pipe, underdrain systems, ditch treatments, rip-rap, stormwater management facilities, etc.
- **Excavation.** This category includes cost for grading, and excavation for various elements such as ditches, benching, and construction roads, or other access features.
- **Guardrail.** This category includes traffic control devices, signage, jersey barrier or other protective elements that may be part of the maintenance of traffic requirements, or ultimately protecting the newly installed noise barrier from vehicle impacts.
- **Utilities.** This category includes costs that may be incurred to relocate overhead or underground utilities that may be affected by the noise barrier construction. Such relocations could be temporary or permanent.
- **Barrier System.** This category includes the basic physical elements of the structural barrier system including posts, panels, and foundations. Also included could be grade beams, special panels, costs associated with architectural, decorative or aesthetic finishes, or absorptive surface treatments. Costs could also be associated with special foundation requirements due to special sub-surface conditions. In some cases, costs for retaining walls may be included.
- **Landscaping.** This category includes all the elements associated with site restoration at the completion of construction activities, trees and shrubs, seeding, mulching, etc.

As referenced earlier, 64-69% of the total barrier project cost is associated with the barrier system. The two pie-charts, Figs. 11 and 12, show the results of bid cost assessments of Type II projects

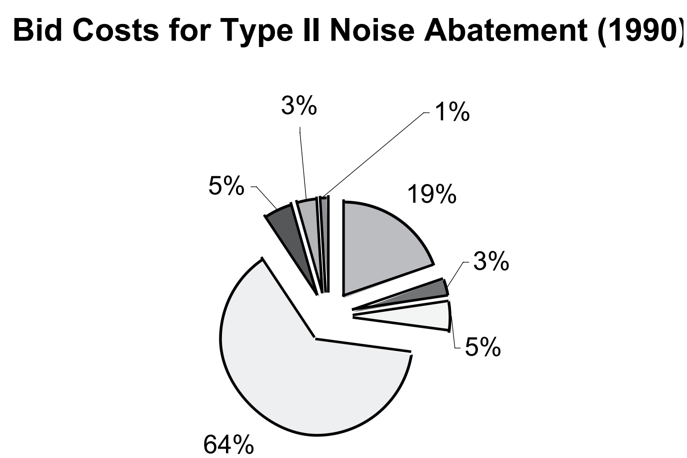

Figure 11

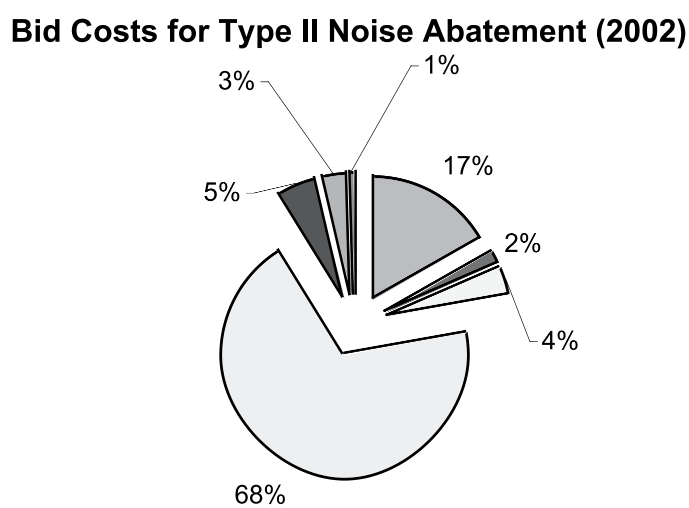

Figure 12

conducted by the MD SHA in 1990 and 2002. An examination of the various cost categories (as a percentage of the total cost) leads to the interesting result that preliminary, landscaping, utilities, and guardrail costs were approximately the same in the 1990 and 2002 cost studies. Excavation and drainage costs were slightly higher as a percentage of total costs in 1990. Barrier system costs, however, have increased from 64% of the total project cost to 69%. More significantly, however, was a substantial increase in the total cost per square meter. The MD SHA study explored the factors and conditions that may be contributing to cost escalations in recent years. While this information is State-specific, it also provides some insight into the factors that could affect any noise barrier project.

Another element that will influence cost is the actual noise barrier design criteria adopted by each State. Specifically, the design noise reduction goal varies from State to State. The range of acceptable levels of noise reduction (A-weighted levels) varies from as little as five dB to as high as 10 dB or more. This range directly relates to overall barrier height; i.e., the taller the barrier, the greater the noise reduction. Depending upon the level of protection or benefit sought by the noise barrier designer, there should be a relationship to overall cost. An examination of the barrier data from the top five States in the FHWA summary showed mixed results, see Figs. 13, 14, 15, and 16. Note the wide scatter in terms of cost/square meter, and the reversed trend in the Ohio, New York and New Jersey data, which showed a *decrease* in unit cost with increasing average barrier height. Only the data for Virginia showed an increase in unit cost with increased average height. Maryland data was inconclusive and is not shown. These results further confirm that there are many other variables influencing the cost, which seem to more than offset the effect of the barrier height alone.

One such variable is in the criteria for foundation design. Foundation designs must consider wind loading and soil conditions. In such places as California, seismic effects may be significant and may even be the controlling factor in the foundation design (even above wind load requirements). All of these factors can influence the design of noise barrier foundations.

Wind loading and other assumptions can vary, and have evolved over the years. In the years prior to 1986, there was not a specific noise barrier design specification, so such documents as building codes and the AASHTO (American Association of State Highway and Transportation Officials) *Standard Specification for Structural Supports of Highway Signs, Luminaries and Traffic Signals* served as the primary guidance tools for noise barrier structural design. In 1989, AASHTO published the *Guide Specification for Structural Design of Sound Barriers*[8], which ultimately provided consistent design criteria for plans and specifications. Since the FHWA summary data dates as far back as the mid to late 1970s and also includes post-1989 projects that utilized the noise-barrier-specific guidance specification, there will inherently be variability in the cost over time due to differing design criteria.

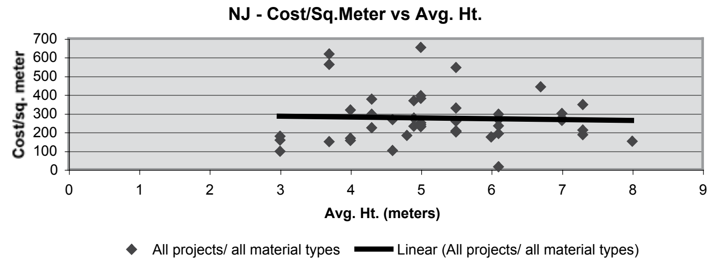

Figure 13

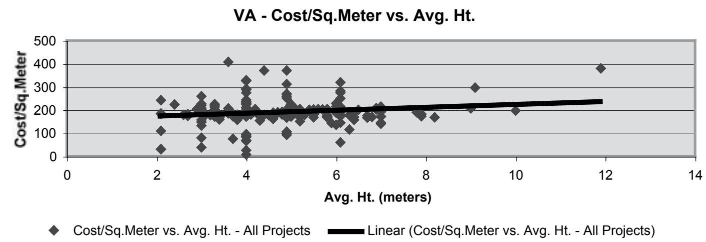

Figure 14

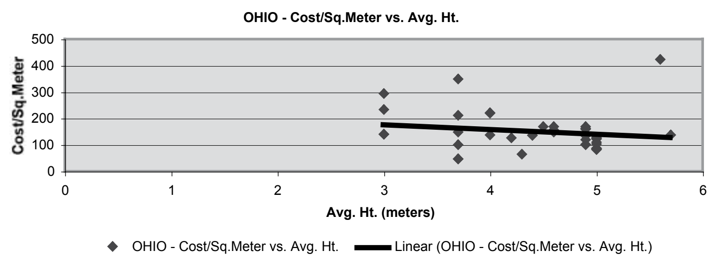

Figure 15

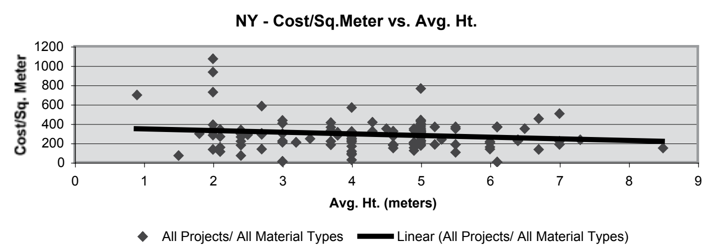

Figure 16

Using the Maryland study[6] of cost factors and recent cost escalations as an example, the results further demonstrate that there are many variables, some typical and expected, and others— not so apparent— that should be considered in the overall cost equation. The study utilized a combination of recent bid data analysis, interviews with design staff, other local highway agencies, contractors and suppliers, and market and economic data from various sources. Eleven potential contributing factors to cost and cost increases were identified and evaluated as follows:

- Site access,
- rock,
- regional cost differences/market conditions,

- foundation design,
- wall design,
- project delivery method (bidding methods),
- quality control,
- project size,
- competition,
- change orders, and
- project schedules.

Site access that is difficult affects several aspects of barrier construction. Larger, more expensive, equipment is often required, and actual placement of foundations and wall panels is more time consuming. These elevated costs are generally reflected in the cost for the barrier system. In the trends towards increased costs, site access was cited as a major factor.

The presence of rock can have a significant effect on foundation costs. As with the site access issue, special equipment is needed to deal with underground rock formations in the augering and placement of caisson foundations, and rock sockets. Depending upon the geographical region, the presence of rock could be a significant factor, or it could be non-existent. Some experiences related to unanticipated encounters with rock formations have had negative effects on costs and project schedules.

Prevailing market conditions have an obvious effect on overall construction costs and are very time dependent. In assessing cost trends of noise barriers over many years, inflation and good or bad economic times may greatly influence unit costs on a short-term basis, and can be seen in the wide scatter of unit cost figures for the five States examined in this article.

Cost associated with noise barrier foundations, as indicated previously, are very affected by design criteria. Designs developed utilizing a more conservative approach, will be more expensive, but safety factors will also be enhanced. The methods by which posts are fastened to the caisson foundations are quite varied, and some are more expensive than others. An interesting fact identified in the NCHRP Synthesis 181, was that, with the development of the guide specifications for noise barrier structural design by AASHTO in 1989, the design criteria resulted in a trend towards lowering costs from relaxed, less stringent design criteria[7]. Yet, current practice seems to be heading back towards a more conservative design approach and thus, increased costs.

Wall panel cost can be substantially affected by surface treatment requirements. Specifications that require special materials that may not be readily available will result in increased cost. Use of standard finishes and form liners can minimize cost yet meet aesthetic goals. Panel size was also cited, in terms of methods, equipment requirements, and ease of delivery to the job site as a factor affecting cost. Coupled with a difficult-access site, excessive panel size could have a substantial negative effect on cost.

There is some anecdotal evidence that alternative methods to the most common bidding process (design/bid/build) may result in lower overall costs. However, there is also the contrasting opinion, and some experience, that suggests that the "design/build" approach may result in some loss of control over the final product by the agency. Allowance for alternative designs at the time of bid submission can also, in some cases, reduce costs, though care and diligence on the part of the oversight agency must be exercised to assure that the final product meets all the project goals.

Quality control efforts may take many forms. Overall, the Maryland study uncovered no evidence that such measures result in increased cost, as reported by contractors, suppliers and designers.

Based on the analysis of the top five states presented in this article, project size seems to have an effect on the overall cost (i.e., unit cost). An "economy of scale" effect does seem to be present, in that, with a larger project, the preliminary cost items common to all contracts are attributable only once whereby two projects with an equivalent overall size would require two sets of preliminary costs items. Whether the effect on unit cost is related primarily to barrier material quantities is not well defined. It is likely that both the above factors play a role in producing the "economy-of-scale" effects seen in this analysis.

The effect of competition on market prices is well known. In the Maryland study, it was the general consensus that adequate competition exists among suppliers and contractors, and was not a factor in recent cost escalations. However, the effect of supply and demand could be important should a large number of contracts be offered in a short period of time in one regional area. In such a case, the available contractor pool may become overloaded, resulting in fewer bidders and ultimately higher overall prices. Conversely, if few projects are offered relative to the available contractor pool, the potential for underbidding is increased.

There is no evidence that quality control measures result in added costs.

The effect of change orders was not well defined. In some instances, the change orders resulted from unexpected encounters with rock layers or other unanticipated site conditions once construction was underway. Analysis of these effects would require a much more detailed examination of billing and invoice information, though in general change orders by definition are more likely to result in slight increases in cost.

Project scheduling was not cited as a source of increased cost in the Maryland study. Some flexibility in scheduling was cited as a potential way to smooth out demand periods for suppliers, and to potentially increase competition.

The cost factors cited above are not intended to be all-encompassing. In presenting this information, the intent is to illustrate the wide range of influences on noise barrier costs, some of which can be affected or controlled by the highway agency and barrier designer. Because of this wide variety of factors, it also illustrates the huge potential for variations in how costs are ultimately reported.

Concluding Remarks

The compilation efforts by the FHWA to summarize nation-wide noise barrier construction efforts have served the highway noise community well over the years. It has provided a focal point for the analysis of important trends and provided insight and guidance to the States in addressing the ever-increasing problem of highway traffic noise. The limited attempt here to expand upon that analysis is done with significant attention to, and recognition of, the sources of variations, non-uniformity, and anomalies in the State data listings.

In analyzing the data, the results point strongly towards a need for more definitive guidance in how data is reported by the States. Under current practice, data reporting is totally State-specific and allows for little, if any, relevant State-to-State comparison, particularly relative to cost. An effort to develop some level of guidance on a national level would at least make future data collection and reporting more uniform, and thereby more easily comparable for statistical purposes. As part of the guidance, some requirement for defining each State's cost parameters would be highly useful in placing each State's statistics in context.

The conclusion to be drawn from the above analysis is that with all the potential variables in reported data on noise barriers nation-wide, only the broadest, general characterizations of cost trends should be considered reliable. The FHWA document on construction trends (Appendix B) clearly illustrates the generalized nature of the statistical conclusions that can be drawn. In assessing the individual State data, some level of confidence can be derived from an examination of a substantial body of data, yet comparisons should be primarily State-specific, and not State-to-State. Some suggested additional information on sources of variability, such as documenting the specific prevailing criteria on cost parameters used by the subject State, would go far to improving the usefulness of the data summary. It is the author's opinion that the efforts by FHWA to document the progress and the benefits from the substantial financial investment, in the abatement of highway traffic noise can be judged as successful and very beneficial to analysts and researchers.

References

1. "Summary of Noise Barriers Constructed by December 31, 1998". Federal Highway Administration (FHWA), Office of Natural Environment, Noise Team, Washington D.C., April, 2000.
2. "Highway Traffic Noise Barrier Construction Trends". Federal Highway Administration (FHWA), Office of Natural Environment, Noise Team, Washington D.C., April, 2000.
3. Reply to e-mail inquiry from Ken Polcak (MD SHA) provided by Elvin Pinckney, Ohio Department of Transportation, June 19, 2003.
4. This information is based upon the author's personal knowledge of practices by MD SHA regarding cost reporting to FHWA. Guidance is also included in the manual on the Statewide Highway Noise Program - *Guidelines and Procedures for Program Administration and Technical Analysis and Reporting*, Maryland State Highway Administration, 2001.
5. Telephone reply to e-mail inquiry from Ken Polcak (Maryland SHA) provided by William McColl , New York State Department of Transportation, June 20, 2003.
6. Report entitled "Noise Wall Cost Analysis" prepared by Construction Dynamics Group, Inc. for Maryland State highway Administration, Baltimore, Maryland, May 2002.
7. NCHRP Synthesis 181 – In Service Experiences with Traffic Noise Barriers, Transportation Research Board, National Research Council, Washington, DC. 1992.
8. Guide Specification for Structural Design of Sound Barriers, American Association of State Highway and Transportation Officials, 1989.

Appendix A

Summary of Noise Barriers Constructed by December 31, 1998[1]

by U.S. Department of Transportation
Federal Highway Administration
Office of Natural Environment
Noise Team
Washington, D.C.
April 2000

The Federal-aid highway program has always been based on a strong State-Federal partnership. At the core of that partnership is a philosophy of trust and flexibility, and a belief that the States are in the best position to make investment decisions that are based on the needs and priorities of their citizens. The FHWA noise regulations give each State highway agency (SHA) flexibility in determining the reasonableness and feasibility of noise abatement and, thus, in balancing the benefits of noise abatement against the overall adverse social, economic, and environmental effects and costs of the noise abatement measures. The SHA must base its determination on the interest of the overall public good, keeping in mind all the elements of the highway program (need, funding, environmental impacts, public involvement, etc.). Congress affirmed and extended the philosophy of partnership, trust, and flexibility in the enactment of ISTEA.

Highway traffic noise should be reduced through a program of shared responsibility. State and local governments should practice compatible land use planning and control in the vicinity of highways. Local governments should use their power to regulate land development in such a way that noise-sensitive land uses are either prohibited from being located adjacent to a highway, or that the developments are planned, designed, and constructed in such a way that noise impacts are minimized. It should be noted that the National Highway System Designation Act of 1995 restricted Federal participation in the construction of noise barriers along existing highways to those projects that were approved before November 28, 1995 or are proposed along lands where land development or substantial construction predated the existence of any highway.

The flexibility in noise abatement decision making is reflected by data indicating that some States have built many noise barriers and some have built none. Through the end of 1998, forty-four SHAs and the Commonwealth of Puerto Rico have constructed over 2,610 linear kilometers of barriers at a cost of over $1.4 billion ($1.9 billion in 1998 dollars). Six States and the District of Columbia have not constructed noise barriers. Ten SHAs account for approximately seventy percent (70%) of total barrier length and cost.

This paper *(Appendix—Ed.)* **contains a listing of data supplied by all SHAs. It should be noted that the cost data in the listing are approximate due to differing State practices for estimating costs and due to the fact that for some barriers (over thirty-seven kilometers), the cost could not be estimated at all. The data represent best estimates of SHAs for barrier construction. There may be nonuniformity and/or anomalies in the data due to differences in individual SHA definitions of barrier information.**

Table 1 lists the ten States with the most barrier construction by area, length, and cost, respectively.

Table 1. Noise Barrier Construction By State Through 1998

Square Meters (Thousands)		Linear Kilometers	
California	2,849	California	777.2
New Jersey	806	Virginia	153.3
Virginia	790	New Jersey	142.1
Ohio	613	Ohio	138.2
Maryland	581	New York	110.7
New York	496	Colorado	104.4
Minnesota	491	Minnesota	101.8
Illinois	346	Maryland	99.6
Pennsylvania	333	Illinois	97.8
Colorado	329	Pennsylvania	83.5
10 State Total	**7,634**		**1,808.6**

Actual Cost (Millions)		1998 Dollars (Millions)	
California	$399.6	California	$487.2
New Jersey	182.3	New Jersey	210.4
Maryland	138.0	Maryland	153.2
Virginia	120.8	Virginia	143.0
New York	104.1	New York	116.5
Pennsylvania	74.8	Pennsylvania	88.3
Ohio	63.1	Illinois	71.0
Illinois	61.2	Ohio	68.1
Florida	55.1	Minnesota	62.7
Michigan	48.1	Florida	62.3
10 State Total	**$1,247.1**		**$1,462.7**

Table 2 lists the distribution of barriers by type of material. Earth (berm), masonry block (block), brick, concrete, metal, wood, other materials (e.g., polyurethane) and combinations of materials have all been used to construct barriers.

Table 2. Total Noise Barrier Area by Material Type Through 1998.

Single Material Barriers: Material	Square Meters (Thousands)	Combination Barriers: Material	Square Meters (Thousands)
Concrete/Precast	4,292	Berm/Wood	279
Block	2,731	Concrete/Block	166
Wood/Post & Plank	508	Wood/Concrete	155
Concrete/Unspecified	456	Berm/Concrete	138
Berm Only	344	Berm/Metal	134
Wood/Glue Laminated	294	Metal/Concrete	85
Metal/Unspecified	240	Berm/Block	72
Wood/Unspecified	239	Concrete/Brick	54
Absorptive	154	Wood/Metal	43
Brick	94	Berm/Wood/Concrete	27
Other	139	Wood/Block	26
		Berm/Wood/Metal	16
		Other	116
Total	**9,491**	**Total**	**1,311**

Table 3 lists the twenty-two States that have constructed at least one Type II barrier (i.e., barriers constructed for an existing highway). It should be noted that the National Highway System Designation Act of 1995 restricted Federal participation in Type II noise barriers to those projects that were approved before November 28, 1995 or are proposed along lands where land development or substantial construction predated the existence of any highway.

Table 3. Type II Noise Barrier Construction By State By Total Barrier Area Through 1998

State	Square Meters (Thousands)	Actual Cost (Millions)	Cost In 1998 Dollars (Millions)
California	1,181	$203.1	$253.0
Maryland	277	82.6	91.5
Minnesota	251	19.8	35.7
New Jersey	218	58.6	61.6
Ohio	170	17.3	18.0
Michigan	121	23.4	30.5
New York	109	26.6	30.1
Colorado	97	14.0	16.3
Wisconsin	81	11.3	13.2
Utah	67	6.1	6.2
Indiana	49	12.0	12.5
Connecticut	29	2.1	3.3
Oregon	9	1.4	1.7
Washington	9	1.6	2.0
Louisiana	5	0.2	0.3
Iowa	4	0.4	0.6
Georgia	3	0.5	0.6
Massachusetts	3	2.1	2.2
Missouri	3	0.5	0.5
Maine	2	0.3	0.3
Florida	1	0.1	0.2
Wyoming	1	0.1	0.1
Total	**2,690**	**$484.1**	**$580.4**

Table 4 lists the six States that have not constructed noise barriers.

Table 4. States That Have Not Constructed Noise Barriers to Date

Alabama
Mississippi
Montana
North Dakota
Rhode Island
South Dakota

Appendix B

Highway Traffic Noise Barrier Construction Trends[2]

by U.S. Department of Transportation
Federal Highway Administration
Office of Natural Environment Noise Team
Washington, D.C.
April 2000

Introduction

The Federal-aid highway program has always been based on a strong State-Federal partnership. At the core of that partnership is a philosophy of trust and flexibility, and a belief that the States are in the best position to make investment decisions that are based on the needs and priorities of their citizens. The FHWA noise regulations give each State department of transportation (DOT) flexibility in determining the reasonableness and feasibility of noise abatement and, thus, in balancing the benefits of noise abatement against the overall adverse social, economic, and environmental effects and costs of the noise abatement measures. The State DOT must base its determination on the interest of the overall public good, keeping in mind all the elements of the highway program (need, funding, environmental impacts, public involvement, etc.). Congress affirmed and extended the philosophy of partnership, trust, and flexibility in the enactment of the Transportation Equity Act for the 21st Century.

The flexibility in noise abatement decisionmaking is reflected by data indicating that some States have built many noise barriers and some have built none. Through the end of 1998, forty-four State DOTs and the Commonwealth of Puerto Rico have constructed over 2,610 linear kilometers of barriers at a cost of over $1.4 billion ($1.9 billion in 1998 dollars). Six States and the District of Columbia have not constructed noise barriers to date. A detailed listing of noise barrier data may be found in “Summary of Noise Barriers Constructed by December 31, 1998.” The paper that follows presents a brief analysis of the data contained in the detailed barrier listing. **It should be noted that the data represent best estimates on barrier construction supplied by State DOTs . There may be nonuniformity and/or anomalies in the data, due to differences in individual State DOT definitions of barrier information and costs. However, some trends are evident.**

Noise Barrier Construction

Tables 1-9 *(Tables 1-8 not included in this edited version.—Ed.)* provide data on barrier construction, height, materials, and unit costs (all cost information is in 1998 dollars). The following points may be made concerning noise barriers:

1. More than thirty-one percent (31%) of total expenditures have occurred in the last five years [sixty-six (66%) in the last ten years; eight-six (86%) in the last fifteen years].
2. Through the end of 1998, the overall average unit cost, combining

all materials, is $179 per square meter. The average unit cost, combining all materials, for the last ten years is $184 per square meter.

3. Approximately fifty-nine (59) kilometers of barriers have been built with highway program monies other than Federal-aid. Approximately sixty-four (64) kilometers of barriers have been built with Toll facility funds, which may or may not be Federal-aid monies.
4. Overall by length, approximately seventy-five percent (75%) of Federal-aid barriers have been Type I (a barrier built on a highway project for the construction of a highway on new location or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment or increases the number of through-traffic lanes).
5. Forty-four (44) States and the Commonwealth of Puerto Rico have constructed more than 1,850 linear kilometers of Type I barriers, at a total cost of more than $1.2 billion.
6. Twenty-two (22) States have constructed at least one Type II noise barrier (a barrier built along an existing highway, i.e., a retrofit noise barrier), at a total cost of more than $580 million.
7. Six (6) States have not constructed any noise barriers to date: Alabama, Mississippi, Montana, North Dakota, Rhode Island, and South Dakota.
8. Ninety-four percent (94%) of barriers that have been constructed range in height from 2-6.9 meters. Two percent (2%) of barriers are less than 2 meters tall and four percent (4%) are more than 6.9 meters tall. The overall average barrier height is 4.1 meters.
9. Barriers have been made from materials that include concrete, masonry block, wood, metal, earth berms, brick, and combinations of all these materials. Concrete and block represent more than two-thirds of total material usage [forty-four percent (44%) and twenty-five percent (25%), respectively] and wood ten percent (10%). Metal, berm, and brick together account for approximately six percent (6%) of the total. Twelve percent (12%) of all barriers have been constructed with a combination of an earth berm and a wall. One percent (1%) have been constructed with other materials, such as recycled materials, plastics, composite polymers, etc. Slightly more than one percent (1%) have been constructed with absorptive materials.
10. Average unit costs for all years for all barrier materials range between $137-244 per square meter, except for earth berms which average only $51 per square meter. Concrete has been the most popular material; however, its cost, $198 per square meter, is only slightly less than that of brick, $214 per square meter. Overall average costs for wood, metal, and combination barriers are approximately the same ($155, $137, and $163 per square meter, respectively). Absorptive barriers average $244 per square meter in cost.
11. There are no brick barriers over 6.9 meters tall or wooden or metal barriers over 7.9 meters tall. A berm/metal combination barrier has been constructed to a height of 12.0 meters, and a cast-in-place concrete barrier to a height of 11.9 meters.
12. Unit costs for barriers do not always appear to increase as the barrier height increases (Note: This may be due to nonuniformity and/or anomalies in the data reported by State DOTs).
13. Barrier height averages more than 5 meters in eight (8) States. Barrier height averages 4-5 meters in fourteen (14) States, 3-4 meters in sixteen (16) States, and less than 3 meters in six (6) States.
14. Barrier costs average $170-265 per square meter in twenty (21) States. In twenty-one (21) other States, barrier costs average $82-168 per square meter.

Summary

Forty-four (44) States and the Commonwealth of Puerto Rico have constructed highway traffic noise barriers; six (6) States have not. The most notable trend in highway traffic noise barrier construction is that State DOTs spend more than $100 million of highway program funds annually for this form of noise abatement. Starting in 1990, State DOTs have averaged spending more than $126 million per year. Since the first highway traffic noise barrier was constructed, sixty-five percent (65%) of all spending has been for Type I projects, and thirty percent (30%) for Type II projects. **Most barriers have been made from concrete or masonry block, range from 3-5 meters in height, and average $175-200 per square meter in cost.**

Table 9. Noise Barrier Construction By State, Average Height, And Average Unit Cost

(Tables 1-8 are not included in this summary).

State	Average Height (m)	Average Unit Cost ($1998/m2)	State	Average Height (m)	Average Unit Cost ($1998/m2)
Alabama	-	-	Montana	-	-
Alaska	3.1	96	Nebraska	4.2	191
Arizona	3.1	102	Nevada	2.9	213
Arkansas	4.0	82	New Hampshire	4.1	220
California	3.7	171	New Jersey	5.7	261
Colorado	3.2	138	New Mexico	2.6	168
Connecticut	5.5	111	New York	4.5	235
Delaware	4.1	47	North Carolina	5.5	98
District of Columbia	-	-	North Dakota	-	-
Eastern Direct Federal	3.4	148	Ohio	4.4	111
Florida	4.6	191	Oklahoma	3.2	101
Georgia	5.5	109	Oregon	3.3	125
Hawaii	2.1	263	Pennsylvania	4.0	265
Idaho	3.0	972	Puerto Rico	4.1	303
Illinois	3.5	205	Rhode Island	-	-
Indiana	4.7	232	South Carolina	5.7	113
Iowa	3.9	105	South Dakota	-	-
Kansas	4.6	215	Tennessee	4.2	170
Kentucky	4.5	142	Texas	3.7	193
Louisiana	3.5	143	Utah	3.4	103
Maine	4.4	118	Vermont	1.8	199
Maryland	5.8	264	Virginia	5.2	181
Massachusetts	2.8	186	Washington	3.1	137
Michigan	3.6	251	West Virginia	3.2	132
Minnesota	4.8	128	Wisconsin	5.3	183
Mississippi	-		Wyoming	2.3	149
Missouri	3.8	179			

First Announcement: page 118 of this issue.

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Describe briefly your interests and/or professional experience in the field of noise and its control. Include any special interests, number of publications, patents, etc.

Endorsement

The endorser, an INCE Member whose signature appears below, verifies that the information supplied by the applicant is accurate to the best of the endorser's knowledge.

Endorser's name *(please print)*____

Endorser's signature ______________________________ Date ______________

Applicant's Statement

I hereby make application for INCE membership. I certify that the statements made in this application are true, complete, and correct. If elected to membership, I will be governed by the articles of incorporation, bylaws, and policies of INCE/USA.

Full signature of applicant ______________________________ Date______________

Product News

Below is a list of exhibitors at NOISE-CON 03, a brief description of the products or services provided by or shown by the exhibitor, the contact person, the mailing address, the telephone and fax numbers, the web URL, and the e-mail address.

01dB, Inc.

31 Jordan Street
Skaneateles, NY 13152
www.01dbsupport.com
Phone: 315-685-3141 • Fax: 315-685-3194
E-mail: mike@techformeas.com

Orchestra, the new multichannel high performance data acquisition system for all 01dB software, was displayed. Our new SOLO sound level meter with real time USB interface and frequency analysis was demonstrated. In addition, the NC 10 and Viper sound quality software as well as our traditional PC-based acoustic and vibration measurement systems were shown.

Industrial Acoustics Company

1160 Commerce Avenue
Bronx, NY 10462
www.industrialacoustics.com
Phone: 718-430-4591 • Fax: 718-430-4599
E-mail: archiac@aol.com

Industrial Acoustics Company's exhibit featured our Metadyne patented perforated metal anechoic chamber systems, reverberation rooms, and other test rooms used in the transportation industry. Also exhibited was our metal absorptive sound barrier panels for the transportation industry.

International Cellulose Corporation

12315 Robin Blvd.
Houston, TX 77045
www.spray-on.com
Phone: 713-433-6701, 800-444-1252 • Fax: 713-433-2029
E-mail: avargas@spray-on.com

International Cellulose Corporation (ICC) is the developer and manufacturer of spray-on acoustical and thermal insulation treatment systems that are ideally suited for a broad range of commercial, industrial, and residential applications, in both new construction and renovation projects. The ICC family of products provides the most flexible solutions available in meeting thermal, acoustical, lighting, and aesthetic requirements. ICC products can also be applied to virtually any properly prepared surface configuration of wood, steel, concrete, glass, or other common construction surfaces. International Cellulose Corporation is ISO 9002 certified.

Kinetics Noise Control

6300 Irelan Place
Dublin, OH 43017
www.kineticsnoise.com
Phone: 614-889-0480 • Fax: 614-889-0540
E-mail: sales@kineticsnoise.com

Kinetics Noise Control featured the following solutions for noise and acoustics control. Our Vibron Products Group displayed a web-based selection program for standard and custom engineered silencers. This powerful tool integrates HVAC duct analysis and silencer selection with the production of submittals, schedules, and order tracking. Acoustical plenums, louvers, noise enclosures, and barrier walls were featured as well. The Interiors Group displayed a variety of acoustical room treatments for absorption, reflection and diffusion. Architecturally, the new ISO-MAX isolation clip for furring channel was highlighted for controlling room-to room noise through walls and ceilings.

Krieger Specialty Products

4880 Gregg Road
Pico Rivera, CA 90660
www.kriegerproducts.com
Phone: 866-203-5060 • Fax: 562-692-0146
E-mail: pgreen@kriegerproduct.com, pgreen@kriegersteel.com

We displayed a sample acoustical door, cam lift hinges, and acoustical door brochures.

LMS North America

1050 Wilshire Drive, Suite 250
Troy, MI 48084
www.lmsintl.com
Phone: 248-952-5664 • Fax: 248-952-1610
E-mail: info@lmsna.com

LMS exhibited the virtual prototyping breakthrough, LMS Virtual.Lab Acoustics, including new pre- and post-processors, LMS SYSNOISE, and the latest testing acoustic products.

MBI Products Company, Inc.

5309 Hamilton Avenue
Cleveland, OH 44114-3909
www.mbiproducts.com
Phone: 216-431-6400 • Fax: 216-431-9000
E-mail: sales@mbiproducts.com

MBI has been a leader in the acoustical industry since 1965. Products include Cloud-Lite® Baffles, Colorsonix® Wall Panels, Lapendary® Panels, and San Pan® Sanitary Ceiling Panels.

MC, Inc. and Precision Pier USA, Inc.

PO Box 3165
Peachtree City, GA 30269
www.MCGroup.US.com and www.PrecisionPierUSA.com
Phone: 770-632-6300 • Fax: 770-632-6302
E-mail: MCInc@mcgroup.us

The Wall Builders and Precision Pier USA: Foundation Experts.

Featured on this page:

MSC Engineered Materials & Solutions Group

Multi Science Publishing

National Instruments

Navcon Engineering Network

OROS Noise & Vibration Solutions

Overly Door Company

PCB/Larson Davis

MSC Engineered Materials & Solutions Group

2200 E Pratt Boulevard
Elk Grove Village, IL 60007
www.matsci.com
Phone: 847-439-8270 • Fax: 847-439-0737
E-mail: mataya@matsci.com

Material Sciences Corporation (MSC) showcased materials used in noise and vibration damping: Sound Trap, MagnaDamp, and NRG Damp. These materials are all multi-layer laminates that provide a significant reduction in sound and vibration levels in structural applications. Developed by MSC's Engineered Materials and Solutions Group, these materials consist of an engineered viscoelastic layer sandwiched between two layers of steel that provide constrained layer damping. The viscoelastic layer is a "tunable" formulation, allowing application designers to attenuate specific frequencies depending on where they use the materials. We displayed examples of how this material works and specific applications that are currently utilizing Sound Trap, MagnaDamp or NRG Damp.

Multi Science Publishing

5 Wates Way, Brentwood
Essex CM15 9TB, UK
www.multi-science.co.uk
Phone: +44 1277 224632 • Fax: +44 1277 223453
E-mail: mscience@globalnet.co.uk

Multi-Science displayed brochures detailing its range of acoustics/noise publications, including the latest addition, the "International Journal of Aeroacoustics."

National Instruments

11500 N Mopac
Austin, TX 78759
www.ni.com
Phone: 800-433-3488 • Fax: 512-683-9300
E-mail: info@ni.com

For more than 26 years, National Instruments has revolutionized the way engineers and scientists work by delivering virtual instrumentation solutions built on rapidly advancing commercial technologies, including industry-standard computers and the Internet. NI increases productivity for customers worldwide by delivering easy-to-integrate software, such as the NI LabVIEW graphical development environment, and modular hardware, such as PXI modules for data acquisition and instrumentation.

Navcon Engineering Network

701 W Las Palmas Drive
Fullerton, CA 92835
www.navcon.com
Phone: 714-441-3488 • Fax: 714-441-3487
E-mail: sales@navcon.com

Navcon Engineering Network exhibited Commercial Software Applications (SoundPLAN, INSUL, AIMAP), Technical Seminars (Acoustic Intensity, Environmental Noise & Modal Testing), and Engineering Consultation (Noise & Vibration Measurement, Analysis & Control). SoundPLAN is a three-dimensional acoustic ray tracing software for exterior and interior noise propagation prediction. The software is an acoustical planning and noise control optimization tool with a wide range of applications (urban planning, environmental assessment, noise analysis, noise control optimization, field noise mapping, OSHA/MSHA). INSUL is used for predicting the sound insulation of walls, floors, ceilings, and windows. The software was developed based on simple theoretical models that only require easily obtainable construction information. AIMAP is a MATLAB based program used for the assessment and display of acoustic intensity and sound pressure data.

OROS Noise & Vibration Solutions

502 Shaw Road, B-101
Dulles, VA 20166-9435
www.OROSInc.com
Phone: 703-478-3204 • Fax: 703-478-3205
E-mail: info@orsinc.com

New from OROS was the OR3x suite of analyzers and NV solutions range comprising sound quality, sound power, and acoustic intensity. Ideal for in-field or lab use, OR3x systems are used daily by companies for noise analyses. From 2 to 64 channels, OROS systems are fast to analyze, easy to learn, and easy to customize.

Overly Door Company

PO Box 70
Greensburg, PA 15601-0070
www.overly.com
Phone: 800-979-7300 • Fax: 724-830-2871
E-mail: overly@overly.com

Overly Door Company exhibited its product line of sound retardant metal doors, wood doors, and fixed window systems.

PCB/Larson Davis

PCB: 3425 Walden Avenue
Depew, NY 14043
Larson Davis: 1681 West 820 North
Provo, UT 84601
www.pcb.com, www.larsondavis.com
Phone: 801-375-0177 (Larson Davis)
Fax: 716-684-0987 (PCB), 801-375-0182 (Larson Davis)
E-mail: sales@pcb.com, sales@LarsonDavis.com

PCB and Larson Davis were teamed to present a variety of microphones, accelerometers, sound level meters, analyzers, and other acoustic test systems. In addition, they showcased their new DSS (Digital Sensing System), a multi-channel, multi-drop, highspeed data acquisition system using revolutionary DSIT (Digital Sensor Interface Transmitter) technology. Also on display, was NOMAD, the squeak & rattle measurement system developed by Ford Motor Company as a means to conduct objective and subjective measurements for NVH and S&R.

PPG Industries

5875 New King Court
Troy, MI 48098
www.ppg.com.
Phone: 248-641-2000 • Fax: 248-641-2266

PPG Industries, Inc. provides original equipment manufacturers with a full range of liquid applied coatings for sound and vibration damping. PPG's patented Audioguard Acoustic Coatings, available in epoxy and waterborne acrylic chemistries, provide superior acoustic performance and application simplicity. PPG Industries coating technologies provide innovative solutions for automotive vehicles, commercial and military aircraft, trucks, appliances, agricultural and construction equipment, and lawn and garden equipment.

Quest Technologies, Inc.

1060 Corporate Center Drive
Oconomowoc, WI 53066
www.quest-technologies.com
Phone: 800-245-0779 • Fax: 262-567-4047
E-mail: sales@quest-technologies.com

A complete line of sound level meters, noise dosimeters, octave band filters, calibrators and QuestSuite Professional "System Solution" Software Application.

Scantek, Inc.

7060 #L Oakland Mills Road
Columbia, MD 21046
www.scantekinc.com
Phone: 800-224-3813 • Fax: 410-290-9167
E-mail: info@scantekinc.com

Scantek demonstrated the newest Norsonic wireless building acoustics system, an advanced community noise analyzer, a new RION sound level meters, the new NC-meter from CESVA, and the latest from DataKustik.

Shannon Enterprises

75 North Main Street
North Tonawanda, NY 14072
www.blanket-insulation.com
Phone: 716-693-7954 • Fax: 716-693-1647
E-mail: info@blanket-insulation.com

Shannon Enterprises Inc. manufactures INSULTECH Acoustic Blanket Systems. INSULTECH Acoustic is a custom fit, removable, reusable, self-contained blanket system. It includes fasteners for install and I.D. tags. INSULTECH is a direct surface treatment generating 4 to 15 DBA reduction. Capable of removing "pure tone harmonics," INSULTECH performance is best suited for frequency concentrations above 125 Hz. INSULTECH Acoustic offers some standard designs, specifically "Liquid Chiller Sound Kits." INSULTECH Acoustic applications include: compressors, gear drives, motors, pumps, steam turbines, gas turbine and engine drives, diffusers, fan housings, piping, valves, liquid chillers, refrigeration machines, blowers, silencers, pressure reducing valves, framework enclosures, almost any irregular surface condition. INSULTECH Acoustic can accommodate temperatures up to 1500 degrees F.

Sound Fighter Systems, L.L.C.

P.O. Box 6075
Shreveport, LA 71106
www.soundfighter.com
Phone: 318-861-6640 • Fax: 318-865-7373
E-mail: soundfighter@soundfighter.com

Sound Fighter Systems displayed the LSE Noise Barrier Wall System. The LSE system is a modular or basic building block design that enables you to meet your specific noise abatement requirements without the cost of custom designing. Further flexibility is obtained by the absorptive and reflective characteristics of the LSE modules. The Sound Fighter Noise Barrier Wall is constructed from high-density polyethylene elements that stack and interlock to the desired wall height. The modules are locked in place at each end by vertical steel 4" H beam columns. The element is perforated on one face, and the cavity holds in place acoustic media and barrier board or other combinations of absorbing and reflective materials to meet specific criteria. The very attractive geometrically designed wall has proven to be very effective and durable for over 30 years. The wall is competitively priced with other structures and has the unique feature of being completely salvable. Should conditions change, the noise barrier wall can be moved to a new location. The LSE Wall has passed hurricane wind load tests equivalent to 200 mph wind, as well as actual hurricane conditions in several installation locations without failure. When temporary noise control walls are required in metropolitan areas, Sound Fighter can design and furnish movable wall sections.

Soundown Corporation

17 Lime Street, Suite 1
Marblehead, MA 01945
www.soundown.com
Phone: 920-683-9998 • Fax: 920-683-9994
E-mail: dhuckins@soundown.com

Soundown is an innovative market leader, providing noise and vibration solutions. The company is a diverse manufacturer of composite acoustic materials for acoustical absorption, barrier, damping, and isolation. Unique products featured include the Sylomer isolation

Featured on this page:
PPG Industries
Quest Technologies, Inc.
Scantek, Inc.
Shannon Enterprises
Sound Fighter Systems, L.L.C.
Soundown Corporation

Featured on this page:

SoundSorb: L.B. Foster & Concrete Solutions, Inc.

Svantek Ltd.

TEAC America, Inc.

Technicon Industries

ViAcoustics

Vibro-Acoustics

BSWA

line. This line has been recognized worldwide for its outstanding performance and versatility, and is now available in North America. Booth 2

SoundSorb: L.B. Foster & Concrete Solutions, Inc.

3300 Bee Caves Road, Suite 650
Austin, TX 78746
www.soundsorb.com, www.lbfoster.com
Phone: 512-327-8481, CSI; 916-705-9076, L.B. Foster
Fax: 512-327-5111, CSI; 619-688-2400, L.B. Foster
E-mail: csi@soundsorb.com, pschubring@lbfosterco.com

We will be displaying our acoustic product, SoundSorb®. Concrete Solutions, Inc. (CSI) licenses manufacturers worldwide to produce CSI's patented, non-structural cementitious product, SoundSorb, which is used as an integral sound absorbing material for all structures where the need to eliminate the reflection of sound is desired. Typically, our product is used on sound walls along major highway and railway thoroughfares. It is the world's most widely used exterior cementitious acoustic material with the dual capability of achieving high acoustic values (NRC ratings of 0.95 or higher) along with the ability to replicate virtually any architectural design or pattern.

Svantek Ltd.

70 Himalaya Court
Alpine, UT 84004
www.svantek.com
Phone: 801-492-4789 • Fax: 801-362-9394
E-mail: thomaslago@msn.com

Established in 1990, Svantek designs and manufactures professional instruments for sound and vibration measurement and analysis.

TEAC America, Inc.

7733 Telegraph Road
Montebello, CA 90640
www.teac-recorders.com
Phone: 978-468-4135 • Fax: 978-468-4171
E-mail: sastulfi@teac.com

TEAC manufactures data recording and acquisition systems for NVH, reliability and performance testing in the automotive, aerospace, and power-generation industries. The GX-1 Portable Data Acquisition and Recording System features programmable sampling rates, plug-in signal conditioning, AIT tape storage media, SCSI data transfer, waveform and FFT displays. The new LX-10/ 20 Portable Data Recorders feature solid-state recording to SDRAM, to removable PC Flash Memory Card, or direct to PC hard-disk. LX Series Recorders utilize Firewire or LAN interface to PC, and selectable DC/ Constant-Current/ Differential input amplifiers. All TEAC Data Recorders provide file-format conversion to many popular analysis software applications.

Technicon Industries

4412 Republic Court
Concord, NC 28027
www.tcnind.com
Phone: 704-788-1131 • Fax: 704-788-7772
E-mail: jgagliardi@tcnind.com

Providing custom manufactured noise control materials for your application: sound absorbers, barrier composites, damping materials, sound patches, vibration isolation, acoustic floor systems, and acoustic trim.

ViAcoustics

2512 Star Grass Circle
Austin, TX 78745
www.viacoustics.com
Phone: 512-444-1961, ext. 257 • Fax: 603-994-4613
E-mail: JeffS@prodigy.net

Hardware and software for acoustic measurement from National Instruments. Anechoic chambers from Acoustic Systems. LabView software from Nelson Acoustical Engineering

Vibro-Acoustics

727 Tapscott Rd
Scarborough, ON Canada M1X 1A2
www.vibro-acoustics.com
Phone: 800-565-8401 • Fax: 888-811-2264
E-mail: tcharlton@vibro-acoustics.com

Vibro-Acoustics is the world leader in supplying the widest range of silencers for fans and air handling systems. From comprehensive product design, laboratory testing and integrated manufacturing, to product specification, selection and application. Vibro-Acoustics delivers over 40 years of industry experience. Vibro-Acoustics has developed innovative yet practical product solutions for some of the most diverse and dynamic projects in the world.

BSWA: New Product Release

USB Soundcard with ICP Inputs.

BSWA Technology is pleased to introduce MC3022 USB Soundcard with ICP inputs. MC3022 has two ICP input channels and one output channel. The ICP input channels can be directly connected to ICP type of sensors. The output channel provides the signal output to loudspeaker or other devices. MC3022 is based 24 bit A/C converters with two channel simultaneous sampling rates of 44.1 kHz. With the microphones and preamplifiers from BSWA, MC3022 is capable of measuring noise from 29 to 125 dBA without gain change. For further information, please contact Dr. Qunli Wu, BSWA Technology. Co., Ltd. Email: qlwu@bswa.com.cn; or visit our WebPages: www.bswa-tech.com.

Conference Calendar

Below is a list of congresses and conferences sponsored by International INCE and INCE/USA. A list of all known conferences related to noise can be found by going to the International INCE page on the Internet, www.i-ince.org.

2004 July 12-14

NOISE-CON 2004, The 2004 National Conference and Exposition on Noise Control Engineering

Baltimore, MD, USA. Contact: Institute of Noise Control Engineering, INCE/USA Business Office, 212 Marston, Iowa State University, Ames, IA 50011-2153. Tel. +1 515 294 6142; Fax: +1 515 294 3528; e-mail: IBO@inceusa.org. Internet: http://www.inceusa.org.

2004 August 22-25

INTER-NOISE 2004, The 2004 International Congress and Exposition on Noise Control Engineering

Prague, Czech Republic. Contact: INTER-NOISE 2004 Congress Secretariat, Technicá 2, 166 27 Praha 6, Czech Republic. Tel. +420 224 352 310; Fax: +420 224 355 433; e-mail: internoise2004@fel.cvut.cz. Internet: http://www.internoise2004.cz.

2004 September 20-22

ACTIVE 2004, The 2004 International Symposium on Active Control of Sound and Vibration

Williamsburg, Virginia, USA. Contact: Richard J. Silcox, Mail Stop 463, NASA Langley Research Center, Hampton, VA 23681. Tel. +1 757 864 3590; Fax: +21 757 864 8823; e-mail: r.j.Silcox@larc.nasa.gov.

2005 August 06-10

INTER-NOISE 2005, The 2005 International Congress and Exposition on Noise Control Engineering

Rio De Janiero, Brazil. Contact: Prof. Samir N.Y. Gerges, Mechanical Engineering Department, Acoustics and Vibration Laboratory, University Campus - Trindade, Florianopolis, SC - CEP 88040-900, BRAZIL. Tel. +55 48 2344074; Fax: +55 48 2320826: e-mail: samir@emc.ufsc.br.

2006 December 03-06

INTER-NOISE 2006, The 2006 International Congress and Exposition on Noise Control Engineering

Honolulu, Hawaii, USA. Contact: Institute of Noise Control Engineering, INCE/USA Business Office, 212 Marston, Iowa State University, Ames, IA 50011-2153. Tel. +1 515 294 6142; Fax: +1 515 294 3528; e-mail: IBO@inceusa.org. Internet: http://www.inceusa.org.

Acknowledgements

INCE/USA Liaison Program

ACO Pacific, Inc. .... Belmont, California
Brüel and Kjaer Instruments .... Decatur, Georgia
Cavanaugh Tocci Associates .... Sudbury, Massachusetts
G.R.A.S. Sound and Vibration .... Vedbaek, Denmark
Colin Gordon and Associates .... San Mateo, California
Harris Miller Miller and Hanson, Inc. .... Burlington, Massachusetts
Higgott Kane Industrial Noise Control .... Cambridge, Ontario, Canada
Industrial Acoustics Company .... Bronx, New York
IBM Corporation .... Armonk, New York
Iowa State University .... Ames, Iowa
Larson Davis Laboratories .... Provo, Utah
Noise Control Engineering, Inc. .... Billerica, Massachusetts
Overly Door Company .... Greensburg, Pennsylvania
The Pennsylvania State University .... State College, Pennsylvania
Purdue University .... West Lafayette, Indiana
Quest Technologies, Inc. .... Oconomowoc, Wisconsin
Scantek, Inc. .... Columbia, Maryland
Vibro-Acoustics .... Scarborough, Ontario, Canada
Wyle Laboratories .... Arlington, Virginia

Sustaining Members of International INCE

Bond Voor Materialenkennis .... Zwijndrecht, The Netherlands
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Norsonic AS .... Tranby, Norway
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France .... Centre Technique des Industries Méchanique, Senlis
Japan .... Sone Lab., Akita Prefectural University
Korea .... Center for Noise and Vibration Control Engineering, Korean Institute for Science and Technology, Science Town, Taejon-Chi
Portugal .... Laboratorio Nacional de Engenharia Civil, Lisboa
Russia .... Noise Control Association of the Baltic State University, St. Petersburg
Sweden .... Department of Applied Acoustics, Chalmers University of Technology, Gothenburg
USA .... Graduate Program in Acoustics, The Pennsylvania State University, State College, Pennsylvania

ACTIVE 2004

September 20-22, 2004

The 2004 International Symposium on Active Control of Sound and Vibration
Williamsburg, Virginia USA

Active 2004 is being organized by NASA Langley Research Center and sponsored by the Institute of Noise Control Engineering of the USA (INCE/USA). The conference will be held at the Williamsburg Hospitality House, which is surrounded by the eighteenth century elegance of historic Williamsburg VA. Plans call for 3 days of technical presentations on September 20-22, 2004 with one or two plenary speakers on each day reviewing topics of special relevance.

Organizing Committee

R J Silcox (General Chair)

G P Gibbs (Technical Chair)

K P Shepherd

C R Fuller

F W Grosveld

C H Gerhold

B J Lumanog

Objectives of the Conference

The aims of ACTIVE 2004 are to review the current research and application areas in the active control of sound and vibration and to highlight future directions for this technology. Papers are invited in any area of active sound or vibration control including but not limited to:

- Active Control of Sound in Vehicles
- Active Control of Outdoor Sound
- Active Control of Architectural Acoustics
- Active Control of Audio Environments
- Active Structural Acoustic Control
- Semi-Active (Adaptive) Control
- Active Vibration Control
- Active Vibration Isolation
- Feedforward Control
- Feedback Control
- Hardware for Active Control
- Transducers for Active Control
- Smart Materials and Structures
- Active/Passive Systems
- Commercial applications of active control

Conference Proceedings

Full versions of all papers will be provided on a CD supplied at the time of registration. It is planed that this CD also will include the papers presented at ACTIVE 95, ACTIVE 97, ACTIVE 99, and ACTIVE 2002

For more information, contact:

Richard J. Silcox
Mail Stop 463
NASA Langley Research Center
Hampton VA 23681
Phone: 757-864-3590
FAX: 757-864-8823
e-mail: r.j.Silcox@larc.nasa.gov

Additional information will be posted, as available, on the INCE WEB Site: www.INCEUSA.org

International Advertising Representatives

Below is a list of international contacts for the advertisers in this issue. The telephone number is followed by the fax number where available. In cases where there are several telephone numbers per location, or several locations within a country, a colon (:) separates the telephone number(s) from the respective FAX number. Advertisers are asked to send updated information by e-mail to: IBO@inceusa.org.

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ed@gelec.com.hk

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heron@es-france.com

India: ACOVIB Enterprises
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acovib@satyam.net.in

Korea-South: ABC Trading
82-234520946 • 82-234520949
kslee@abctrd.com

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metelka@aztec-net.com

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info@synotech.de

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handelsvertretung.schmeisser@t-online.de

Greece: Paragon LTD
+3010-2220008 • +3010-2220019
paragon1@otenet.gr

Hong Kong: S & V Samford Instruments Ltd
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sales@svsamford.com

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+91 22-6518768 • +91 22-6415747
dadachanji@vsnl.com

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g.m.amadasi@scs-controlsys.com

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tsaito@marubun.co.jp

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+81 45 935 6995 • +81 45 935 6993
yas-riko@mars.dti.ne.jp

Malaysia: INFO-TRAX SDN BHD
+603 4270 6085 • +603 4270 6054
faisal@infotrax.com.my

Mexico: Christensen, S.A.
+52 56 832 857 • +52 56 556 156
christen@terra.com.mx

The Netherlands: AcouTronics B.V.
+31 (0)162 42 44 21 • +31 (0)162 42 56 52
mailbox@acoutronics.nl

Norway: Norsonic A/S
+47 32 85 89 00 • +47 32 85 22 08
sbohn@norsonic.com

Portugal: MRA Instrumentacão, S.A.
+351 21 421 7472 • +351 21 421 8188
mra@taguspark.pt

P. R. China: Landtop Technologies CO., Ltd
+86 10 6802 5665 • +86 10 6801 8063
landtp@public.bta.net.cn

P. R. China: PCB CHINA
+86 10 6494 5682 • +86 10 6494 5724
pcbchina@pcb.com

P. R. China: S & V Samford Instruments Ltd
+85 228 339 987 • +85 228 339 913
sales@svsamford.com

Russia: OCTAVA + Company
+7 (095) 799 90 92 • +7 (095) 799 90 93
info@octava.ru

Singapore: Sound & Vibration Control Pte Ltd
+65 6742 0722 • +65 6742 6009
wupsj@singnet.com.sg

Singapore: SHAMA Technologies (S) Pte Ltd
+65 776 4006 • +65 773 5056 • +65 776 0592
shama@singnet.com.sg

South Korea: SV Corporation
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jyjoo@svdigital.com

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sales@famtech.co.kr

South Korea: SEVIT Tech
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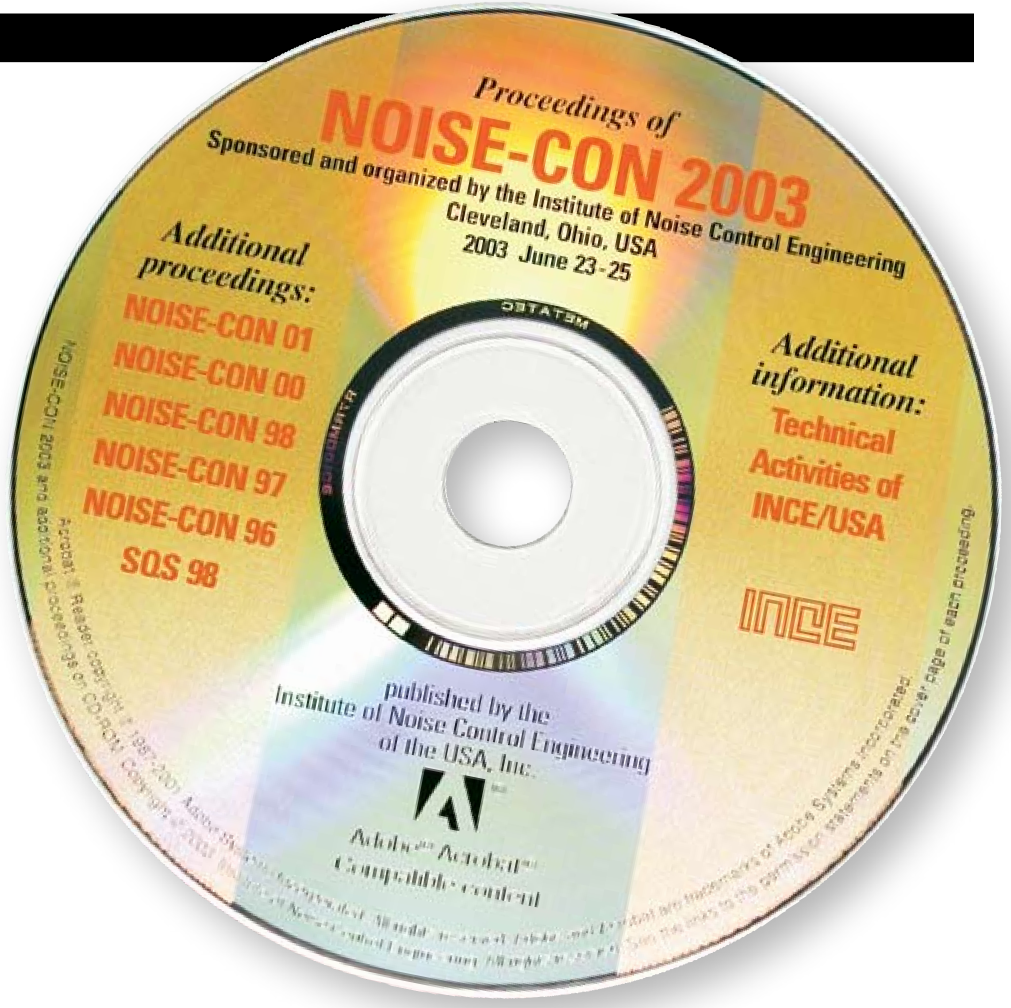

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