The Wall Journal™ 11

The International Journal of Transportation–Related Environmental Issues

January/February 1994

Milwaukee's I-94 Retrofit — 3,200 Feet of Parallel Sound-Absorptive Noise Barriers *(story on page 6)*

Also In This Issue:

The Wall Journal

The International Journal of Transportation-Related Environmental Issues

Volume Three, Number 11
January/February, 1994

The Wall Journal is published six times a year. Issues are mailed bi-monthly on or about the middle of the first month in the two-month issue date.

The Wall Journal is a publication of AcoustiCom Publishing Corporation. Editorial, subscription and advertising offices are located at 3011 Voyage Drive, Stafford, Virginia 22554. Tel: 703 720-0282, FAX: 703 720-0598.

Submissions of papers, articles, letters, and photographs for publication should be addressed to The Wall Journal, P.O. Box 1286, Stafford, VA 22555-1286.

Editor
El Angove

Director of Publications
John G. Piper

All material submitted becomes the property of The Wall Journal, and may be edited for length, clarity and accuracy. Material will not be returned without special arrangements prior to submission. The Wall Journal will not be responsible for lost or damaged materials.

Published articles, comments, letters, papers and advertisements do not necessarily represent the views and/or endorsements of The Wall Journal. The authors of submitted material are solely responsible for the truth and accuracy of their submissions, and The Wall Journal cannot be held liable for any damages suffered by our readers as a result of their use of published material.

Circulation is made to government agencies, consulting engineers, scientists, universities, contractors, vendors and others with an interest in transportation-related environmental issues.

Subscription and advertising information are shown on the back cover page.

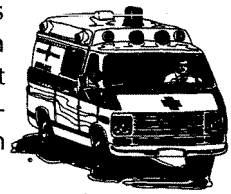
* * * * *

The Wall Journal is composed in its entirety on Apple Macintosh computers using QuarkXPress electronic publishing software.

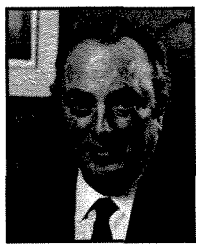
Printed in the U.S.A.

EDITOR'S CORNER by El Angove

The fat little gentleman at the left wasn't very good to me this past Christmas. I had been hoping for a new, faster Macintosh to go with my new scanner and laser printer. Instead of a Mac, I got a shiny new ambulance delivered to my door a few days before Christmas, a fast ride to Mary Washington Hospital in Fredericksburg, and a triple by-pass operation. It was bad enough spending the holidays in the hospital, but getting home to recuperate in the coldest and iciest January in many a year was the absolute pits. Christmas! Bah! Humbug!



I would not trouble you with this story, except that it is the reason this issue is a little slow in reaching you. My creative juices froze up in the cold weather, and I simply couldn't seem to get going in putting this issue together, what with all the dreary cold weather here in the Washington, D.C. area, and with my friends in Fort Myers, Orlando and Clearwater calling me up to tell me, "it was 76 degrees today and we went sailing", or "it's been in the 70's all week down here; last week, we had to turn on the air conditioner (ha,ha)".



Enough! Enough! There are two things I wish to tell our readers. The first is that we will get back on scheduled issues as quickly as possible. The second is that I am positively going to move my home and office to Florida (probably on the Gulf Coast side), so that next year I can call my family and friends in the northern regions and say to them, "I see on television that you have two feet of snow on the ground, it's below zero, and you have more on the way. Too bad. It was 78 degrees here yesterday. Eat your heart out".

The Wall Journal, being of a desktop publishing nature, can be composed anywhere in the world. In an office, on a boat, in an airplane, in bed, anywhere. Then, why in the world, at my advanced age, am I sitting and shivering in the cold, snow and ice, trying to type and think with numb fingers and brain?

I should be sitting under a palm tree, in my shorts, clutching a mai tai in my left hand, pecking on my keyboard with one finger of my right hand, a large panama hat on my head, watching the ladies on the beach, and enjoying my work. My mama didn't raise no fool.

Watch this space. Sooner than you may imagine, the world headquarters of The Wall Journal will be in the Sunbelt. As they say in Florida, "Come on Down".

In Coming Issue:

The Fundamentals of Sound — Part IV

A Report on the Active Noise Control Demonstration on a Highway in California

The July 1994 Earthquakes in Los Angeles, and What They Did to Some Noise Barriers

Update on New FHWA Model — Part III

Caltrans' Simi Wetlands Replacement Exceeds Design Expectations

And More ...

LETTERS TO THE EDITOR

Dear Sir:

As I read the November/December 1993 issue of The Wall Journal and the previous issues, I thought about the valuable information service and voice you are providing readers with an interest in transportation-related environmental issues. The Wall Journal is the only publication of its kind that I know of, and I usually read it cover to cover soon after it arrives.

Serving as Chair of Transportation Research Board Section F - Environmental Concerns, I am very grateful for your coverage on transportation-related environmental research, particularly your series of articles summarizing the professional papers from the TRB A1F04 Committee Summer Meeting held last July.

I applaud you and your contributors' efforts in publishing a fine journal and I look forward to future issues.

Sincerely,
Wayne W. Kober, Director
Bureau of Environmental Quality
Commonwealth of Pennsylvania
Department of Transportation

(Ed: Thanks very much for your kind words, Mr. Kober. I don't receive much feedback from our readers, and sometimes wonder if all this work is worth it. Your letter has given me a boost for the new year, and I will try to keep improving and expanding The Journal).

PRESS RELEASE

January 26, 1994

Oldcastle Precast Group announced today an agreement reached with Pickett Wall Systems for a national license to market and manufacture the Monowall Noise Barrier system. With 30 manufacturing plants located throughout the continental U.S., the Oldcastle Precast Group is uniquely positioned to service most of the country's major markets, creating a single reliable source for the control of radiated energy, noise, light and radio frequency interference. Oldcastle's long history of service in the construction products industry means that, regardless of location, consistent, high quality products may be specified and purchased with confidence.

Monowall is a patented system invented by Bill Pickett, who was also responsible for the design of the Fanwall noise barrier system. The Monowall design provides for several features and benefits which are not possible with other precast, built-in-place or alternative wall systems. The post, panel and unique rotatable panel joint are integrated into one monolithic panel. These innovations allow for significant production, site preparation and installation savings as well as providing for an aesthetically superior finished product. These savings result in lower installed wall costs overall.

The innovative features of the Monowall system combined with the resources of the Oldcastle network and Mr. Pickett's experience in the noise barrier field offers an exciting new solution to transportation-related noise. For further information, call or write George Heusel at:

Oldcastle
P.O. Box 1200
Tucker, GA 30085
Tel 404 493-5430

ANNOUNCEMENT

The Subcommittee on Research of TRB Committee A1F02, Environmental Analysis in Transportation, is coordinating an update of TRB Circular 389, Transportation Environmental Research Needs, to be published in the fall of 1994. The subcommittee will be working with over 30 TRB Committees, the State Departments of Transportation, and other organizations to update the collection of research problem statements in Circular 389. The research problem statements in 14 topic areas contained in Circular 389 were generated at the National Conference on Transportation Environmental Needs in Denver, Colorado in November 1991. Circular 389 has proven to be a valuable source of problem statements on needed transportation environmental research. Several research projects being funded by FHWA and NCHRP originated from Circular 389 problem statements.

If you wish to participate in this important effort, please contact Mr. Andras C. Fekete, Chair of the Subcommittee on Research, at New Jersey Department of Transportation, telephone 609 530-2824.

Wisconsin DOT's Entry Into the World of Parallel Noise Barriers

By John Jaeckel

The Wisconsin Department of Transportation (WisDOT) recently constructed over 3,200 feet of parallel noise barriers on the southeast side of Milwaukee, parallel to IH-94 and immediately north of the Airport Spur Freeway. This was the first use of two tone Durisol absorptive noise barrier panels with an ashlar stone relief pattern.

WisDOT constructed their first four noise barriers in 1976 in the Milwaukee metropolitan area as part of the construction of an interchange with IH-94 and the new Airport Spur Freeway (STH-119) to General Mitchell International Airport. From 1984 through 1988, seven additional noise barrier segments were built along the interstate in the Milwaukee metropolitan area. These seven noise barriers were authorized by legislative mandate in the State's budget bills.

With this increase in noise barrier construction came the realization that a systematic approach was needed to determine future noise barrier construction. In 1987, the State Legislature required WisDOT to develop criteria and procedures for siting noise barriers that resulted in the preparation of Administrative Rule, TRANS 405. WisDOT's recommended criteria and procedures were approved by the state Legislature and became effective on September 1, 1989.

WisDOT and its consultant, Howard Needles Tammen & Bergendoff (HNTB) then embarked on a retrofit noise barrier study of 135 miles of freeways in 28 Wisconsin municipalities. This study identified 209 locations, with 3,042 residences, exposed to noise levels at or above 67 dBA L_{eq}. Of the 209 locations, 51 were in the four county Milwaukee Metropolitan area and met the three requirements of TRANS 405:

- An abutting residence must be at or above 67 dBA $L_{eq}(h)$
- Noise barriers shall reduce noise levels by a minimum of 8 decibels at abutting residence
- The WisDOT share of the total cost for a noise barrier may not exceed $30,000 per abutting residence

Upon completion of the retrofit noise barrier study, the cities of Glendale, Milwaukee, and West Allis requested that WisDOT begin scheduling the public involvement, design, and construction of all noise barriers in their communities that did not require any local cost participation. The two barriers designed by HNTB ranked seventh and eighth statewide and became first and second in the city of Milwaukee after two higher ranked noise barriers failed to receive the necessary local support to continue with final design.

The barriers, located on the southeast side of Milwaukee, parallel IH-94 and are immediately north of the Airport Spur Freeway. The residences west of the freeway are primarily single-story, single-family homes. Residences along the southern half of the north bound lanes are single-family with a mix of tri-level- and two story homes. The next quarter was vacant. However, by completion of the noise barrier, four or five new single-family residences were built. The last quarter of the noise barrier provides attenuation for a multi-story apartment complex, a community playground, and a few single-family homes.

On the east side of IH-94, near the barrier's center, the residences backyards are 10 feet below the freeway elevation. West of IH-94, the backyards are almost level with the freeway. West of the first row of homes the terrain rises to 14 feet above pavement elevation.

The eight-lane IH-94 carries over 130,000 vehicles per day with heavy truck percentages ranging from 10 to 30 percent, depending on the day of the week. The freeway carries travellers to the CBD, the northern and western suburbs and serves as a major tourist route through Milwaukee as commerce and vacationers travel to Minnesota, the Upper Peninsula of Michigan, and Canada. Emphasizing the importance of this route, WisDOT's District 2 Environmental Design Supervisor, Mike Gonia, charged HNTB's architects with the responsibility to design aesthetically pleasing noise barriers that would present a gateway to the city, something new, but conservative in nature, matching the character of the residents in this area of Milwaukee.

The project would be the Department's second barrier constructed with Reinforced Earth Company's Durisol

As seen from the adjacent roadway, the natural earth-tone colors (not shown here) and texturing pattern blend with the surrounding vegetation and architecture.

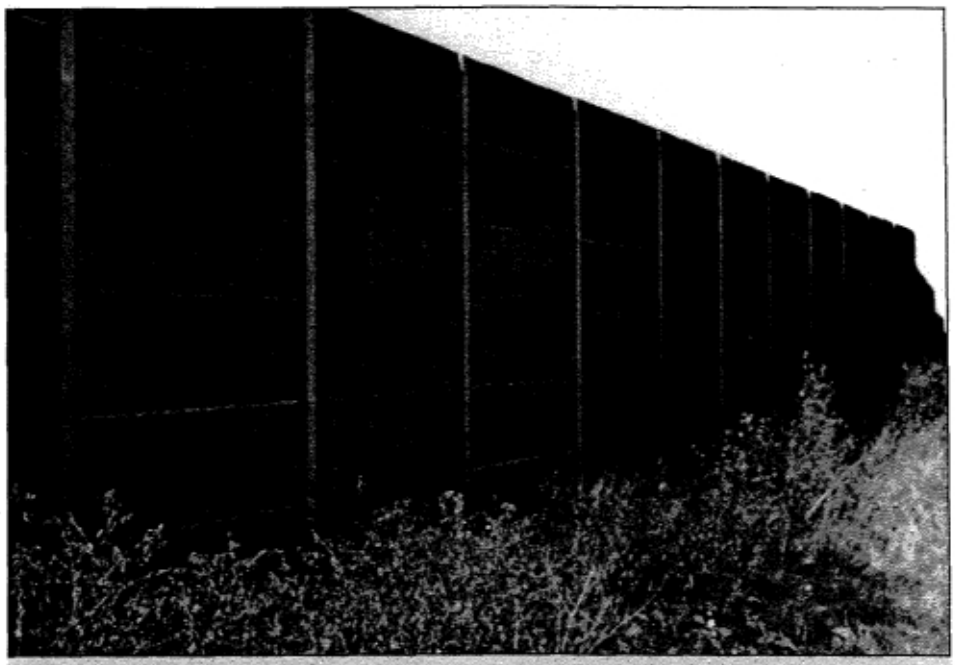
absorptive noise barrier panels, and the first project constructing noise barriers on both sides of the road.

Noise barriers were constructed on top of cut sections adjacent to the right-of-way, on fill sections set back six feet from safety barriers (this space being reserved for snow storage) and on a bridge. Slightly over 2,200-feet of the barrier was in a parallel section with a 140-foot separation. Noise barriers nearest the driving lanes included irregularly spaced planters. The planters were created by stepping the noise wall away from the freeway three feet for a distance of 30 feet. Although not yet implemented, the goal is to plant hardy vegetation in these planters to add live color to the wall.

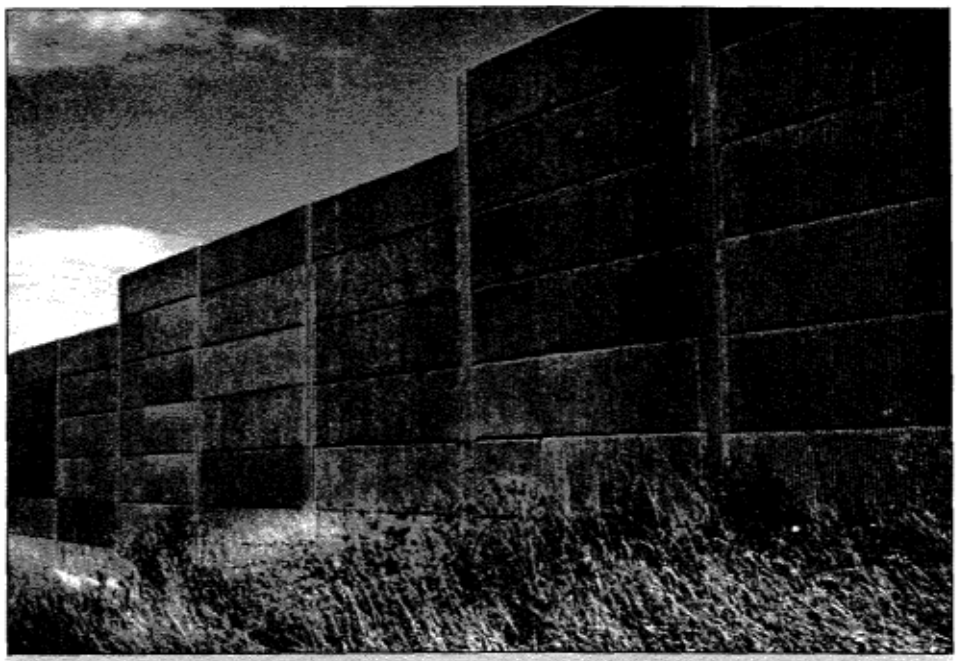
Public support for the proposed noise barriers was high. Residents looked forward to summer afternoons when they could reclaim their backyards from the din of highway noise. They also welcomed potential relief from road dirt, car and truck parts, and hoped that the noise barrier, made from concrete, would deter errant vehicles from paying visits to their yards.

The Durisol noise barrier panels are designed to span horizontally between vertical wide-flange steel posts. The ends of the panels fit between the flanges of the posts, and are wedged in place with preservative-treated wood shims. The ground-mounted steel posts are embedded in three-foot-diameter augered holes filled with concrete. The foundation depths are nominally 10 feet, and each concrete foundation is strengthened with a cage of reinforcing steel bars.

The steel posts are also attached to the sides of the concrete deck and parapet of two bridges. HNTB performed a structural evaluation of the IH-94 bridges to determine if the they could withstand the additional weight of the noise barrier and additional bending forces caused by wind loading. The wind loading pressure was 37.5 pounds per square foot, based on a wind velocity of 85 miles per hour, and appropriate design equations for structure mounted noise barriers. Anchorage details at the bottom of the posts included welded plates and stiffeners to suit the bridge geometry. Holes were drilled in the concrete for one-inch-diameter stainless steel anchor bolts, using four bolts per attachment. Adhesive anchor assemblies consisting of high-strength resins were used to chemically bond the anchor bolts in the drilled holes.



The darker colored cap and vertical sections of the panels serve to reduce the viewer's perception of the wall's height and length.



Spacing of the smooth-textured columns were coordinated with wall grade changes. Panel joints were aligned horizontally to create a neat and flowing appearance to the highway travelers and to the residential community.

The double-sided Durisol noise barrier panels specified for this project were a slight departure from the normal panels produced by Reinforced Earth. HNTB's team of architectural designers worked in conjunction with Reinforced

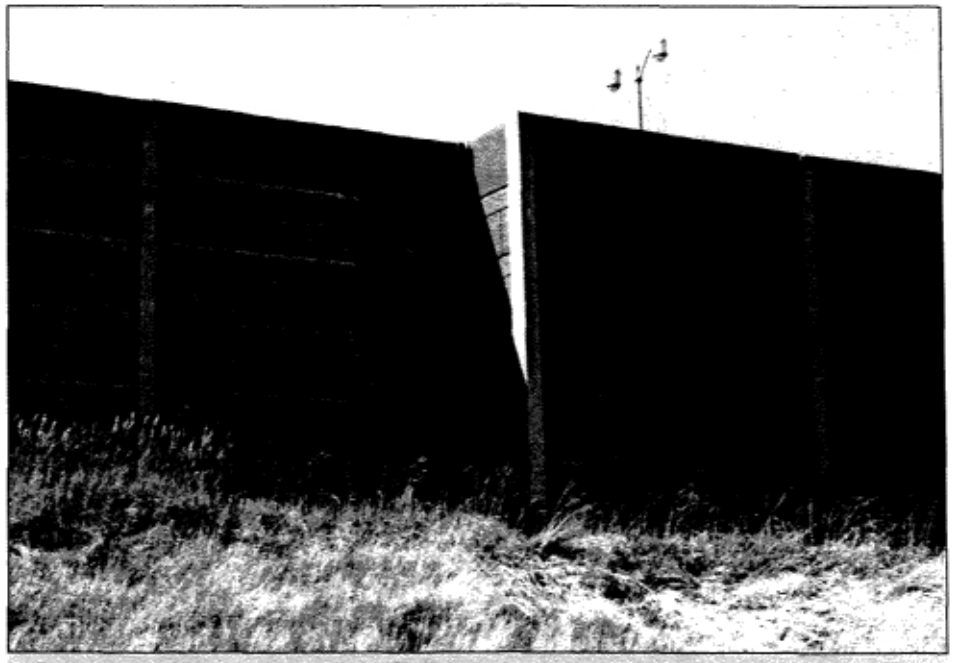
Earth to study a variety of aesthetic treatments to develop a pleasing design which fully utilized the texture choices available with Durisol panels.

The design team's goal was to enhance the traditional elements of a wall (column, cap, and field) through the use of contrasting colors and textures. The design selected for the highwayside of the wall consists of a simple, but handsome, combination of light brown fluted texture fields edged by smooth textured grey-brown cap and column panels. The large field areas of fluted texturing provide the maximum sound absorption while the smooth grey-brown column and cap create an attractive, but non-distracting, pattern to be viewed by the drivers moving at highway speeds.

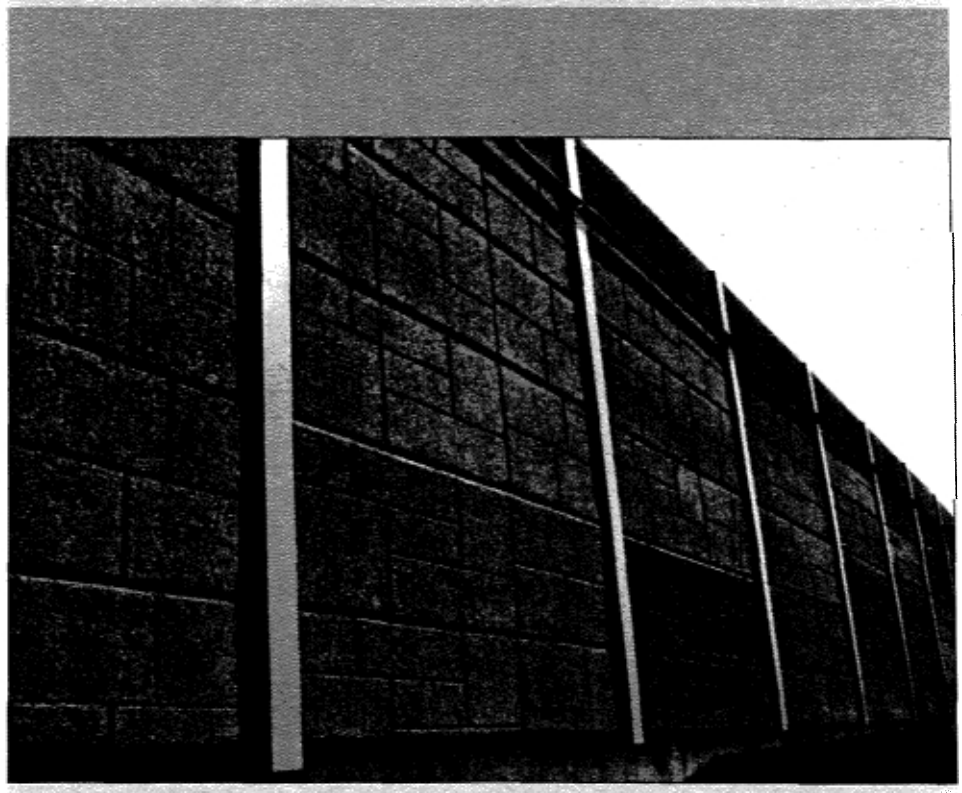
The dark-color cap de-emphasized the height of the 18- to 21-foot noise walls. The smooth texture grey- brown columns occur every 45 feet to break up the linearity of the 2,500-foot-long noise barrier and provide transition points for wall grade changes to occur.

Because the residential side of the wall is viewed from a fixed position, HNTB chose an intense textural pattern to make it more aesthetically pleasing to the residents. The residential side of the panels utilize the same colors in the same proportions. However, the fluted surface was replaced with an ashlar stone pattern pressed into the flat Durisol. The ashlar stone pattern was created with 3/4-inch steel chamfers welded to a steel platen. The double sided panels were then placed in a hydraulic press with the steel platen forming the back face of the panels.

The design of the panels, with a mixture of fluted and flat textures, allows the color shading of the wall to change as the angle of the sun changes. In the morning, the west wall will be bright while the east wall will appear darker to the drivers. The many shadows created by the fluting causes the wall to change color as the drivers pass the panels. On the residential side, shadows created by the stone patterns allow the wall to vary in color as the angle of the sun's rays meeting the surface changes. When it rains, the wall portrays a much darker, richer looking surface. The panels are chameleon in nature providing many different shades of earth tone colors as the angle of the sun changes from sunrise to sunset, winter to summer.

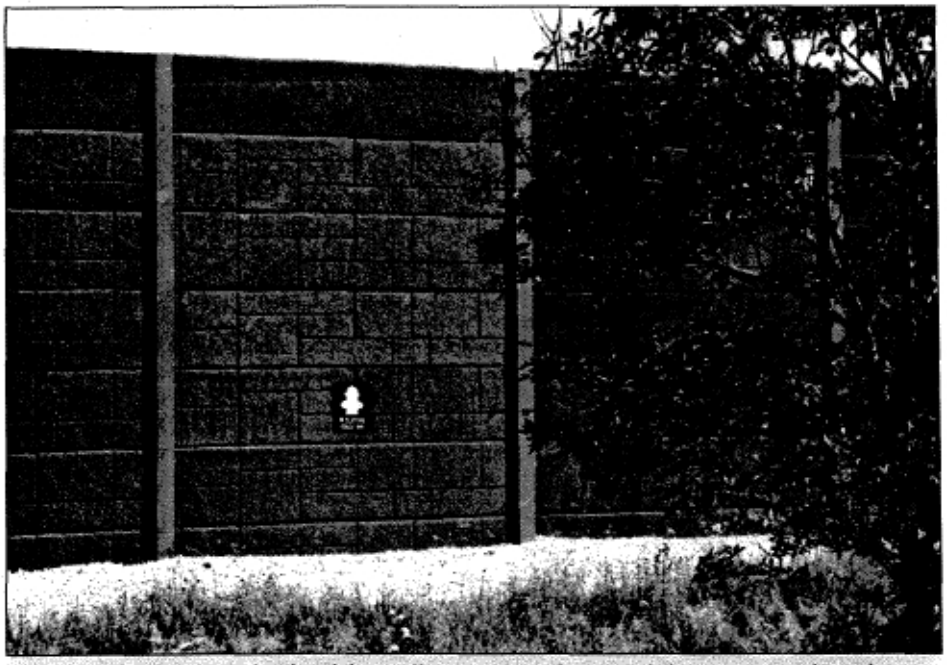


In locations where both sides of the wall directly abut the roadway shoulder, 3' x 30' planting pockets were designed to minimize the potential for drivers to reduce speed.

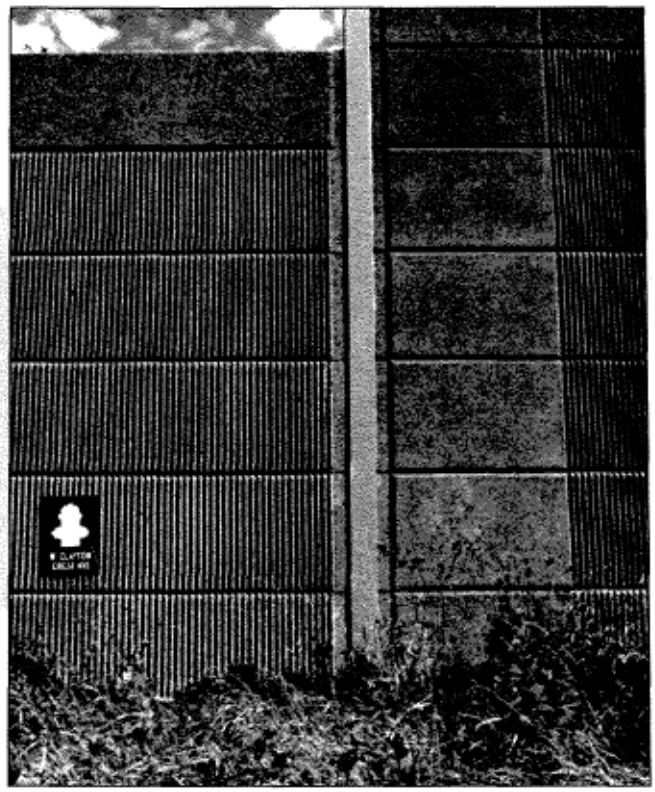


Steel posts are attached to the sides of the concrete deck and parapet of two bridges. Extra care was taken to see that the anchorage details remained aesthetically pleasing while satisfying the structural engineering criteria.

The noise barriers were designed to provide 9 to 10 decibels of attenuation for the backyards of the first row of abutting residences and minimize the amount of reflection from the far barriers while designing for 6 to 7 decibels of attenuation for the second and third row receptors. Field measurements taken before and after construction indicated that the insertion loss for the first row of homes ranged from 8.5 to 12.5 decibels. Second and third row insertion losses ranged from 3 to 6.5 decibels. ■



For the residential side of the wall, HNTB's architectural design team selected light brown fields textured in a random ashlar pattern. This pattern echoes the stone masonry found in many of the traditional homes in the area.



The highway side of the wall consisted of light brown fields textured with darker brown, smooth-textured panels defining the wall cap and columns.

The plaques on the walls identify the locations of fire hose connections for firefighters responding to highway accidents.

Additional information regarding this project may be obtained from:
Michael P. Gonia, P.E., District Environmental Design Supervisor,
WisDOT, Transportation District 2,
141 N.W. Barstow Street, Waukesha, WI 53188-3789
(414) 548-5954, fax (414) 521-5357
or
John R. Jaeckel, P.E., Principal Engineer-Environmental Quality,
HNTB Corporation, 11270 West Park Place, Suite 500, Milwaukee, WI 53224,
(414) 359-2300, fax (414) 359-2310.

National Council of Acoustical Consultants

The National Council of Acoustical Consultants is a non-profit, voluntary organization dedicated to management and related concerns of professional acoustical consulting firms and to safeguarding the interests of the clients and publics which they serve. Established in 1962, NCAC now represents over 125 firms located in North America, Canada, Europe, Asia and Australia.

Service performed by acoustical consultants has become many and varied. Some provide comprehensive services in practically all areas of acoustics, while others restrict their services to certain specialized areas. It represents the bulk of the acoustical consulting business activity in North America, especially in the field of architectural, environmental and industrial acoustics. Generally, the services performed by acoustical consultants include: architectural acoustics, environmental impact assessment and community noise control, expert testimony, product development, industrial acoustics, testing and measurement, sound and vibration measurement, and acoustical training seminars and manuals.

General Membership Meetings are conducted at least once a year. Through workshops held at these meetings, members learn to deal effectively with situations facing today's acoustical consultant. Topics addressed in the past include expert witnessing, value-based compensation, seismic awareness, personnel issues, financial and business management, and time management. Attendance also gives the members an opportunity to exchange ideas with other consultants and gain new perspectives to help in everyday practice. More and more frequently, NCAC consultants undertake consulting assignments on a collaborative basis. The NCAC Newsletter, produced quarterly, provides NCAC members with news in the association and the acoustical profession.

For more information, a list of members, or application forms, please contact Executive Secretary Virginia Maguire, NCAC, 66 Morris Avenue, Suite 1A, Springfield NJ 07081-1409: tel 201 564-5859, fax 201 564-7480.

NCAC members' projects literally span the globe and are routinely recognized in national competitions for their excellence. NCAC strives to maintain the following purposes:

Establish and encourage adherence to the highest standards of professional ethics and business practices;

Inform the public of the existence of acoustical consultants and the service which they provide;

Provide members with a forum for discussion and exchange of information on matters of common interest;

Cooperate with representatives of other organizations on matters of mutual interest and concern;

Preserve and protect the public welfare by encouraging accurate and proven representations concerning acoustical products, materials and services;

Participate in the development of performance and measurement standards and regulations, and;

Encourage and promote continuing growth and education in the profession.

Honesty, justice and courtesy form the foundation for NCAC Canons of Ethics.

NOTICE

ACOUSTICAL ENGINEER with over 20 years of consulting experience in industrial, transportation, community and HVAC noise abatement seeks challenging position with consulting firm or engineering corporation. Also experienced in proposal writing, project management and marketing. Mechanical engineering background, MS in Acoustics, INCE Board Certified, registrations, languages, and overseas work experience. Willing to relocate. Please send responses to The Wall Journal, P.O. Box 1286, Stafford, VA 22555-1286, Attention: "Positions" for forwarding. ■

ATTENTION ENTREPRENEURS

Did You Know That...?

An article in the November issue of "Public Innovation Abroad" describes the use of photovoltaic solar cells with noise barriers along highways in Switzerland. It is expected that 8,800 modules will produce approximately 450,000 kwh annually to meet the electric power needs of approximately 360 homes.

Ease of installation, access, and maintenance, and short trouble-free connections to the power grid are seen as advantages of installing the cells on noise barriers along main highways.

(Contributed by Bob Armstrong, FHWA)

Carsonite International One of First to use Maryland SHA's Facility for Demonstration/Display of Vendor Noise Barriers

As announced in our last issue (in Ken Polcak's column Maryland Minutes), the Maryland State Highway Administration (SHA) has constructed a facility where manufacturers of highway noise barrier systems may furnish and install a demonstration sample of their system for evaluation by SHA.

One of the first vendors to make use of the facility was Carsonite International of Carson City, Nevada. The SHA facility features movable I-beam posts 16 feet high, which can be set on 8-, 12-, 16-, or 24-foot centers, thus accommodating one, two or three panels depending on their length. All costs involving panel fabrication, transportation, erection and removal are the responsibility of the vendor. The in-place time for each vendor is limited to two weeks. For further information, contact the MdSHA Office of Environmental Design, phone 410 333-8072 or fax 410 333-3139.

Carsonite International, for nearly two decades, has been one of the leading manufacturers of highway safety products. As a specialist in pultrusion technology, Carsonite supplies flexible composite guideposts and headlight glare screen to the highway industry. Development of the Carsonite Sound Barrier began in 1990, with the first submissions for approval to state Departments of Transportation taking place in 1992.

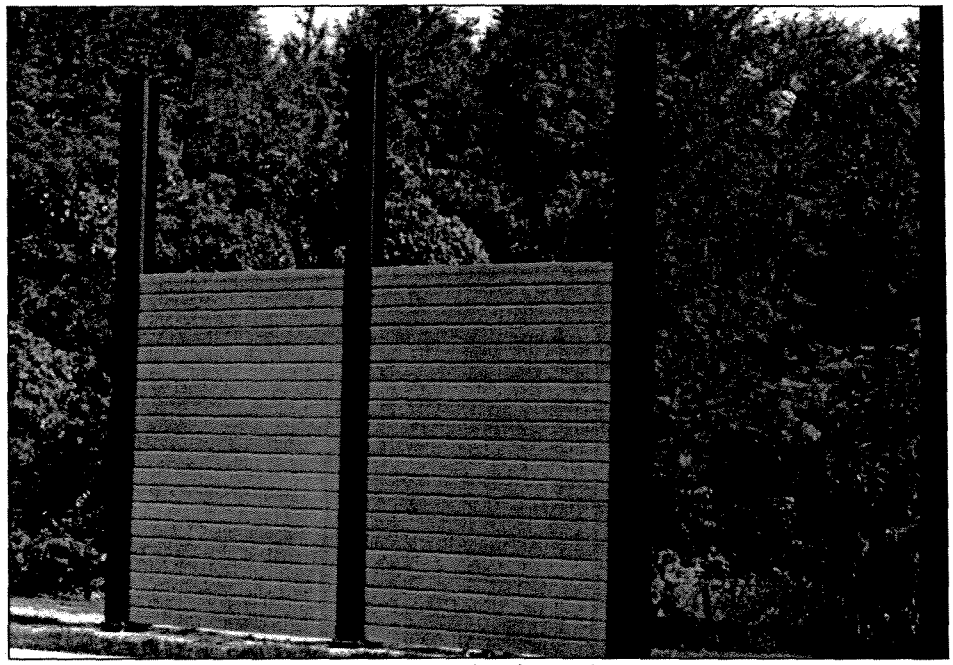
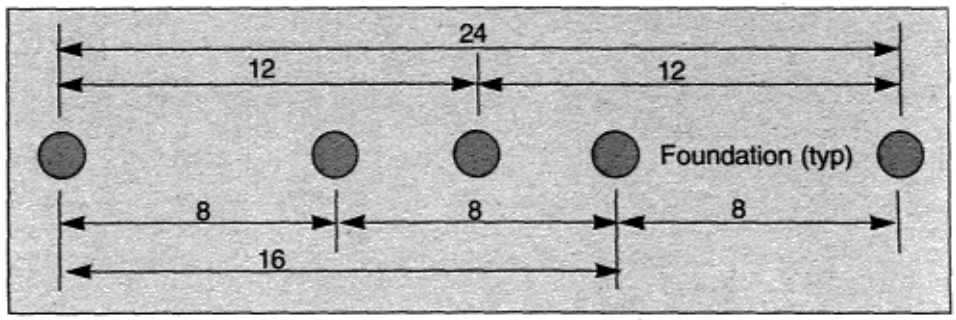


Photo of the Maryland SHA Demonstration/Display Facility, showing the pre-assembled Carsonite Sound Barrier panels installed in the I-beam posts. Locations of the poured concrete pile foundations for the posts are shown in the drawing below.



Close-up photo shows Carsonite panels installed between the flanges of the I-beam posts.

According to a spokesman for Carsonite, their sound barrier system offers an environmentally-friendly approach to noise abatement. Available in spans (widths) from two to ten feet, the barrier is fabricated with a shell of reinforced, composite channels. These channels surround an interior composed of post-consumer scrap plastics and rubber tire scrap. A 10-foot high wall of the Carsonite Sound Barrier can consume up to 250,000 pounds of scrap tires per barrier mile. The result is a functional noise barrier that is lightweight yet as effective at noise transmission reduction as concrete barriers. The Carsonite Barrier, when tested by Riverbank Acoustical Laboratories, registered a Sound Transmission Class (STC) of 36, and a Noise Reduction Coefficient (NRC) of 0.15. The pre-assembled, tongue-in-groove panels allow for a quick installation and are available in various color combinations and surface designs.

Installations of the Carsonite Sound Barrier have occurred in Salem, Oregon under the direction of the Oregon DOT. A contract for highway improvement in Las Vegas that includes the Carsonite Sound Barrier has been awarded by the Nevada DOT. Other state DOT approvals are pending. Too, the Carsonite barrier will be included in a project for AMTRAK in Boston.

As a final note, a modification to the Intermodal Surface Transportation Efficiency Act (ISTEA) has been proposed that would allow states to use rubber tire crumb in civil engineering projects and other traffic appurtenances. This modification would qualify the Carsonite Sound Barrier as a candidate for compliance with these requirements. ■

Highway Traffic Noise Analysis

The Federal Highway Administration (FHWA) has issued further guidance to assist State highway agencies in improving the highway traffic noise analysis process. The guidance addresses (1) the definition of "approach or exceed the noise abatement criteria (NAC)," used to identify traffic noise impacts; (2) appropriate speeds to be used in predicting traffic noise levels and assessing noise impacts; and (3) the noise insulation of private dwellings.

Section 772.5(g) of 23 CFR defines traffic noise impacts as those which occur when the predicted traffic noise levels approach or exceed the NAC or when they substantially exceed the existing noise levels. The regulations do not define "approach or exceed." Since the definition of traffic noise impact first appeared, most state highway agencies have chosen to define "approach or exceed" as "equal or exceed." FHWA has accepted this use of "equal" for "approach' but has continually encouraged the use of flexibility and judgment in identifying traffic noise impacts. However, in the future all state highway agencies must establish a definition of "approach" that is at least one dBA less than the NAC for use in identifying traffic noise impacts in traffic noise analysis.

Section 772.17(b) of 23 CFR states that traffic characteristics which will yield the worst hourly traffic noise impact on a regular basis for the design year shall be used to predict traffic noise levels and assess noise impacts. State agencies should use either the posted speed limit or the operating speed to predict traffic noise levels. The states are required to use the operating speed if it is determined to be consistently higher than the posted speed limit..

Private dwellings may only be noise-insulated under the provisions of Section 772.13(d) of 23 CFR — that is, when severe traffic noise impacts are anticipated and normal abatement measures are physically infeasible or economically unreasonable. In these instances, the Regional FHWA Administrator may approve a state's request for unusual or extraordinary abatement measures on a case-by-case basis.

When considering extraordinary abatement measures, the state agency must demonstrate that the affected activities experience traffic noise impacts to a far greater degree than other similar activities adjacent to highway facilities, i.e., residential areas with absolute noise levels of 75 dBA $L_{eq}(H)$ or more, and residential areas with noise level increases of 30 dBA or more over existing noise levels. ■

Sound Fundamentals
Part 3 — The Sound Path

Author:
Roger L. Wayson, Ph.D., P.E.
University of Central Florida

Presented by:
The A1F04 Institute On Noise ION

In our last installment, we talked about the source of sound and concentrated on transportation noise sources. After a sound is generated, any sound, certain physical phenomenon determine how it is transmitted, or propagated, from the source. Remember from our very first "class" we defined a propagating wave and discussed the basic concept of wavelength, frequency, and amplitude. In this "class" we will look into propagation of sound more deeply

We usually think of a sound as being transmitted through the air. However, sound may propagate through other media as well, and in certain instances, it may be these paths that are most important. In this discussion, we will concentrate on propagation in the outdoor air.

The use of the term propagation seems to imply that something is physically transferred from the source to a receiver location. As we all know, the air does not make this trip, rather air only acts as a medium to transfer energy in the form of small pressure fluctuations. So we must think of propagation of sound as energy propagation. Characterization of this energy transfer requires the use of analytic methods that have been based both upon theory and empirical determinations.

For surface transportation, there are two principal types of sound propagation: ground waves and sky waves. Ground waves travel along the surface of the ground and are affected by the ground interaction. Sky waves radiate upward and are unaffected by the ground. For aircraft, another type of propagation is possible, air-to-ground, and can be thought of conceptually in the same way as a sky wave.

The speed of sound is the rate that these pressure fluctuations travel. In air, at 20° Centigrade (68° Fahrenheit), sound travels approximately 344 meters-per-second (1127 feet-per-second). We have probably all used this fact before during a thunder storm. The flash from the lightning reaches us almost instantaneously but there is a delay before the thunder follows. Each count of five delay (i.e., about five seconds) tells us how many miles away the lightning was from us.

Temperature has a significant effect on the speed of sound. The speed of sound in air changes about 0.6 meters-per-second for each degree Centigrade change in temperature. As temperature increases, so does the speed of sound.

Another concept about propagation that should be understood is how waves are displayed graphically to portray concepts and ideas. As shown in Figure 1 for a single plane, waves radiate in all directions from a source. As the wave travels, it can be thought of as a wave front passing through space. The concept of the wave front is sometimes approximated by the use of ray tracing (see Figure 1). Rays are drawn using a vector concept to show the direction of travel of the wave front. The vector representing the sound path is perpendicular to the wave front and shown in the direction that the wave is propagating. It must always be remembered that use of the ray concept shows only the primary direction of the wave front and that energy is actually propagating in all directions.

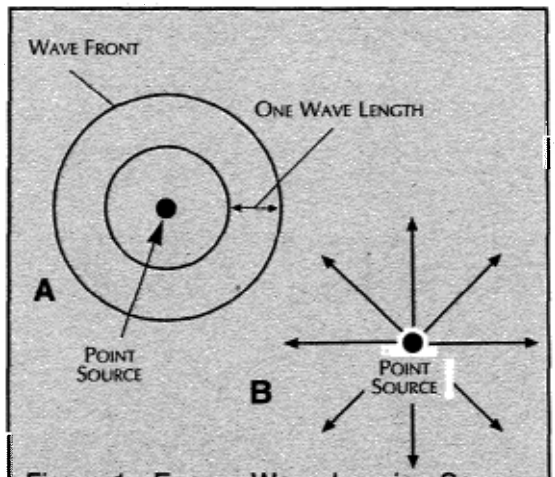


Figure 1 Energy Wave Leaving Source
A - Wave fronts leaving source in a single phase
B - Ray tracing to show advance of wave front

As this acoustic energy propagates in the form of pressure fluctuations, it can be affected by obstacles in the path and by changes to the medium (air). These effects can be roughly grouped in six defined categories. The categories are:

- geometric spreading
- diffraction
- reflection
- ground effects
- absorption
- refraction

Let's take a look a more in depth look at these effects.

Geometric Spreading. Geometric spreading may be thought of as a distribution of the acoustic energy over greater and greater volumes, resulting in a reduction of sound energy density. To better illustrate this idea, lets define some terms first. We have already alluded to sound energy density which is the energy per unit volume. We can also discuss acoustic energy as the acoustic intensity, I, which is the average power transmitted per unit area (e.g., watts/m^2). The area is the surface of the defined volume used to determine sound energy density (see Figure 2 next page).

Mathematically acoustic intensity can be defined as:

$$I = \frac{(p_{rms})^2}{\rho c}$$

where: ρ = density of air
c = speed of sound

As such, the root-mean-square pressure p_{rms}^2 defined in the first "class" is directly proportional to the intensity.

Now consider a noise source emitted from a single point in space (a point source). As shown in Figure 1, as the sound energy propagates away from the source, it travels in all directions. With each instance in time, the energy is passed through the theoretical surface of a sphere. As the radius of the sphere increases, the area of the surface becomes ever larger. Since energy is conserved, the same amount of acoustic energy is spread over greater and greater areas and the intensity is reduced. Remember that p_{rms}^2 is proportional to intensity and the definition of SPL is based on p_{rms}^2 , so the continual "spreading" of energy with increased distance from the source results in ever decreasing sound pressure levels. Accord-

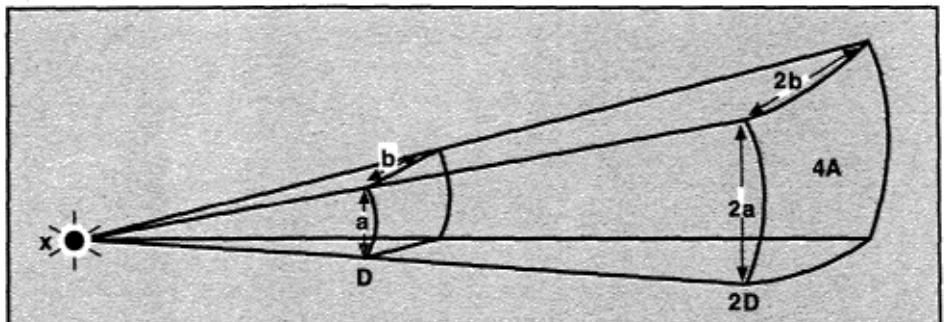


Figure 2 - Geometric Spreading of Point Source

ingly, distance from the source and sound pressure level are inversely proportional.

For the point source shown in Figure 1, the surface area of a sphere increases as shown by Figure 2 and can be described by:

$$A = 4\pi r^2$$

where: A = surface of sphere
r = radius of sphere.

Consider the wave divergence or "energy spreading" as the wave propagates from the source. Mathematically:

$$I_r = W/A = \frac{W}{4\pi r^2}$$

where: I_r = sound intensity at r
W = sound energy emission rate (sound power)

This equation shows that the intensity is inversely proportional to the square of the distance from a point source (commonly referred to as the inverse square law).

The difference in intensity with varying distances can be computed by:

$$\blacktriangle I = I_{r_2} - I_{r_1} = \blacktriangle W/A_{r_2} - \blacktriangle W/A_{r_1}$$

Using the relationship that dB are logarithmic results in:

$$\blacktriangle L = 10 \log \left(\frac{r_2}{r_2}\right)^2$$

This equation may then be used to calculate the change in sound pressure level for varying distances from a point source. It should be noted that very close to the source (called the near field) this equation is not valid because falloff is not a linear function in this range.

QUESTION: If a receiver location in the far field is moved to a distance twice as far from a point source ($r_2 = 2r_1$), what is the change in sound pressure level.

ANSWER: – 6 dB

Accordingly, in the far field from a point source, the sound pressure level decreases by 6 dB each time the distance is doubled.

For surface transportation another geometric shape to consider is the cylinder. In the case of the point source, sound radiated in all directions forming a sphere. However, transportation sources such as heavily traveled roadways propagate from a series of points along a line. The shape of sound propagating from this line then resembles a cylinder (see Figure 3). If end effects are not considered, or in other words if the line is infinite in length, then the sound energy propagates outward from the line and

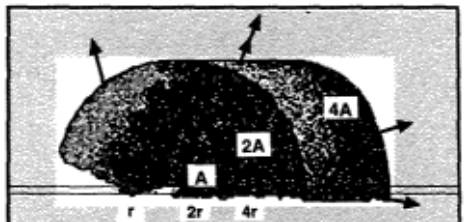


Figure 3 - Line Source Geometric Spreading

diverges as the circumference of a circle. Using this geometric relationship, and proceeding as we did for the point source, it can be concluded that:

$$\blacktriangle L = 10 \log \left(\frac{r_2}{r_2}\right)$$

It can then be calculated that for a line source in the far field, each time the distance from the receiver doubles the sound pressure level decreases by 3 dB.

These equations must be modified for the directivity of the source and other effects that add excess attenuation. These effects are discussed in the following sections.

Diffraction. As the wave propagates it may come in contact with solid surfaces. Some of the energy that strikes the solid surface is changed to heat and is absorbed by the solid object. Other portions of the energy that strike the surface are transmitted through the surface or reflected. The remainder of the wave spreads around the edges of the surface or is diffracted. When diffraction occurs the wave is stopped by the obstacle, but then radiates in all directions after passing the obstacle. This results in an apparent change in directions by the wave behind the solid object. Figure 4 provides a graphic example of diffraction by a noise barrier. It is illustrated in Figure 4 that the sound wave bends over the top of the wall. The zone where the acoustic shadow results is called the shadow zone and noise reduction occurs. This reduction in sound pressure levels, the algebraic difference in levels with and without the object, is called insertion loss.

It should be noted that diffracted waves bend over the top of the barrier and no sharp definition of an edge to the shadow zone really exists. The shadow zone diminishes with distance behind the barrier. In common terminology, there is a shadow zone, a transition zone, and a bright zone. In a later "class" we will discuss diffraction, barrier effectiveness, and barrier insertion loss calculation in much more detail.

QUESTION: Where is the shadow zone best defined?

ANSWER: The shadow zone is best defined immediately behind the solid object.

Reflection. Notice that in Figure 4, part of the wave was also reflected. Reflection depends on the incident wave, the angle of incidence, and characteristics of the surface. The angle of incidence is equal to the angle of reflection

The reflected wave may be in phase or out of phase with the sound wave emanat-

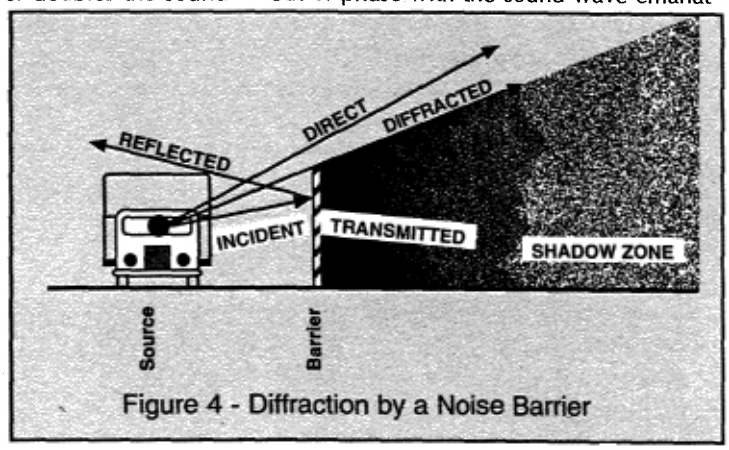


Figure 4 - Diffraction by a Noise Barrier

(Continued next page)

ing directly from the source. This means that the intensity could be increased or decreased depending on location. Reflection could result in an increase of acoustic energy in the direction of the reflection and increased sound pressure levels on the source side of the barrier. This is a concern when highway noise barriers are constructed. Again, we will discuss this in more detail when we discuss barrier design.

Ground Effects. When the source is near the ground, as in the case of surface transportation, ground wave propagation is affected due to interaction with the surface. This excess attenuation occurs as a function of frequency, soil type, the grazing angle, topography and vegetative covering. When the wave comes into contact with the ground, some energy is reflected and a portion is transmitted into the soil. The amplitude and the phase of the reflected wave is determined by the acoustic impedance of the ground. As porosity changes, so does the amplitude and phase of the reflected wave. The reflected wave may interfere with the directly transmitted wave and in narrow frequency ranges may result in a large degree of excess attenuation. (The term excess attenuation refers to attenuation beyond that due to geometric spreading.) Excess attenuation due to ground interaction is usually most prominent in the frequency ranges of 250 to 600 Hz. This attenuation continues to increase with distance from the source as expected. Ground attenuation is usually not a linear function, although prediction methodologies have made this assumption.

Vegetative ground coverings (e.g., grass and bushes) cause additional excess attenuation. There is a general trend of the higher frequencies being attenuated more. The rate of this change is roughly 5dB per 100 meters for each doubling of frequency. The amount of attenuation due to trees is debatable. However, it is generally agreed that unless trees are very thick, the extra attenuation is small when A-weighted values are used.

Several prediction methodologies have been developed to predict ground attenuation. To do this, two general assumptions are usually made: 1) that the ground can be classified according to its acoustic properties; and, 2) that a continuous function can be derived.

The ground classifications are generally hard or soft ground. A hard ground indicates pavement, water, or other surfaces with low porosity. Soft ground is porous soil generally with vegetative covering such as grass or bushes. When different surface types are present, the problem with impedance discontinuities makes prediction very difficult.

One very simple prediction approach that has provided adequate prediction capabilities over the last decade is that used in the FHWA Highway Noise Prediction Model. Ground waves are considered to be those waves traveling within about 3 meters above the ground or less. Over hard surfaces, no excess attenuation is considered and for a highway source, only geometric spreading is considered (the attenuation rate is 3 dB per doubling of distance). For soft surfaces, an additional 1.5 dB is added for each doubling of distance based on empirical data (for a total of 4.5 dB per doubling of distance). This can be stated mathematically as was done for geometric spreading, but in a more generic way, by:

$$\blacktriangle L = 10 \log \left(\frac{D_2}{D_2}\right)^{1+\alpha}$$

where: D_1, D_2 = the distance from the source

α = an attenuation factor.

In the case of the FHWA model, α equals 0.0 for a hard site and 0.5 for a soft site.

To account for the excess attenuation due to heavy foliage in the FHWA model, 5dB, A-weighted, is subtracted for every 30 meters of very thick foliage in addition to the above equation. This "rule of thumb" is very approximate and should be carefully checked.

The new FHWA model now being developed will be greatly enhanced in regards to ground effects.

Absorption. As we know from the study of thermodynamics, no process is 100% efficient. This also applies to the transmission of sound by air. As sound is propagated by molecular vibration, some energy is converted to heat, or simply stated, is absorbed. This absorption is proportional to the characteristics of its medium (air), namely; pressure, temperature, and relative humidity. Because these characteristics of the surrounding air do not change rapidly with distance, a linear function allows excellent prediction accuracy. The accepted prediction scheme used by ISO and ANSI is to use an air attenuation coefficient. This coefficient, which has the units of dB/km, is selected based on temperature, frequency, and relative humidity from charts or tables. It is then multiplied by the propagation distance to determine the excess attenuation due to atmospheric absorption. Table 1 shows an example of these coefficients. Notice that the attenua-

Temperature	Relative Humidity	Frequency, Hz 125	250	500	1000	2000	4000
30°C (86°F)	10%	0.96	1.8	3.4	8.7	29	96
	20%	0.73	1.9	3.4	6.0	15	47
	30%	0.54	1.7	3.7	6.2	12	33
	50%	0.35	1.3	3.6	7.0	12	25
	70%	0.26	0.96	3.1	7.4	13	23
	90%	0.20	0.78	2.7	7.3	14	24
20°C (68°F)	10%	0.78	1.6	4.3	14	45	109
	20%	0.71	1.4	2.6	6.5	22	74
	30%	0.62	1.4	2.5	5.0	14	49
	50%	0.45	1.3	2.7	4.7	9.9	29
	70%	0.34	1.1	2.8	5.0	9.0	23
	90%	0.27	0.97	2.7	5.3	9.1	20
10°C (50°F)	10%	0.79	2.3	7.5	22	42	57
	20%	0.58	1.2	3.3	11	36	92
	30%	0.55	1.1	2.3	6.8	24	77
	50%	0.49	1.1	1.9	4.3	13	47
	70%	0.41	1.0	1.9	3.7	9.7	33
	90%	0.35	1.0	2.0	3.5	8.1	26
0°C (32°F)	10%	1.3	4.0	9.3	14	17	19
	20%	0.61	1.9	6.2	18	35	47
	30%	0.47	1.2	3.7	13	36	69
	50%	0.41	0.82	2.1	6.8	24	71
	70%	0.39	0.76	1.6	4.6	16	56
	90%	0.38	0.76	1.5	3.7	12	43

Table 1. Air attenuation Coefficient, dB/km, for an Ambient Pressure of 101.3 kPa (One Standard Sea-Level Atmosphere) for Sound Propagation in Open Air

tion increases with frequency and decreases with humidity.

Simplifications have been made to allow development of an A-weighted air attenuation coefficient. In the FHWA model this formulation is for 500 Hz. but applied to the overall A-weighted value. The equation is:

$$A = 5.4\ (10^{-4})D$$

where: A = excess attenuation, dB

D = source to receiver distance, ft.

Unfortunately, these simplifications are usually only valid over narrow ranges of temperature and humidity. In the case of the FHWA model, this range is only 50 to 70 percent relative humidity at 60 degrees Fahrenheit. However, in practice, this is applied over the entire range of predictions. Fortunately, for short range propagation (first or second row homes along a highway) the attenuation is small and so the loss in overall accuracy has been acceptable.

Refraction. In some cases, the direction of travel for the wave front can be significantly changed; in other words, the wave is bent. This is different from diffraction where the wave bent around an object and is called refraction. Refraction occurs when wave propagates through changing media. This is the same concept of light being bent (refraction) as it passes from air through a denser media such as glass (change of transmission medium). The speed of sound, relative to a fixed location, increases with increased temperature and/or wind speed changes. This causes a redirection of the wave front; refraction. Accordingly, refraction of sound in air occurs when the sound path travels through varying temperatures or wind speeds.

In the case of outdoor sound, the wind speed and temperature normally change with height. A change of wind speed with height is called wind shear. A temperature change with height is called a lapse rate. Accordingly, refraction is a normal phenomenon in the outdoor air, and may cause large variations in the sound pressure level. Unfortunately, it is complex and often overlooked.

We have probably all experienced refraction. Remember back to when you were on the playground and there was a strong wind. Your classmate could hear you shout but you could not hear him. It is not that the wind blew the sound, this is not possible since the propagating wave does not have mass. What did occur was that the wave was bent upwards in the upwind direction and bent down in the downwind direction. In days when the temperature decreases with height (normal lapse rate) the wave is bent upwards. When the lapse rate is inverted (when temperature increases with height and called an inversion) the wave is bent downwards. Figures 5 & 6 show this refraction concept for wind and temperature.

Research has shown that at short distances, such as the first or second row homes, excess attenuation due to the lapse rate is not as great as the effects of wind shear. Another refraction effect also occurs at short distances, that due to turbulence. Turbulence is the random circular motion of the wind. At larger distances, the refraction effects caused by the lapse rate and wind shear are about equal.

We will revisit refraction in a later "class".

QUESTION: If the wind is blowing at 100 mph and is constant with height, will the refraction be severe?

ANSWER: No refraction will occur since the wind speed is constant with height.

Overall Effect. The various effects on sound propagation are all interrelated. For example, refraction causes the angle of propagation to change; the wave strikes the ground at a different angle, causing ground effects to change. As such, the overall effect on noise propagation is a complex combination of the six described effects, all relying on area variables. Simple considerations leaving out any of the six components can lead to errors. However, to simplify this involved process, it has been assumed that each component could be treated independently and used as a correction to the source level. This series of correction assumption is widely used, including the FHWA Highway Noise Prediction Model.

I hope you enjoyed this installment of the A1F04 ION course. If so, please forward your comments to The Wall Journal. Next class, we shall look at the Receiver. ■

Could Ancient Mayan Temple Walls Provide A Model for Today's Sound Barriers?

By Frank Hodgson

Abstract

A new type of surface is proposed for the modification of sound. The technology seems to be a form of parametric amplification and is based on walls first constructed over 1,000 years ago by the Maya Indians in Mexico. Applications of this new surface can be considered for freeway sound walls, as gratings under airport taxiways, as gratings under or along rail tracks, as embedded liquid-filled walls for the reduction of vibration and noise (said surfaces being on the interior of the embedded wall), for novel musical instruments and as surfaces to enhance the acoustic properties of theaters.

A new type of surface is proposed for the modification of sound by means of parametric amplification. This effect, the modification of sound upward in frequency by a specific wall structure, is hereby reported by the author and is based on his personal observations of a specific Mayan wall which exhibits these characteristics.

The essential conditions for the creation of this effect seem to be the use of square-bottomed gaps used in conjunction with and and as a part of a structure having steps or indentations. Please refer to Figure 1 which shows a typical structure. The gaps can have curved bottoms and/or "fat" portions to alter and perhaps improve the character of the resulting reflected sound. The gaps surround each brick.

In electrical engineering applications, the most common usage of parametric amplification is the p-n junction diode which is in wide use. The underlying theory for these and other devices (up converters, down converters, negative resistance amplifiers and other specialized devices) is summarized by Collin (Robert E. Collin, 1992, Foundations for Microwave Engineering, McGraw Hill, pp 807-829). For a more detailed review, refer to Manley and Rowe (J.M. Manley & H.E. Rowe: Some General Properties of Nonlinear Elements, Part 1, General Engineering Relationships; Proc IRE, vol. 44, pp 904-913; July 1956; see also Proc IRE vol 47, pp 2115-2116, December 1959).

In theory, it would appear that frequencies should be capable of conversion downward as well as upward, and that spreading should be possible (i.e., to clear out a given bandwidth converting frequencies both up and down away from the central frequency). It appears that the base frequency required to generate this conversion is created in the gaps themselves. These surfaces, herein termed Kilo surfaces, constitute a new method for transforming sound.

Since the surface does not need to be massive, fiberglass panels can be considered for some applications. The surface could be moulded onto freeway sound walls which should eliminate much of the reflected sound, both because much of the energy would be converted to inaudible frequencies and because the remaining high frequencies should quickly dissipate over short distances. These walls should not be painted as paint will reduce or eliminate the desired effect.

The surface can be made into a grating for use on airport taxiways and under or along railroad tracks to convert the impinging sound. Ground-propagated noise and vibrations should be capable of being modified through the use of embedded wall-like structures through which the vibrations and noise would have to pass. The interior of the wall should be filled with liquid and the interior surfaces would be special Kilo surfaces.

More complex patterns should give rise to unusual effects which should be of interest to musicians. Some of these patterns should enhance the acoustic properties of theaters. The most promising area of inquiry seems to be Bessel function related surfaces which are bounded by shock wave curves.

The technology described above has been placed in the public domain by the Kilo Foundation which invites inquiries and participation in the creation of new applications. For additional information, please contact Frank Hodgson, The Kilo Foundation, Inc., 708 Matadero Avenue, Palo Alto, CA 94306, tel 415 493-5511. ■

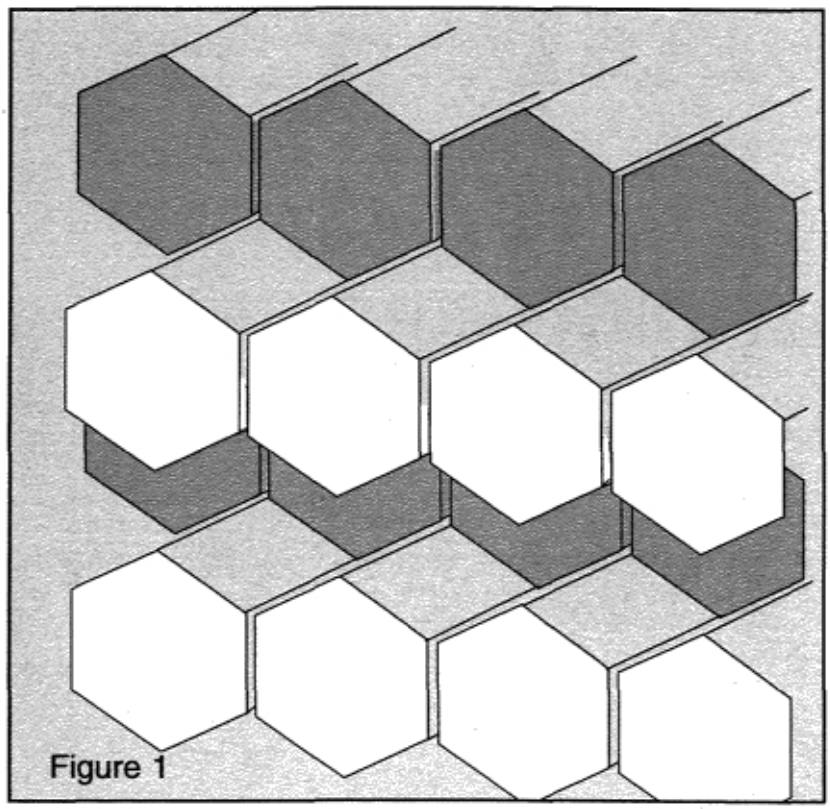


Figure 1

TRB Committee A1F04

By Domenick Billera, Chairman

Barrier Backlash

In my job at the New Jersey Department of Transportation, I get to see all correspondence coming in to the Department on the issue of noise barriers. For years, all the mail was from people who wanted barriers to help improve their quality of life. Eventually, we started building barriers and now we have some 70+ miles erected, with many installations of considerable height and length along our busiest highways.

In the past few years, we have been receiving a different kind of mail, at first an occasional letter and more recently a steady stream. These letters are from the highway users who travel the corridors where noise barriers have been erected. These people are concerned because the noise barriers, mile after mile of repetitious monoliths, have robbed them of their view of the varying countryside.

As was remarked to me by a noted architect, Americans identify their country by driving through it, and noise barriers have denied them that identity. What we have done is improve the quality of life of the homeowners at the expense of the quality of life of the highway users.

However, this doesn't have to be so. With thought and foresight we can satisfy both groups. As the professionals in this field, we have a responsibility to ensure that we do justice for all taxpayers, both homeowners and highway users.

TRB Committee A1F04 wants to help this happen through our research and our activities as a clearinghouse for information. Catch my next column for more information on how we plan to assist barrier designers in keeping abreast of what's happening around the country. ■

NOISE BARRIER CONSTRUCTION FORECAST

Compiled by **LEAP** ASSOCIATES International, Inc. of Tampa, Florida and Denver, Colorado

This database has been compiled by a polling of state highway officials and other research. This material is intended for use only as a general guide to upcoming noise barrier construction projects. For consultants, contractors and vendors, we recommend that you contact directly the appropriate state highway officials for verification and further information. We assume no responsibility or liability for the correctness or completeness of any data presented here. The majority of the projects in this forecast are for precast concrete or masonry block construction, both reflective and sound-absorptive. On many of these projects, no decision for barrier construction type has yet been made. Blank spaces indicate that no data was available in those categories at this time. **If you have questions, contact LEAP Associates International, Inc. at 303 426-0222.**

LOCATION	STATE	HIGHWAY	LINEAR FEET	WALL HEIGHT	SQUARE FEET	BID YEAR
Chandler	AZ	I-10	200,000	8-18	2,600,000	
Phoenix	AZ	State Rte 101	20,000	10-16	260,000	
Chandler	AZ	State Rte 101		6-12		
Lake Forest	CA	I-5	1,200	16	19,200	93
Lake Forest	CA	I-5	1,200	12-16	16,800	93
Buena Park	CA	State Rte 39	1,200	8-9	10,200	93
San Mateo	CA	State Rte 101	6,500	12-14	84,500	93
Fremont	CA	I-680	2,800	12	33,600	93
Oakland	CA	I-580	3,500	12-14	45,500	93
Santa Rosa	CA	State Rte 101	3,500	12-14	45,500	93
Fullerton	CA	State Rte 91	5,350	14-16	80,250	93
Anaheim	CA	State Rte 91	1,730	14-16	25,950	93
Hayward	CA	State Rte 92	4,300	12-14	55,900	93-94
Buena Park	CA	State Rte 91	2,320	14	32,480	93-94
Buena Park	CA	State Rte 91	5,500	14-16	82,500	93-94
Fullerton	CA	State Rte 91	1,830	12-16	23,790	93-94
Anaheim	CA	State Rte 91	5,510	12-14	71,630	93-94
Commerce	CA	I-5				93-94
El Monte	CA	I-10				93-94
W. Covina/Pomona	CA	I-10				93-94
San Juan Capistrano	CA	I-5	1,300	14	18,200	94
San Juan Capistrano	CA	I-5	550	16	8,800	94
San Juan Capistrano	CA	I-5	600	16	9,600	94
San Juan Capistrano	CA	I-5	600	8	4,800	94
San Juan Capistrano	CA	I-5	3,900	10-16	50,700	94
San Juan Capistrano	CA	I-5	600	8	4,800	94
San Juan Capistrano	CA	I-5	950	12	11,400	94
San Diego	CA	I-5	590	4-8	3,540	94
Mission Viejo	CA	I-5	1,000	16	16,000	94
Mission Viejo	CA	I-5	2,000	14-16	30,000	94
Lake Forest	CA	I-5	2,100	16	33,600	94
Lake Forest	CA	I-5	3,550	14-16	53,250	94
Lake Forest	CA	I-5	950	14-16	14,250	94
Lake Forest	CA	I-5	2,300	16	36,800	94
Pomona	CA	State Rte 60	48,315	12-16	676,410	94
Bakersfield	CA	State Rte 99	12,000	9-12	126,000	94
National City	CA	State Rte 54	850	6	5,100	94
National City	CA	State Rte 54	3,400	6	20.400	94
Escondido	CA	State Rte 78	1,000	6	6,000	94
Santee	CA	State Rte 52	11,320	6-10	90.560	94
San Clemente	CA	I-5	1,400	8-12	14,000	94
Oakland	CA	I-880				94-95
San Jose	CA	State Rte 101				94-95
Sunnyvale/Mtn View	CA	State Rte 85				94-95
Anaheim	CA	State Rte 91	1,200	16	19,200	94-95
Anaheim	CA	State Rte 91	4,480	14	62,720	94-95
Rancho Cordova	CA	State Rte 50				94-95
W. Sacramento	CA	I-80	3,500	12-16	49,000	94-95
Anaheim	CA	I-5	2,100	14	29,400	94-95
Anaheim	CA	I-5	6,170	14	86,380	94-95
Norwalk	CA	I-5				94-95
Studio City	CA	State Rte 101				94-95
Agoura Hills	CA	State Rte 101				94-95
Sherman Oaks	CA	I-405				94-95
Commerce	CA	I-710				94-95
Oceanside	CA	I-5	700	7	4,900	95
Hollister	CA	Hollister By-Pass	630			95
Coronado	CA	State Rte 75	680	6	4,080	95
Oceanside	CA	State Rte 76	5,580	6-10	44,640	95
Santa Ana	CA	State Rte 55	5,000	12-14	65,000	95
Santa Ana	CA	State Rte 55	1,650	14-16	24,750	95
Orange	CA	State Rte 55	1,540	10	15,400	95
Oceanside	CA	State Rte 76	4,400	6	26,400	95

LOCATION	STATE	HIGHWAY	LINEAR FEET	WALL HEIGHT	SQUARE FEET	BID YEAR
Anaheim	CA	State Rte 91	850	12	10,200	95
San Diego	CA	I-15	13,600	6-8	95,200	95
Riverside	CA	State Rte 60	26,000	12-16	364,000	95
Rocklin	CA	I-80	3,500	12-16	45,500	95-96
Sacramento	CA	State Rte 51	600	12-16	8,400	95-96
Stockton	CA	I-5	1,860	15	27,900	95-96
Vallejo	CA	I-780	4,400	8-15	50,600	95-96
Modesto	CA	State Rte 99	2,100	15	31,500	95-96
Oakland	CA	State Rte 92				95-96
San Jose	CA	I-680	2,550	16	40,800	95-96
Millbrae	CA	I-280	4,790	10-12	52,690	95-96
Garden Grove	CA	State Rte 22	1,340	14	18,760	95-96
Garden Grove	CA	State Rte 22	2,630	16	42,080	95-96
El Monte	CA	I-10				95-96
Pomona	CA	I-10				95-96
N. Hollywood	CA	State Rte 101				95-96
Torrance	CA	I-405				95-96
Van Nuys	CA	I-405				95-96
San Juan Batista	CA	Hwy 156	2,000	10-12	22,000	96
Anaheim	CA	State Rte 91	700	16	11,200	96
McFarland,Delano	CA	State Rte 99	2,400	14	33,600	96
Moreno Valley	CA	State Rte 60	26,000	12-16	364,000	96
Anaheim	CA	I-5	2,100	14	29,400	96
Anaheim	CA	I-5	6,100	12-14	79,300	96
Orange	CA	I-5	1,800	10-12	19,800	96
Anaheim	CA	I-5	1,500	10	15,000	96
Anaheim	CA	I-5	700	14	9,800	96
Anaheim	CA	I-5	1,500	10	15,000	96
Fresno	CA	State Rte 99	3,700	12-13	46,250	96-97
Sacramento	CA	State Rte 99	3,000	12-16	42,000	96-97
Del Mar	CA	I-5	5,600	8	44,800	96-97
San Diego County	CA	State Rte 54	7,300	6-8	44,800	96-97
Concord	CA	State Rte 242	6,500	12	78,000	96-97
Oakland	CA	State Rte 13				96-97
Anaheim	CA	I-5	6,400	10	64,000	96-97
Norwalk	CA	I-5				96-97
Anaheim	CA	I-5	4,500	12	54,000	97

(continued next page)

(continued from previous page)

LOCATION	STATE	HIGHWAY	LINEAR FEET	WALL HEIGHT	SQUARE FEET	BID YEAR
Anaheim	CA	I-5	1,900	14	26,600	97
San Diego	CA	I-15	1,500	6-8	10,500	97
Anaheim	CA	State Rte 91	3,326	12-16	46,564	97
Buena Park	CA	State Rte 91	650	14	9,100	97
Anaheim	CA	State Rte 91	800	16	12,800	97
Anaheim	CA	State Rte 91	1,250	14-16	18,750	97
Summerland	CA	State. Rte 101	1,265	16	20,240	97-98
Stockton	CA	I-5	1,630	15	24,450	97-98
Stockton	CA	I-5	12,050	12	144,600	97-98
Industry	CA	State Rte 60				97-98
Hacienda Heights	CA	State Rte 60				97-98
Lawndale	CA	I-405				97-98
Orange	CA	State Rte 55	2,550	12-16	35,700	98
Orange	CA	State Rte 55	1,800	14	25,200	98
Orange	CA	State Rte 55	2,200	12-16	30,800	98
Orange	CA	State Rte 55	1,450	12-14	18,850	98
Orange	CA	State Rte 55	2,500	12-14	32,500	98
Orange	CA	State Rte 55	2,850	12-14	37,050	98
Tracy	CA	I-205	7,000	15	105,000	98-99
Arleta	CA	I-5				98-99
Industry	CA	State Rte 60				98-99
Hollywood	CA	State Rte 101				98-99
Pico Rivera	CA	I-605				98-99
Industry	CA	I-605				98-99
Ventura	CA	State Rte 126				98-99
San Diego	CA	State Rte 125	10,610	6-8	74,270	99
Seal Beach	CA	I-405	1,900	12	22,800	99
Fresno	CA	New Highways				
Riverside	CA	State Rte 91	8,000	12-16	112,000	
Ontario	CA	State Rte 60	4,500	10-16	63,000	
Riverside/Ontario	CA	State Rte 60	23,000	12-16	322,000	
Stockton	CA	I-5	44,000	12	528,000	
Stockton/Manteca	CA	State Rte 99	10,000	10-12	110,000	
San Clemente	CA	I-5	670	8-16	8,040	
San Clemente	CA	I-5	2,380	12	28,560	
San Clemente	CA	I-5	1,240	10-12	13,640	
Garden Grove	CA	State Rte 22	3,960	12	47,520	
Garden Grove	CA	State Rte 22	2,780	14-16	41,700	
Garden Grove	CA	State Rte 22	2,790	16	44,640	
Garden Grove	CA	State Rte 22	2,320	12-16	32,480	
Garden Grove	CA	State Rte 22	3,160	12-14	41,080	
Garden Grove	CA	State Rte 22	4,880	12-16	58,500	

NEW PRODUCT PRESS RELEASE

SANDERS ENTERPRISES, INC. OF SCOTT CITY, MISSOURI IS THE MANUFACTURER OF A NEW, INNOVATIVE PRODUCT CALLED THE

"RECYWALL, GREEN, LIVING SOUND BARRIER WALL"®

This product is made completely of 100% recycled plastic materials and was developed, mainly, for sound barrier purposes. The construction of the wall actually serves several purposes. One, it serves as a sound barrier wall, that will actually absorb noise, rather than reflecting the noise. Two, it helps our environment by not disposing the plastic waste into our landfills. Three, it works as an air filter against carbon monoxide, due to the living plants inside the structure. The **RecyWall, Green, Living Sound Barrier Wall** was developed primarily for sound barrier purposes, however, it could also be used as an in-earth retaining wall system. **RecyWall** can be used in the landscaping of parks, gardens, or as attractive barriers between properties. Only your imagination is the limit. Once the wall is installed, it can be landscaped to your desire. Plant many varieties of shrubs, draping evergreens, or regional varieties of flowering plants for year round beauty. The **RecyWall** used as a **Green, Living Sound Barrier Wall** should be planted with varieties of non-maintenance ground cover, wild flowers or a wide blend of local grasses.

RecyWall in comparison to a concrete, wooden, or metal version of a sound barrier wall, is very competitive in pricing and requires minimum maintenance. The quick and easy installation techniques eliminate long traffic delays. You don't need heavy equipment or a large force of manpower to install the **Green, Living Sound Barrier Wall.** The height ranges between 2 -21 ft. Standard elements are able to support a 21 ft. wall, with the base being 7 feet.

The difference between existing sound barrier walls and the **RecyWall, Green, Living Sound Barrier Wall** is the way the design actually absorbs the noise rather than reflecting the noise and creating additional problems. **RecyWall** also creates a vertical berm offering aesthetic value to any design.

Height: The standard height of the **RecyWall** is 14.3 ft. We are currently constructing a 21 ft. high **RecyWall**

Height to Base Ratio: The **RecyWall** construction is a triangle shape, angled at 78 degrees, making the base of the **RecyWall** wall 7 ft. wide.

Foundation: RecyWall does not require a special foundation. It is sufficient, if the soil on which the **RecyWall** will be constructed is an unyielding, uniformly prepared subgrade, with an adequate density between 87-90% of standard proctor density.

Test Data: Test data has been completed by Allied Signal, in conjunction with the Department of Energy, for wind load and degradation. The test results clearly indicated that the structure will withstand four times the windload, as is currently required by most states. The freeze/thaw test results were very encouraging as well, showing no degradation, using the ASTM D790 test method.

For complete details contact Glen H. Beussink, Sanders Enterprises, Inc., 3019 Nash Road, Scott City, MO 63780, 314-334-9600. ■

TRB Committee A1F04 Summer Meeting

Announcement

The TRB A1F04 Committee on Transportation-Related Noise and Vibration will hold its Annual Summer Meeting on July 10-13 1994 at the Holiday Inn Center City in Philadelphia, Pennsylvania.

Call for Papers

Presentations should be submitted to:

Mr. David R. Still
Senior Environmental Scientist, Acoustics
Gannett Fleming, Inc.
P.O. Box 67100
Harrisburg, PA 17106
Tel 717 763-7211 x2428 fax 717 763-8150

Please contact Mr. Still with the title of your paper before April 4, 1994. Abstracts are due by May 2, 1994. Please limit presentation and 'question and answer' time to a total of 30 minutes. Additional Meeting information may also be obtained from:

Mr. Roy Osborne
Environmental Scientist
Bureau of Environmental Quality
Pennsylvania Department of Transportation
Room 1009
Transportation and Safety Building
Harrisburg, Pennsylvania 17120
Tel 717 772-0832
Fax 717 772-0834

Ms. Tamar Arslanian
Meeting Coordinator
McCormick Taylor, Inc.
Mellon Independence Center
Suite 6000
701 Market Street
Philadelphia, Pennsylvania 19106
Tel 215 592-4200
Fax 215 592-0682

Back Copies

Issues #1 through # 10 are available at a cost of $3.00 each to cover postage and handling (this applies to both public and private sector readers)

Keep your collection complete to provide a chronology of the events and workings of professionals in the field of transportation-related environmental issues

Our Advertisers are the Principal Financial Supporters of The Wall Journal. We hope that you will favor them with inquiries concerning their products and services.

INDEX OF ADVERTISERS

Subscriptions

Subscriptions to **The Wall Journal** are free of charge to federal, state and local government agencies and their officials, to government associations, and to universities, provided they have registered in writing by sending name, department and complete mailing address. We would also like to have telephone and fax numbers for our referral records.

Subscriptions for the private sector (e.g.,consulting engineers, contractors, equipment manufacturers and vendors) are available at the costs per year (6 issues) shown below. Please include your check with your subscription order.

U.S. Subscribers: $17.95. Please send checks and subscription orders to The Wall Journal, P.O. Box 1286, Stafford, VA 22555-1286.

Canadian Subscribers: $26.00 (CDN, including GST). Please make checks and subscription orders payable to Catseye Services, Postal Outlet Box 27001, Etobicoke, Ontario M9W 6L0.

All Others: $30.00 (U.S.). Please send subscription orders and drafts payable in U.S. funds through U.S. banks to The Wall Journal, P.O. Box 1286, Stafford, VA 22555-1286, USA.

Advertising

Display advertising rates and sizes are contained in our Advertising Rate Schedule, available on request sent to The Wall Journal, P.O. Box 1286, Stafford, VA 22555-1286, or by fax to 703 720-0598.

The Wall Journal
P.O. Box 1286
Stafford, VA 22555-1286

BULK RATE
U.S. POSTAGE
PAID
PERMIT NO. 77
MANASSAS VA

ADDRESS CORRECTION REQUESTED

PRINTED WITH SOY INK
Printed on Recycled Paper