The Wall Journal™

THE INTERNATIONAL JOURNAL OF TRANSPORTATION-RELATED ENVIRONMENTAL ISSUES

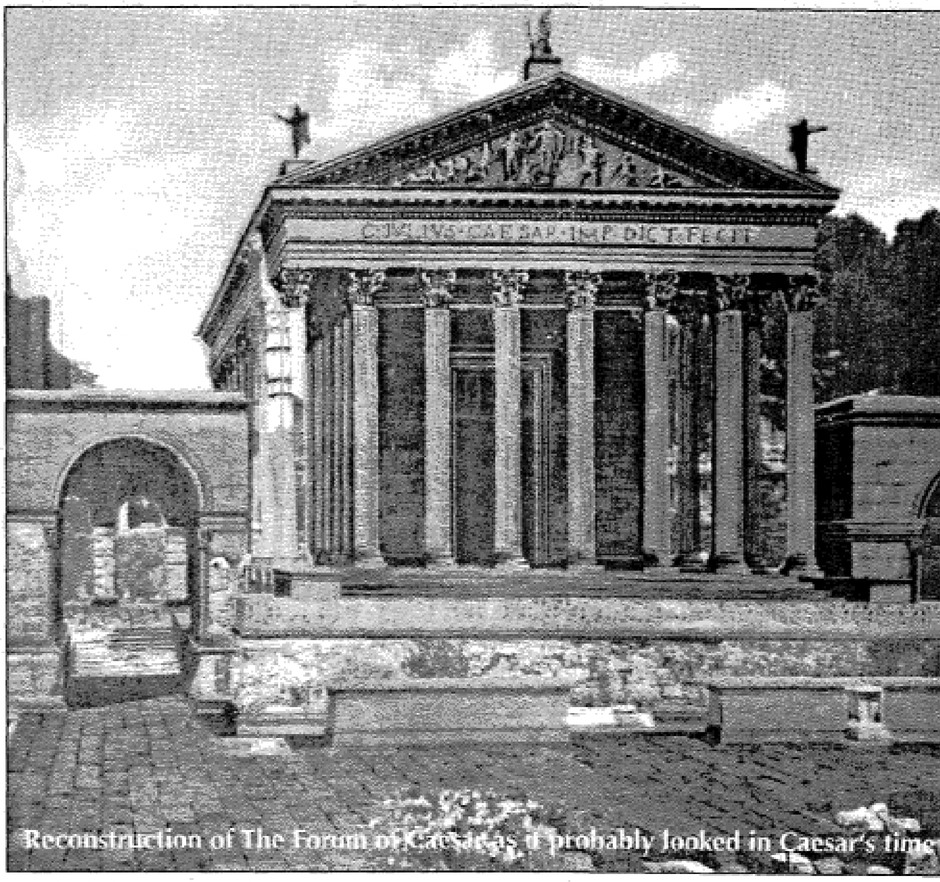
Issue No. 22

Mar/Apr1996

Friends, Readers and Countrymen — Welcome to The Forum*

The Wall Journal Forum is beginning to shape up. Rudy Hendriks' and Ed McNair's articles in the last issue seem to have ignited the spark that is encouraging others to come forth with ideas and opinions of their own. We think you will find some very interesting and useful reading in this issue.

Unlike Caesar's Forum, no knives are allowed in The Wall Journal Forum.



Reconstruction of The Forum of Caesar as it probably looked in Caesar's time

In This Issue:

Forum Discussions

Also In This Issue:

* With apologies to the opening address from "Rienzi to the Romans"

The Wall Journal

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Editor's Corner

by El Angove

et tu Brutus?

You bet. Everybody's getting into the act. The senators in the Forum are on their feet and shouting out to be heard. The brave are expounding their innermost beliefs and venting their pent-up frustrations. The search for justice, truth and morality has burst upon us, and the brave senators will not be stifled nor swayed by the naysayers among us, until the absolute truth is brought to the fore. Long live the technological and scientific revolution which will cleanse our minds and hearts and give us more purchase on life. Let the games begin!

Rudy Hendriks was the first brave soul to step forward and sow the seeds of disputation. Now, others have come to the Forum to be heard, and you will hear them speak in these pages.

You have all seen the Op/Ed pages in the newspapers — Opinions and Editorials. The Wall Journal is instituting the Opinions and Comments pages with this issue, which we have dubbed Op/Com pages. These will be identified by the following logo:

Op/Com

This logo will appear in the header of each article of such nature, to indemnify the author from slanderous attack, and instead encourage others to come forward with their own views and comments so that we may all benefit from the interchange of ideas.

If you watch C-Span, you have some feeling for this, although I trust that we shall not descend to levels which are often plumbed on the floors of the U.S. Senate and House of Representatives.

I hope that many of you will join in the discussions on matters of interest to all of us. If you have no opinions to offer, then send in questions you would like the experts to answer, in order to give you a better understanding of the subject. I will open a "Question Box" where we will publish your bothersome questions and hope to get some knowledgable responses.

AASHTO have done a very good job in bringing order to structural specifications for noise barriers. If you design noise barriers, you should have a copy of "Guide Specifications for Structural Design of Sound Barriers, 1989". The last time I got a copy, it cost $8.00. It is available from: American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Suite 225, Washington, D.C.

What is really needed now are standards for noise barrier materials and for materials testing. The article on page 10 of this issue goes to a certain amount of dispute over durability testing of sound absorptive materials. You will hear more about that in future issues.

You transportation noise abatement people are a select group among all of the environmentalists. As far as I know, The Wall Journal is the only publication entirely devoted to **your** interests, And, we have international readership. There are readers in Canada, France, Hong Kong, Israel, Australia, Denmark, Taiwan, Japan and Saudi Arabia.

The Wall Journal was started with the encouragement of Bob Armstrong of FHWA, and pushed and shoved by Bill Bowlby, Soren Pedersen and Ken Polcak, among others. This was purely **designed** to be **your** forum. I only get to write this column.

I want to hear from more of you. It gets lonely in here. ■

Coming Attractions

- **A Report on the First Noise Barrier on the Massachusetts Turnpike**
- **A Detailed Noise Barrier Status Report by Florida DOT**
- **An Index of All Articles in the Wall Journal from Issue No. 1**
- **And More Op/Com**

Reader Registration is Important

See page 23

PRESS RELEASE

SoundTrap® approved for use by Japan Ministry of Construction

FOR IMMEDIATE RELEASE
Contact: Boone Bucher
Phone 512 327-8481, fax 512 327-5111

AUSTIN, Texas—SoundTrap®, a sound absorptive cementitious highway noise barrier product was approved by the Japan Ministry of Construction on Feb. 14, 1996 to be imported for use by the Public Works and commercial enterprise. SoundTrap is licensed by the patented technology provided by Concrete Solutions, Inc., Austin, Texas.

"It is the first construction sound insulative material to be approved for importation into Japan from the United States for use by the Public Works" said Naoki Akiyama, president of Concrete Solutions Japan (CSJ). Akiyama is on the International Advisory Board of Concrete Solutions, Inc. (CSI).

"CSI supplies a science to the highway noise abatement problem with their advanced technology. The SoundTrap product offers not only a more advanced and durable material, but a unique composition that creates the ***super-inductive intercellular structure.*** This structure serves to deaden the soundwaves impacting the face of the barrier, thereby eliminating the noise, rather than merely reflecting it. This is very important in Japan, as most transportation corridors are narrow, heavily traveled and have residences and businesses on both sides", said Akiyama.

Boone Bucher, President of CSI said, "The unique aspect of our technology is that our material excels in absorbing the sound waves created by truck and auto tire noise. The frequency of the tire noise falls between the 500 Hz and 1000 Hz range and the SoundTrap ***super-inductive open cells*** provide the highest absorption rating possible within this range, serving to eliminate this type of sound energy impacting the barrier material. We are very pleased with the acceptance of our product by Japan and view this as an important step in our continuing effort to develop the expansion of the markets for SoundTrap, both internationally and in the United States".

This sound absorbing material is recognized as the leader in the noise absorptive barrier market in the U.S. and was the first all-weather U.S. patented noise absorptive cement based product approved. This material is integrated into millions of square feet of highway barriers to provide a common sense solution to noise abatement.

CSI licenses qualified manufacturers within the United States and throughout the world to manufacture SoundTrap using patented manufacturing technology which provides a very durable, freeze-thaw resistant, aesthetically versatile and highly effective sound absorptive material. ■

Letter from a Long-Time Good Friend

January 26, 1996

El Angove
Editor

Dear El:

Your Issue 20 just came across my desk, and since 20ths are on our mind up this way (CTA's 20th year of operations commenced on September 1, 1995),we had a party January 18th at the MIT Faculty Club, to which you and Bill Pickett would have been more than welcomed. I'm sure you know most of the consulting crowd and clients who came.

We'll just have to have a special celebration when you are up here next.

Best to all in Florida Land,

Bill Cavanaugh
Cavanaugh Tocci Associates, Inc.
Sudbury, MA

Congratulations Bill and Greg. It's hard to believe that 20 years have passed since you hung out your shingle. Also, at about that time, you were instrumental in encouraging Bill Pickett and me to hang out the Fanwall shingle. Good times revisited.
Best Regards
— El

Letter to the Editor

Mr. El Angove
Editor
The Wall Journal
P.O.Box No. 1389
Lehigh Acres, FL 33970-1389

Dear El:

Again, I wish to express my appreciation, this time for printing the press release on my wall patent (Issue No. 21). Including the photographs was great!

I also want to thank you for a unique compliment. No one has ever before said that my opinions were "short".

I thought Rudy Hendricks' opinion article was very good, and, since I am selling lower cost with my design, it was serendipitous. I will be very happy to answer any criticism of my article; in The Wall Journal if I am right, privately if I am wrong.

The guy that said "Build a better mousetrap, etc." was a darned liar. It is going to take a lot of selling on my part for my product to be successful. I really appreciate your giving me a boost.

Regards,

Ed McNair
Morristown, NJ

Editor's Note: Thanks for your letter, but it is our policy to publish any news of new products or services for the benefit of our readers. Also, it is policy to publish opinions submitted by our readers and also to publish responses to those opinions. I consider The Wall Journal to be a forum for the exchange of ideas which further the state of the art. Your contributions, and those of others, will always find a home on these pages. Good luck with your invention.

— El

TRB Committee A1F04 on Transportation Related Noise and Vibration

By Gregg G. Fleming, Chairman

In recent weeks several committee members have queried me with regards to A1F04 activity at the 1996 Winter Meeting. As most of you know, many individuals could not attend the meeting due to the weather, including myself. However, thanks to Bill Bowlby's diligent note taking, I was able to put together a set of minutes from the A1F04 full committee meeting (thanks Bill!). Highlights of the meeting are as follows:

Committee A1F04 Annual Meeting
January 9, 1996 Jefferson West Room
Washington Hilton Hotel

1. Domenick Billera called meeting to order at 9:15 am.

2. Attendees introduced themselves.

3. Jon Williams (new TRB liaison replacing Ken Cook) made some announcements:
   - Jan 12-16, 1997 is the next annual meeting date.
   - TRB is exploring options to deal with continually growing attendance, in taking a firm August 1 deadline for papers (D. Billera expressed opposition to this idea).
   - Jon presented a certificate of appreciation to outgoing chairman D. Billera.

4. Meeting minutes were not available as Secretary Win Lindeman could not attend.

5. Membership:
   - D.Billera announced that the new Chairman will be Gregg Fleming of the USDOT, Volpe National Transportation System Center.
   - Committee membership is up for renewal; D. Billera expects G. Fleming to review the membership. Note: Rotation of membership has since been postponed until January of 1997.
   - D. Billera felt G. Fleming would welcome any suggestion on membership or future direction.

6. D. Billera reported that the Summer Meeting of 1995 was hosted by Acentech & Volpe, and included excellent papers, technical briefs & social activities.

7. Subcommittee Meetings: None of the chairs were present for highway, air or guided-transit meetings, but D. Billera ran all three with light attendance. The biggest agenda item was research needs, discussed below.

8. Research Needs: Statements are due by end of January, and there will be a follow-up conference November 14-16 in Washington D.C. Noise has fared well relative to other environment areas in getting previously identified needs funded, but face stiff competition due in part to previous success. D. Billera circulated copies of the research needs, statement form.

9. D. Billera announced a subsequent research topic for the Cooperative Research Program. Topics are due at the end of the month.

10. Ulf Sandberg raised issue of whether the committee should widen scope to address vehicle/tire design for noise control.

11. D. Billera felt that the committee should broaden itself in that direction. He noted that we should not limit ourselves to identifying research that we would only expect state DOTs to fund.

12. Gary Billiard noted that the ASTM F-9 committee looks at tire noise (he serves on the ASTM E-17 subcommittee, which deals with other noise issues).

13. Ulf Sandberg asserted that noise control regulations were essential to get European tire manufacturers to deal with the issue. He also noted that transverse grooving, a common US noise problem, has been dealt with over a decade ago in Europe.

14. HNTB felt that tire design was beyond scope of our work, but we can, and do focus on pavement design. He noted that porous pavement designs used in Europe wouldn't be embraced in much of the U.S. because of environmental conditions. HNTB is doing work for Wisconsin DOT identifying those pavements, and their tonal characteristics which tend to cause increased annoyance. They have found conflicting results in the literature.

15. D. Billera concluded the discussion, noting a difference in philosophies in Europe ("prevention") versus the U.S. ("cure").

16. Roger Wayson noted SAE's active work in the area.

17. Bill Bowlby called for stronger liaison with SAE, ASTM, ISO & ANSI in part because we need to be educated in their research and standards activities.

18. Parviz A. Koushki of Kuwait called for more international interaction and focus on land-use compatibility, perhaps through ASCE. Wayson noted that he chaired the ASCE UTP environmental committee and would be willing to be a liaison to this committee for some of their international interests.

19. D. Billera presented a report from Ron Moulder, our liaison to the coordinating group at Noise Control Engineering.

20. Presentations: Thomas Oderbrant of DNV-Ingemansson presented information on Swedish rail noise standards which focus on L_{Aeq24h} L_{ASmx} and percent-annoyed noise descriptors. He also described several noise assessments of rail lines done by his firm. Copies of Mr. Oderbrant transparencies are available from him.

21. 1995 Best Papers Awards went to Panos D. Prevodorous and C.S. Papcosta for "Analysis of Rural Community Perceptions of Helicopter Noise".

22. The Awards Dinner was rescheduled for the Anna Maria restaurant.

23. D. Billera announced that the Summer Meeting for 1996 will be on July 21-24, 1996, in the Chicago area. Mike Bruns of Illinois DOT is the organizer.

24. D. Billera noted that the A1F04 Newsletter will be mailed, March or April, probably by Gregg Fleming.

25. The Wall Journal's editor El Angove has requested articles and information for publication. D. Billera urged all of us to support the Wall Journal.

26. D. Billera announced a Vehicle Infrastructure Interaction Conference to be held on June 2-7, 1996 in San Diego, CA, sponsored by the Engineering Foundation.

27. The meeting adjourned at 11:45 am ■

(Gregg Fleming may be reached by phone at Volpe National Transportation Systems Center in Cambridge, MA @ 617 494-2876 or fax 617 494-2497).

FHWA Traffic Noise Model, Version 1.0 – REMEL Data Base

By: Cynthia S.Y. Lee and Gregg G. Fleming (Volpe Center), Robert E. Armstrong and Steven A. Ronning (FHWA), and Grant S. Anderson (HMMH Inc.)

This article presents a synopsis of a presentation originally scheduled for the morning session of the A1F04 Highway Noise Subcommittee at this year's TRB Annual Meeting in Washington, D.C., but cancelled due to extreme weather conditions. It focuses primarily on the development of the emission level Data Base of the Federal Highway Administration's Traffic Noise Model (FHWA TNM®).

The FHWA TNM is an entirely new, Windows-based, computer program which uses state-of-the-art acoustic algorithms to predict noise impacts in the vicinity of highways. A primary building block for TNM around which the acoustic algorithms are structured is its Reference Energy Mean Emission Level (REMEL) Data Base. The REMEL Data Base was developed by the U.S. Department of Transportation, John A. Volpe National Transportation Systems Center (Volpe Center), Acoustics Facility, in support of the FHWA, Office of Environment and Planning and Office of Engineering and Highway Operations Research and Development, and a 25-State National Pooled-Fund Study, titled: "Highway Noise Model Data Base Development."

The REMEL Data Base contains over 6000 individual pass-by events (almost three times more than those collected in the development of the FHWA's current highway noise prediction model, STAMINA). These events include constant-flow REMEL data, interrupted-flow REMEL data, and subsource-height data measured in 9 states across the country.

Specifically, constant-flow measurements were performed by the Volpe Center, with the assistance of the Maryland State Highway Administration (MSHA), at 40 sites in California, Connecticut, Florida, Kentucky, Maryland, Massachusetts, New Jersey, Michigan, and Tennessee. Interrupted-flow measurements were performed by the Volpe Center, with the assistance of MSHA, Vanderbilt University, the University of Central Florida, and Ohio University, at 5 sites in Florida, Kentucky, and Tennessee. Lastly, one-third octave-band subsource-height measurements were performed by Florida Atlantic University under the direction of FHWA, Florida DOT, and the Volpe Center.

The constant-flow data helped correct many of the limitations of STAMINA, such as limited speed ranges, vehicle types, and the inability to account for vehicles on grade. The interrupted flow data allowed for the modeling of traffic at various traffic-control devices, such as toll booths, traffic lights, and highway ramps, by allowing us to develop a relationship between interrupted-flow data and the corresponding constant-flow data. Lastly, the subsource-height data allowed for a percent-energy apportioning of the constant-flow levels to fractional noise-levels representative of typical vehicle noise subsources, that is, engine/exhaust noise and tire/pavement noise.

The REMEL data and related subsource-height data were used to develop the regression equations of sound level versus speed versus frequency versus subsource-height required for TNM. The general form of the regression equations differ from STAMINA in that they contain not only a "tire/pavement noise" component that increases with vehicle speed (similar to STAMINA), but also an "engine/exhaust noise" component that is independent of vehicle speed. Baseline regression equations were developed for automobiles (A), medium trucks (MT), heavy trucks (HT), buses (B), and motorcycles (MC). The resultant curves are presented in Figure 1. Baseline conditions refer to dense-graded asphaltic concrete (DGAC) and Portland cement concrete (PCC) pavements combined, level-graded roadways, and constant-flow traffic.

To account for specific pavement types, grade conditions, and interrupted-flow traffic, similar regression equations were developed by applying adjustments to the "tire/pavement noise" component and/or the "engine/exhaust noise" component of the above baseline regression curves.

For example, Figure 2 shows the baseline curve for heavy trucks, along with the associated curve for heavy trucks on grade, as well as heavy trucks subject to interrupted-flow conditions. As can be seen, the engine/exhaust portion of the curve was adjusted upward to account for the increased throttle associated with grade/interrupted-flow operations of heavy trucks.

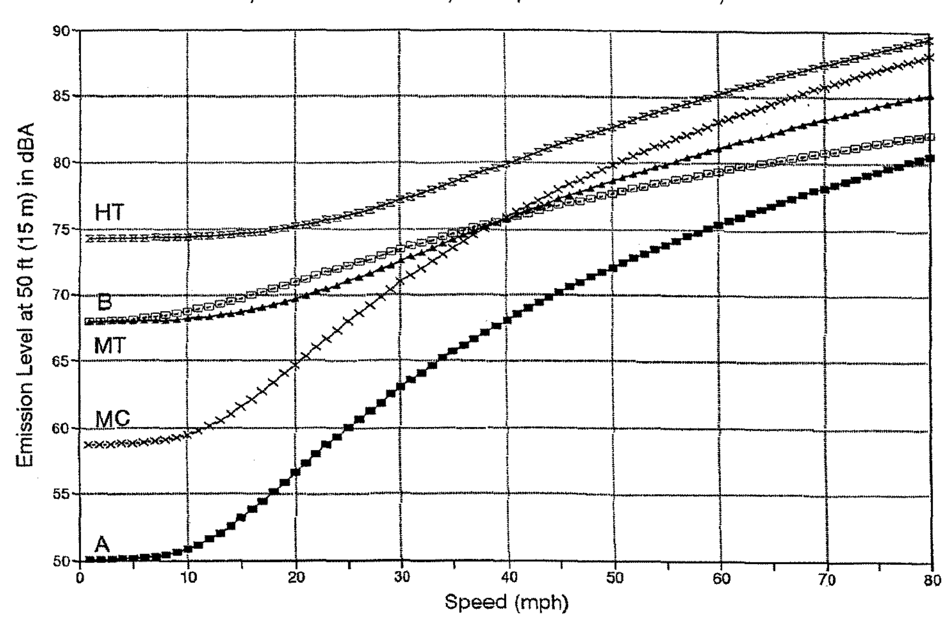

Figure 1. Emission Level Comparison

The general REMEL equation, expressed as a function of vehicle speed (mph) and frequency (Hz), is defined as follows:

$$L_E(s,f)=10*\log_{10}[10^{(C+\Delta Ec)/10}+(s^{A/IO})(1O^{(B+\Delta Eb)/IO})]$$
$$-(K1+K2*s)+D1+D2*s+(E1+E2*s)\log_{I0}f$$
$$+(F1+F2*s)(\log_{I0}f)^2+(G1+G2*s)(\log_{I0}f)^3$$
$$+(H1+H2*s)(\mathrm{Log}_{I0}f)^4+(I1+I2*s)(\log_{I0}f)^5$$
$$+(J1+J2*s)(\log_{I0}f)^6$$

where:

A is the slope of the tire/pavement-noise portion of the regression curve;

$B+\Delta Eb$ is the height of the tire/pave ment-noise portion of the regression curve;

$C+\Delta Ec$ is the height of the engine/exhaust-noise portion of the regression curve;

D1 through J2 are for the sixth-order polynomial fit through the one-third octave-band spectral data as a function of speed; and

K1 and K2 calibrate the A-levels resulting from the sixth-order polynomial fit, such that they are essentially equal to the A-levels from the A-level REMEL equations expressed independent of frequency, i.e., $L_E(s)$ instead of $L_E(s,f)$.

Finally, to apportion REMELs to fractional noise levels representative of the "tire/pavement" and "engine/exhaust" subsources, one-third octave-band subsource-height adjustments were applied to all regression equations.

The general subsource-height-ratio equation, expressed as a function of frequency, is defined as follows:

$$\text{Subsource-height-ratio } (f) = L+[1-L-M][1+e^{[(N\log f)+P]}]Q$$

where:

L is the subsource-height ratio at low frequencies;

1-M is the subsource-height ratio at high frequencies; and

N, P, and Q control the exponential transition which occurs at the mid-frequencies.

In total, the regression equations developed are as follows:

- 10 subsource, one-third octave-band, average-pavement (data from both DGAC and PCC combined) regressions for constant-flow vehicles on level grade;
- 24 subsource, one-third octave-band, specific-pavement (representing data from three pavement types: DGAC, PCC, and open-graded asphaltic concrete (OGAC)) regressions for constant-flow vehicles on level grade;
- 2 subsource, one-third octave-band, grade/interrupted-flow adjustment regressions (heavy trucks); and
- 8 subsource, one-third octave-band, adjustment regressions for interrupted-flow vehicles (autos, medium trucks, buses, and motorcycles).

These regressions exist in TNM as a matrix of coefficients expressed as a function of vehicle type, vehicle speed, one-third octave-band frequency, pavement type, roadway grade condition, traffic-flow condition, and vehicle subsource height. The coefficients have been integrated into the Data Base of TNM and are used for computing sound levels in the vicinity of a roadway, and for designing noise barriers. It is important to note that this relatively complex matrix will be transparent to the TNM user.

The measurements, analysis and results are documented in more detail in the Volpe Center Final Report, "Development of the Reference Energy Mean Emission Level Data Base for the FHWA Traffic Noise Model (FHWA TNM), Version 1.0." For individuals interested in receiving a copy of the report contact Cynthia Lee at (617) 494-2372, e-mail: lee@volpe2.dot.gov. Note: Members of the TRB A1F04 Highway Noise Subcommittee will automatically receive a copy. ■

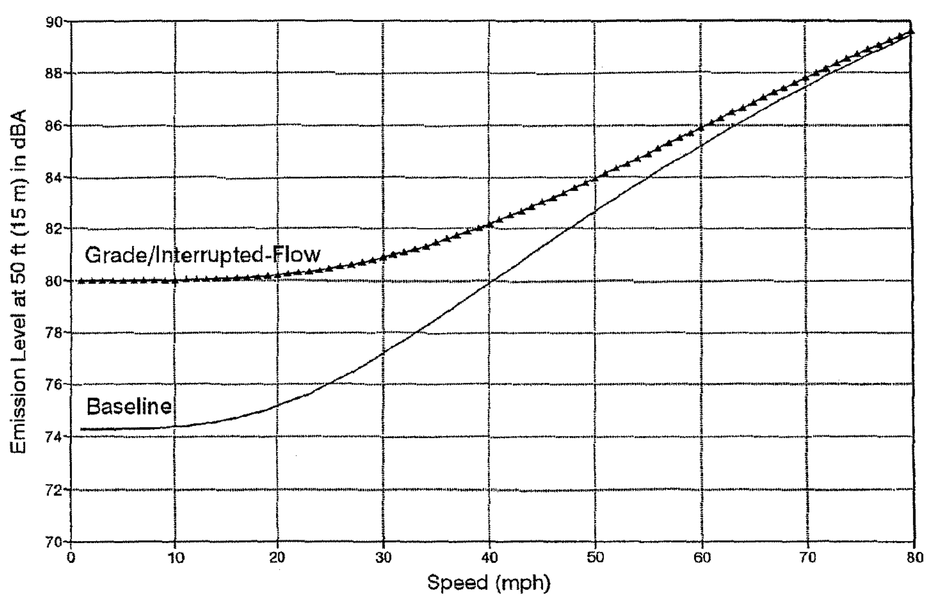

Figure 2. Baseline Versus Grade/Interrupted-Flow Conditions

On the durability of concrete noise barrier products

By Soren Pedersen

Every product that is installed along highways is required to meet certain expectations for safety performance and durability. Noise barriers are no exception to these requirements. With respect to safety and performance, the requirements and evaluation of noise barriers are specific, and are usually described in great detail by structural design codes and environmental regulations. However, when it comes to durability, the individual specifying agencies are usually left to develop their own evaluation procedures. Defining an appropriate test method that predicts long-term performance under actual field conditions is the challenging task, particularly for cement based products.

In an effort to resolve these concerns, I would like to share the experience of the Ministry of Transportation, Ontario (MTO) in developing their evaluation procedures.

Before MTO could start their noise barrier program in 1972, specifications had to be developed which were to include a method of measuring durability. At that time, MTO was using a procedure similar to the current **ASTM C672 (Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals**) with slight modifications. It was used on all concrete products, both precast and cast-in-place to evaluate the effects of air content, cement factor, slump, water-to-cement ratio, surface treatment, curing and other variables on concrete's resistance to salt scaling and rapid freezing and thawing. The MTO modifications mentioned include the use of a 3% sodium chloride solution and a quantitative method of measuring deterioration during the test period. The MTO acceptance criteria require that, after 50 freeze/thaw cycles, the loss of mass from the surface of any sample shall not exceed 0.8 kg per m^2 and that the samples shall exhibit no deterioration in the form of cracks, spalls, delamination, aggregate disintegration or other objectionable feature.

From years of experience, the **ASTM C672** (modified) method proved to be a very reliable indicator of how concrete slabs and other similar structures survived long term exposure to very severe and harsh environments, including freezing and thawing, deicing chemicals, wetting and drying. However, very little experience was available on its reliability for evaluating freestanding, vertical structures such as concrete light poles and noise barriers. Although other methods were considered, MTO decided to use **ASTM C672** (modified) as the primary durability test for concrete noise barriers.

An alternate test method available was **ASTM C666 (Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing)**. This test determines the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing in the laboratory by two different procedures: **A**-Rapid Freezing and Thawing in Water, and **B**-Rapid Freezing in Air and Thawing in Water.

This method was rejected as an appropriate test for noise barriers, on the basis that, by its own admission. the standard states that "Neither procedure (**A** or **B**) is intended to provide a quantitative measure of the length of service that may be expected from (any) type of concrete". In addition, only distilled water is used during the test procedure. This does not represent common field conditions in northern or coastal regions where these products are constantly subjected to salt laden moisture.

More recently, a number of other concerns related to **ASTM C666** test procedures have been documented by the Strategic Highway Research Program, in a 1994 report (SHRP-C-391) identifying problems with the design of the apparatus used for the test as well as the inadvertent drying of the samples during the air freezing cycle.

Since the first noise barrier installation in 1972, MTO has installed nearly 60 km of cement based noise barriers. Samples of actual panels and posts have been taken from every project and have been subjected to various quality assurance testing, including **ASTM C672** (modified). In addition, a large number of these samples were also subjected to **ASTM C666** testing for comparison purposes. From the time of construction, each installation has been monitored on a regular basis for any signs of deterioration. When all of this data was examined. the evidence was quite clear that:

- The **ASTM C672** (modified) test provided consistent results which directly correlated with actual field performance and proved to be a remarkably accurate predictor of service life.
- The **ASTM C666** test does not predict performance in the field. In fact, all the products that failed in the field had passed the **ASTM C666** test method.

A key point commonly missed is that both standards clearly state that no relationship has been established between the results obtained from specimens cut from hardened concrete and specimens prepared in the laboratory. Therefore, to obtain valid results, the specimens used should be cut from a finished production run product as opposed to small handmade blocks that are made specifically for the test. By insisting on this, the test results can also be used to evaluate in-plant quality control and production operations.

As a result of these findings. the **ASTM C672** (modified) test method was officially adopted by the Ontario Ministry of Transportation in the late 80's as the primary test method for determining the durability of all cement based noise barrier products whether they are precast, dry cast, cast-in-place or porous. This method has also been recently adopted by the Canadian Standard Association as the nationally accepted standard method of testing cement based noise barrier products. ■

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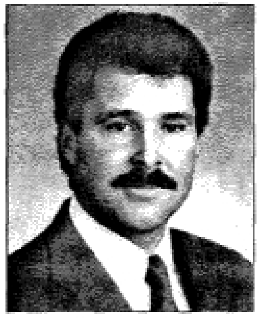
To Absorb or not to Absorb — How much does absorption cost?

A Response by Gary Figallo

Op/Com



In a previous issue of the Wall Journal, the editor invited opinions from the readers on the merits of sound absorptive barriers. In the Wall Journal Issue 21, a distinguished member of the transportation noise community authored the article entitled "To Absorb or Not To Absorb, that is the question." The article explained the science of highway noise propagation and quantified the benefits of sound absorptive barriers versus reflective barriers. It was proposed that given equal durability, aesthetics, and structural integrity, that the primary obstacle to the use of sound absorptive barriers is price.

There are basically four questions to address. They are: (1) How much do sound absorptive barriers of the same durability, and architectural quality as reflective barriers cost? (2) How do states get absorptive walls at competitive prices? (3) What is the cost of retrofitting walls? and (4) What are the performance improvements obtained from absorptive sound barriers and are they cost effective?

1) How much do sound absorptive barriers of the same durability, and architectural quality as reflective barriers cost?

Prices for absorptive walls vary with market conditions, just as prices vary in all markets for all types of products. The fact is, however, that absorptive systems have been supplied for unit prices less than the cost of reflective walls in California. The cost of reflective walls in California was reported as $1,000,000 per mile using an average wall height of 13 feet. The average price, therefore, is $14.57 per square foot.

The Virginia Department of Transportation, with the longest running absorptive barrier construction program, uses an average unit price of $16.00 per square foot for walls. In-place prices for absorptive walls have been less than $12.00 per square foot on some projects. Prices for absorptive walls recently bid in Wisconsin are $14.00, $12.00, and $14.50 per square foot.

On several projects, absorptive walls have been substituted for reflective. Competition among suppliers has spawned new materials, suppliers and improved wall designs. On the other hand, New Jersey estimates that absorptive surfaces on their concrete walls add $3.00 to $4.00 per square foot. Another survey indicated that absorptive treatments add 15 to 20% to the cost. Therefore, the cost of absorptive versus reflective systems varies from state to state.

2) How do states get absorptive walls at competitive prices?

Here are some ways that have been used to purchase absorptive materials.

1) Pre-approve suppliers and manufacturers and specify that all sound barriers must be absorptive and must meet established criteria for approval.

2) Allow suppliers to design walls using the features and benefits of their systems to lower cost, such as variable post spacing.

3) Create a level playing field by defining geotechnical parameters, safety factors, and wind pressures for each project for all suppliers to use in design.

4) Allow contractors to select the most cost effective wall system by creating specifications that allow the direct substitution of pre-approved absorptive systems for reflective systems.

5) Purchase materials directly from suppliers to obtain quantity dis counts or to obtain architecturally compatible materials for large projects.

6) Create a large and consistent market to encourage research and development and capital investment in absorptive material manufacturing.

7) Establish the value of improved performance to your community and allow communities to pay for the improved performance through adjustments in marginal property tax rates.

There exist today, manufacturers of sound absorptive systems that can supply every region of the country with approvable systems. Once established, an approval procedure should be fairly and consistently applied. A list of approved manufacturers can be maintained for each state or region.

3) What is the cost of retro-fitting walls with absorptive cladding materials?

Retro-fitting walls with an absorptive cladding has been done where persistent citizen complaints demanded action. The FHWA reported that cladding a wall in Wisconsin cost $8.15 per square foot in place. Cladding may be installed in selected areas to correct acoustical deficiencies of reflective sound barriers.

Retro-fit costs will vary with site conditions, such as maintenance of traffic, wall height, condition of existing wall, and ease of access for construction. Certainly a range of costs from $6.00 to $10.00 per square foot could be anticipated. There is no doubt that constructing absorptive walls in the first place is less costly than building reflective walls and applying cladding later. Absorption also reduces the probability of adverse community reaction and poor public relations regarding sound wall programs.

4) What are the performance improvements from absorptive sound barriers and are they cost effective7

Since the community inevitably determines the acceptable level of performance, consider the incremental cost of absorptive materials versus the cost of failure.

Absorptive materials are typically considered where parallel wall situations exist. The benefits of absorption are documented and recommendations have been promulgated by the Federal Highway Administration for use. In these considerations, we often are reminded that people cannot distinguish the difference between two sounds that are less than 3 dB apart. But when the metric being considered is L_{eq} (time averaged noise level in dBA,) 3 dB is the equivalent of a doubling of traffic count. Do you really think people can't tell the difference in noise levels when traffic count doubles?

Several single wall situations have created acoustical conditions that generated intense and non-transient community reaction far out of proportion to a non discernible 3dB impact. Some noise from the highway reaches the home owner via a direct path and a ground reflected path. Sound waves can arrive in phase (hot spot) or out of phase (cold spot). When a sound wall is erected a mirror image source is created and energy is propagated over an additional set of direct and ground reflected paths.

The LaGuardia Airport Ground-Noise Abatement Study (by Harris Miller Miller and Hanson) demonstrated significant variations in sound levels at frequencies between 200 Hz and 3000 Hz due to the effect of sound barriers on reflective geometries. In one situation, sound barrier induced ground effects were predicted to produce insertion loss variations of +25 dB at 250 Hz, -20 dB at 2500 Hz, yet only one dBA difference in overall insertion loss.

Therefore, although L_{eq} dBA may not be measurably affected, the change in the quality of the noise may be dramatic and apparently very annoying, just the same. A fully sound absorptive wall will eliminate this virtual source and preclude the possibility that ground effects will transform certain receiver locations into hot spots.

So, using absorption in the first place will reduce unit costs, the probability of negative community reaction, screaming headlines regarding upset homeowners, inappropriate use of taxpayer dollars, and sound walls that don't work while (literally and figuratively) improving the state of sound wall art. Indeed, the question is **"Why build a sound barrier <u>without</u> absorption?"** ■

The author is product manager for Transportation Noise Control Products including NoiShield®, Soundcore™, and Soundcore Plus for Industrial Acoustics Company (see advertisement below), and may be reached by phone 718 430-4515, 4530 fax, http://www.industrialacoustics.com, and was formerly General Manager of The Fanwall Corporation, and Sound Barrier Product Manager for The Reinforced Earth Company.

FHWA Traffic Noise Model, Version 1.0: Introduction to its Capabilities and Screen Components

By Grant S. Anderson, Christopher W. Menge, Christopher F. Rossano (HMMH Inc.);
Robert E. Armstrong and Steven A. Ronning (FHWA); and Gregg G. Fleming and Cynthia S. Y. Lee (Volpe Center)

This article summarizes the FHWA Traffic Noise Model (FHWA TNM E9, Version 1) and shows several of its typical screens and printouts. An active demonstration of TNM was planned for last January's TRB meeting in Washington, which was canceled by snow. That TNM demonstration will be given at this summer's meeting of TRB Committee AIFO4 in Chicago.

TNM computes highway traffic noise at nearby receivers and aids in the design of roadway noise barriers. It is an entirely new, Windows-based computer program that uses state-of-the-art emission levels and acoustical algorithms to compute noise levels along highways.

The emission-level database was developed by the Volpe Center's Acoustics Facility, with help from many others throughout the country, including initial analysis design plus review by Harris Miller Miller & Hanson Inc., Vanderbilt University, and the University of Central Florida. The acoustical algorithms were developed by Harris Miller Miller & Hanson Inc. and tested jointly by the Volpe Center, the FHWA, and several state transportation agencies.

Input. Within Windows, TNM allows digitized input using a generic Windows digitizer driver, plus the import of DXF files from CAD programs and input files from Stamina 2.0. To aid during input, TNM shows and plots the following graphical views:

- plans
- skew sections
- perspectives
- roadway profiles, which help during input of roadway Z coordinates.

These input graphics are dynamically linked to input spreadsheets, where non-coordinate input is entered and digitized input may be modified. Figures 1 through 3 show typical graphical views, while Figure 4 shows a portion of the noise-barrier input spreadsheet.

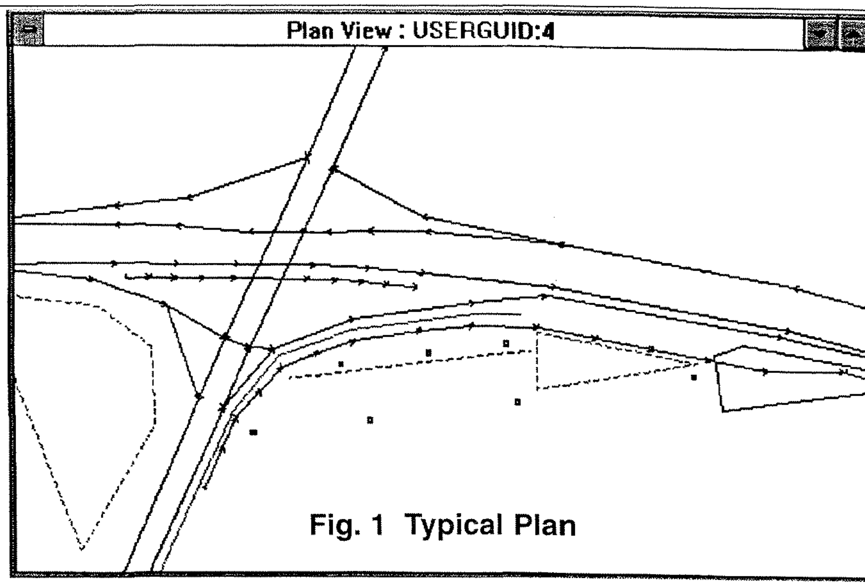


Fig. 1 Typical Plan

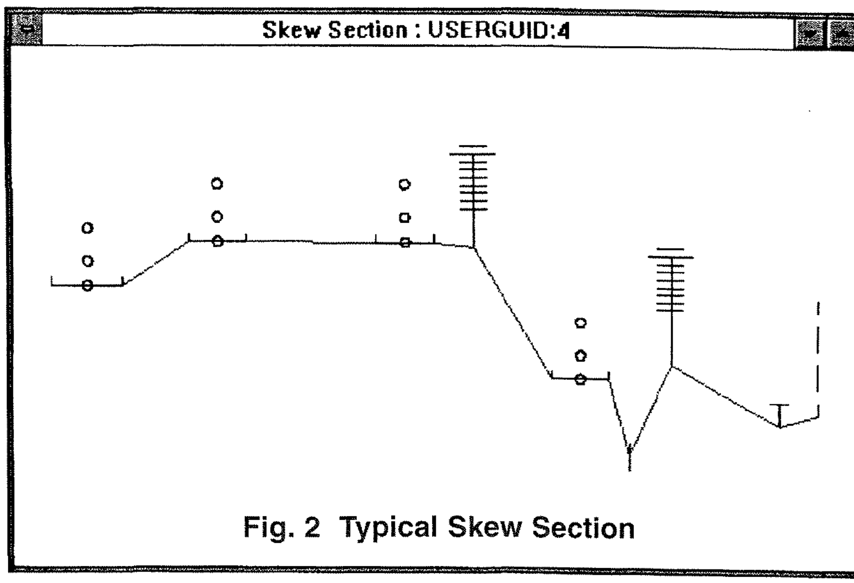


Fig. 2 Typical Skew Section

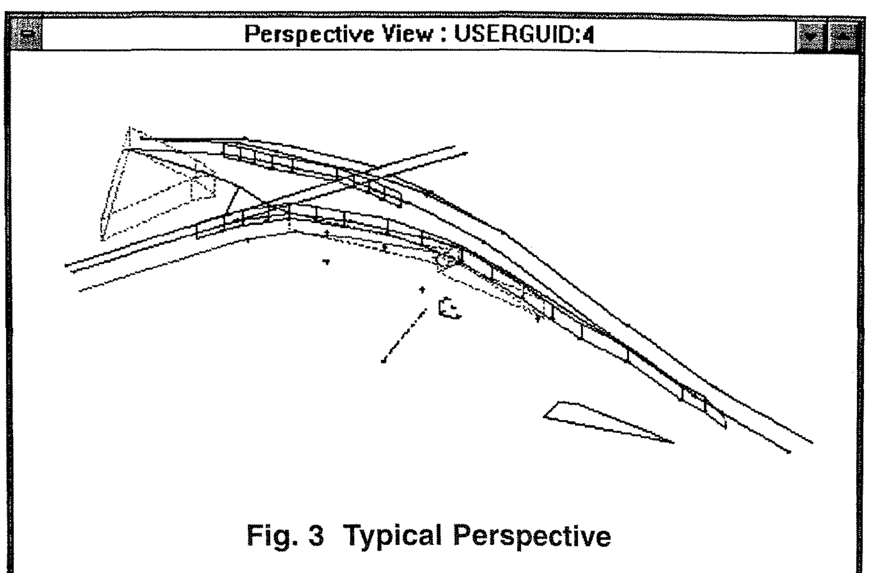


Fig. 3 Typical Perspective

Barrier Input : USERGUID:5

Name: Main barrier | Pert. Increment (m): 0.50 | #Pert. Up: 8 | #Pert Dn: 4

Barrier Type: Wall | Height (m): 4.00 | Min. Height (m): 0.00 | Max. Height (m): 8.00

Exit | Apply | New | Delete

	Pnt. Name	Pnt. No.	X [m]	Y [m]	Z [bottom] [m]	Height [m]	Increment	#Up	#Dn
1	point34	34	39.7	-14.5	55.00	7.00	0.50	1	7
2	point35	35	45.1	-2.4	55.00	7.00	0.50	1	7
3	point36	36	49.0	6.6	55.00	7.00	0.50	1	7
4	point37	37	56.2	14.4	55.00	7.00	0.50	1	7
5	point38	38	62.2	21.2	55.00	7.00	0.50	1	7
6	point39	39	73.0	25.5	54.00	7.00	0.50	1	7
7	point40	40	83.3	28.8	53.00	7.00	0.50	1	7

General | More | Structure | Reflections | Notes

Fig. 4 Portion of Input Spreadsheet

Vehicle noise emissions. As sources of noise, TNM includes 1994-1995 noise emissions for the following cruise-throttle vehicle types:

- automobiles
- medium trucks
- heavy trucks
- buses
- motorcycles.

Noise emissions consist of A-weighted sound levels, one-third-octave-band spectra, and subsource-height strengths for three pavement types:

- dense-graded asphaltic concrete (DGAC)
- Portland cement concrete (PCC)
- open-graded asphaltic concrete (OGAC).

In addition, TNM includes noise emissions for vehicles on upgrades and vehicles accelerating away from traffic-control devices:

- stop signs
- toll booths
- traffic signals
- on ramp startpoints.

TNM combines these noise emissions with its internal speed computations to account for the full effect (noise emissions plus speed) of roadway grades and traffic-control devices.

TNM also allows user-defined vehicles. For each, the user must enter three measured parameters for A-level emissions as a function of speed (cruise throttle, average pavement). A companion article in this issue of the Wall Journal provides further detail about TNM noise emissions.

To document input, TNM plots its input graphics and the following input tables: roadways, traffic for TNM vehicles, traffic for user-defined vehicles, receivers, barriers, building rows, terrain lines, ground zones, tree zones, contour zones, receiver adjustment factors,- structure barriers, and barriers with important reflections.

Calculation and sound propagation. TNM propagates sound energy, in one-third-octave bands, between roadways and receivers. Sound propagation takes the following factors into account:

- divergence
- atmospheric absorption
- intervening ground: its acoustical characteristics and its topography

(continued next page)

HMMH Inc. | 18 March 1996
Grant S. Anderson | TNM Beta 1.0

RESULTS: SOUND LEVELS
PROJECT: FHWA
RUN: G:\PROJECTS\292760\D_DEVLMT\USERSMAN\TNM_RUNS\TRB_DEM
BARRIER DESIGN: INPUT HEIGHTS
ATMOSPHERICS: 20 deg C, 70% RH

Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.

Receiver												
Name	No.	#DUs	Existing	No Barrier					With Barrier			
			LAeq1h	LAeq1h		Increase over existing		Type	Calculated	Noise Reduction		
				Calculated	Crit'n	Calculated	Crit'n Sub'l Inc	Impact	LAeq1h	Calculated	Goal	Calculated minus Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
Receiver20	20	3	55.0	66.5	66	11.5	10	Both	51.0	15.5	8	7.5

Dwelling Units	# DUs	Noise Reduction		
		Min	Avg	Max
		dB	dB	dB
All Selected	3	15.5	15.5	15.5
All Impacted	3	15.5	15.5	15.5
All that meet NR Goal	3	15.5	15.5	15.5

Fig. 5 Results Table: Sound Levels

(continued from page 15)

- intervening barriers: walls, berms, and their combination -- including multiple barriers in sequence
- intervening rows of buildings
- intervening areas of dense trees and undergrowth.

TNM computes the effect of intervening ground (defined by its type, or optionally by its flow resistivity) with theory-based acoustics that have been calibrated against field measurements. In addition, TNM allows sound to propagate underneath selected intervening roadways and barriers, rather than being shielded by them. TNM also computes single reflections from vertical wall barriers, with user-chosen Noise Reduction Coefficients.

Barrier design. During calculation, TNM perturbs intervening barriers up and down from their input height, to calculate simultaneously for many possible heights. Then during barrier design of selected barriers, combined with selected receivers, TNM dynamically displays sound-level results for any combination of height perturbations as the user increments barrier-segment heights up and down.

TNM also contains an input-height check, to determine if noise barriers break the lines-of-sight between sources and receivers.

Results. TNM produces the following results tables: sound levels, diagnosis by barrier segment, diagnosis by vehicle type, barrier descriptions (including cost/benefit information), and barrier segment descriptions.

Figures 5 through 7 show portions of these three tables. Each of these tables is dynamically linked to TNM's barrier-design perspective, so that tabulated results change dynamically as the user increments barrier-segment heights up and down.

TNM computes three measures of highway traffic noise:

- L_{Aeq1h}: hourly A-weighted equivalent sound level
- L_{dn}: day-night average sound level
- L_{den}: Community Noise Exposure Level, where "den" stands for day/evening/night.

TNM computes these three noise measures at user-defined receiver locations.

HMMH Inc. — **18 March 1996**
Grant S. Anderson — **TNM Beta 1.0**

RESULTS: BARRIER DESCRIPTIONS
PROJECT: **FHWA**
RUN: **G:\PROJECTS\292760\D_DEVLMT\USERSMAN\TNM_RUNS\TRB_DEMO**
BARRIER DESIGN: **INPUT HEIGHTS**

Barriers										
Name	Type	Heights along Barrier			Length	If Wall	If Berm			Cost
		Min	Avg	Max		Area	Volume	Top Width	Run:Rise	
		m	m	m	m	sq m	cu m	m	m:m	$
Barrier2	W	6.00	6.00	6.00	353	2116				430300
									Total Cost	430300

Fig. 6 Results Table: Barrier Descriptions

HMMH Inc. — **18 March 1996**
Grant S. Anderson — **TNM Beta 1.0**

RESULTS: BARRIER-SEGMENT DESCRIPTIONS
PROJECT: **FHWA**
RUN: **G:\PROJECTS\292760\D_DEVLMT\USERSMAN\TNM_RUNS\TRB_DE**
BARRIER DESIGN: **INPUT HEIGHTS**

Barriers		Segments										
Name	Type	Name	No.	Heights			Length	If Wall			If Berm	Cost
				First Point	Average	Second Point		Area	On Struc?	Important Reflections?	Volume	
				m	m	m	m	sq m			cu m	$
Barrier2	W	point5	1	6.00	6.00	6.00	19	116				23600
		point11	2	6.00	6.00	6.00	19	116				23600
		point6	3	6.00	6.00	6.00	45	268				54400
		point12	4	6.00	6.00	6.00	45	267				54300
		point7	5	6.00	6.00	6.00	44	265				53900
		point13	6	6.00	6.00	6.00	44	264				53800
		point8	7	6.00	6.00	6.00	52	314				63900
		point14	8	6.00	6.00	6.00	52	314				63800
		point9	9	6.00	6.00	6.00	16	96				19500
		point15	10	6.00	6.00	6.00	16	96				19500

Fig. 7 Results Table: Barrier-Segment Descriptions

In addition, it computes three types of contours:

- sound-level contours
- insertion-loss contours for noise barriers
- level-difference contours between any two noise-barrier designs.

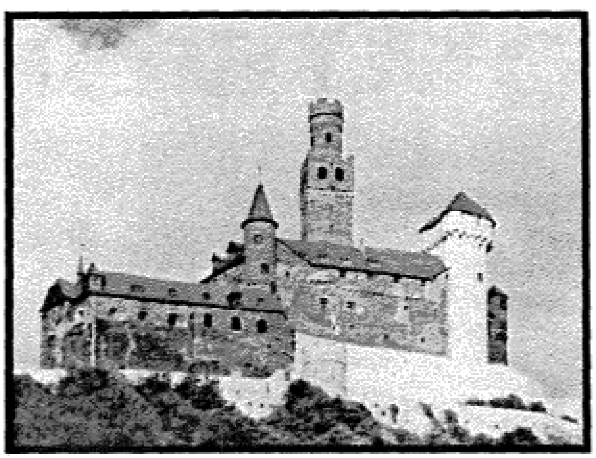
Parallel-barrier degradation. For selected cross sections, TNM also computes the effect of multiple reflections between parallel barriers or retaining walls that flank a roadway. The resulting parallel-barrier degradations can be entered as adjustment factors for individual receivers in TNM's full set of calculations.

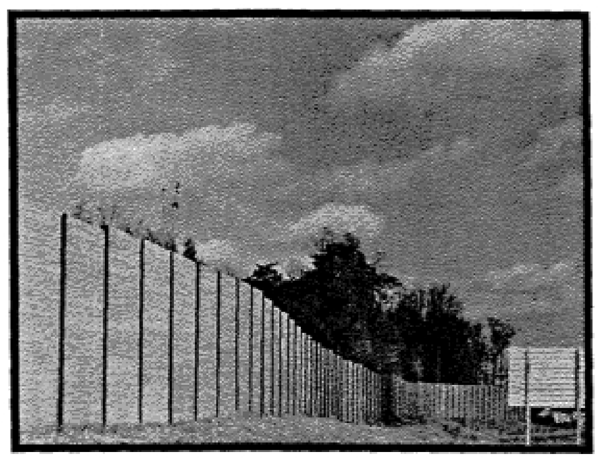
To document parallel-barrier input and results, TNM produces the following parallel-barrier tables: roadways for TNM vehicles, roadways for user-defined vehicles, cross section, and analysis locations (including results). ■

Note: For those of you who would like some extremely detailed information on the development of the reference energy mean emission levels used in the TNM, a 428-page document has recently been made available through the National Technical Information Service, Springfield, VA 22161. The agency report number is FHWA-PD-96-008.

The title of the report is:
Development of National Reference Energy Mean Emission Levels for the FHWA Traffic Noise Model (FHWA TNM®), Version 1.0

If you need assistance in ordering this document, please contact Cynthia Lee at the Volpe Center, telephone 617 494-2372 or fax 617 494-2497.





Absorptive vs. Reflective Costs of Noise Barriers
A Tempest in a Teapot
By Boone Bucher

Op/Com

What is the additional cost of a sound absorptive barrier versus a reflective barrier? That is the question!

The answer is NONE, to NOMINAL.

Our absorptive material, SoundTrap®, is a highly sound absorptive intercellular structured cementitious product that costs between $1.25 and $1.50/$ft^2$ when integrated with the wall structure. The cost to gain absorptive qualities is at most, nominal.

There, the lid is off the teapot.

Furthermore, if an efficient precast wall design is used that eliminates steel posts, the cost can actually be the same or at least extremely competitive to the basic reflective wall.

Absorptive walls have been delivered to the installation site for under $8./ ft^2 to over $28/$ft^2$. These prices are based on design, ultimate height (as high as 35 feet), geographical location, soil conditions, varied wall lengths and a multitude of other criteria that are unique to each project. Generalizing on price/ft^2 of a barrier can be very misleading, as the installation can become quite costly, (or perhaps that's where all the margin is for the contractor).

Nevertheless, there was a project recently won by a CSI licensee using the SoundTrap material for in excess of 250,000 ft^2 at under $8/$ft^2$. There is another relatively smaller SoundTrap project that falls more under the architectural category priced under $14/$ft^2$. Conversely, we are aware of reflective walls that the Department of Transportation recently paid $32/$ft^2$.

Sound absorptive barriers are available at a reasonable cost and it is our experience that there is NOT a heavy premium associated with the cost to provide the elimination of sound reflection, thereby providing the most efficient use of taxpayers dollars.

O. Boone Bucher
Concrete Solutions, Inc.
Licensor of SoundTrap®
Austin, Texas
Phone: 512 327-8481
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More commentary on the high NRC

By Richard J. Peppin

March 19, 1996

Editor
The Wall Journal

Mr. McNair is right. The ASTM C423 test method is not for barriers. But neither is ASTM C384 or one Mr. McNair forgot, ASTM E1050.

He's right because the high sound absorption coefficient (SAC) is not only a function of the "surface sound" but also because the diffraction around the specimen edges, coupled with an increase in unaccounted for specimen area due to finite thickness, contributes most to a high SAC. The NRC >1.0 is just a consequence of this.

But there is no evidence showing highway barriers are subject to known amounts of diffuse- or normal-incidence sounds. In fact, intuition suggests neither. Moreover, the above tests do not simulate insitu tests for ceiling tiles, functional absorbers, anechoic wedges or almost anything else.

The result? Take all sound absorption data with a grain of salt. As an assessor for NIST's NVLAP*, I have seen lab data that are impossible and manipulated to get high results. This, coupled with the non correlation between lab and field situations, makes any chance of accurate use of data slim to none.

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Rockville, Maryland
Phone: 301 770-3863
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*NIST (National Institute for Standards and Technology)
NVLAP (National Voluntary Laboratory Accreditation Program)

Another Response to "To Absorb or not to Absorb"

By Edward P. McNair

In his opinion article, "To Absorb or Not to Absorb", Rudy Hendriks states that "The widely accepted threshold of human perception of change of traffic noise is 3dB". Actually 3dB was a figure that was determined by a committee; specifically, the Operating Subcommittee on Roadway Design in a 1974 American Association of State Highway Transportation Officials (AASHTO) publication. Because it was determined by a committee doesn't mean that the 3dB figure isn't reasonable; just that it isn't infallible.

Rudy states that at a sufficient distance, the single reflection from a reflective noise barrier across a highway will cause the total noise to be 3dB higher than the direct noise by itself (if the barrier is large enough). The same thing is true with parallel barriers; that is, the single reflection from the far barrier will add 3dB to the noise level at a sufficient distance from the highway. Parallel barriers are built where noise sensitive areas exist on both sides of the highway, so single reflections can cause a 3dB degradation in parts of both noise sensitive areas. This won't justify an additional expenditure if the absolute noise levels at those distances are below the established criteria, but it may be a source of public criticism about the parallel barrier performance.

Another opinion of 3dB was given by an official of the Port Authority of New York and New Jersey in an October 9, 1994 article on air traffic noise in the Newark Star Ledger. He referred to 3dB as the "flashpoint" because the Authority found that many people in New Jersey had complained about changes of that magnitude.

Rudy points out that 3dB represents doubling the sound energy, the maximum increase from a single reflection. Decibels are actually common logarithms so the statement, that the combination of two noises cannot be more than 3dB higher (double) the greater noise, is a mathematical fact, not acoustical theory. Although Rudy has concluded that cases where total noise (i.e. barrier insertion loss degradation, or BILD) increases up to 5dB are fairly rare, a correlation of that mathematical fact is that whenever BILD is greater than 3dB, then the reflected noise is louder than the direct noise.

Edward P. McNair
59 Chimney Ridge Drive
Morristown, NJ 07960

The Real Problem with NRC

By David A. Collings PE

Op/Com

Mr. McNair's opinion in the Jan/Feb issue regarding the correct standard for sound absorption rating deserves some comment. While I agree with his conclusion that simply measuring normal incidence absorption in an impedance tube (ASTM C 384 method) is good enough to establish the properties of an absorptive barrier, I disagree with some of his logic. In the first place, ground waves are the result of reflections and wave interference and are not really relevant to the issue of absorption. It is true that diffraction effects account in part for the high coefficients measured in a reverberant test chamber, but specimen mounting and edge effects are often significant and can result in misleading results for some types of absorptive panels.

The quote from ASTM standard C 384 that "normal sound absorption coefficients are more useful than random incidence coefficients..." should have been followed by the words "....in certain situations". The example given is for sound absorbing material in a small enclosed space such as inside a machine. Not exactly applicable here!

Nevertheless, for comparing sound absorbing barriers, the important measure of performance should relate to the absorption of the direct sound field since the conditions are a long way from those of a reverberant chamber. An impedance tube measurement of normal incidence sound absorption is quite appropriate in this case but the test limitations should be understood. The upper frequency for this method is determined by the diameter of the tube (A 3 inch diameter tube has an upper limit of approximately 2,500 Hz). Larger specimens are limited to proportionally lower frequencies. Absorption coefficients are reported at each of the measured frequencies and a single number rating is not normally reported under this procedure.

In my opinion, the use of a single number rating such as NRC that averages sound absorption coefficients over a range of frequencies has never been appropriate to this application. Barriers are less effective at low frequencies and any further degradation due to reflection of low frequency noise from parallel walls or buildings can be critical. The specification of realistic normal incidence sound absorption coefficients at frequencies of say 125, 250, 500 and 1,000 Hz seems to be entirely appropriate for absorptive barriers and would remove much of the confusion that presently surrounds the use of a single number rating.

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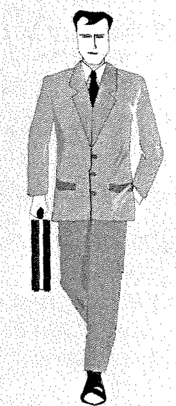

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