MICHIGAN DEPARTMENT OF TRANSPORTATION
M•DOT

FIRST YEAR PERFORMANCE OF THE EUROPEAN CONCRETE PAVEMENT ON NORTHBOUND I-75 - DETROIT, MICHIGAN

MATERIALS and TECHNOLOGY
DIVISION

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FIRST YEAR PERFORMANCE OF THE EUROPEAN CONCRETE PAVEMENT ON NORTHBOUND I-75 - DETROIT, MICHIGAN

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A Research Demonstration Project by the
Michigan Department of Transportation
in Cooperation With the
Federal Highway Administration

Research and Technology Section
Materials and Technology Division
Research Project 92 B-105
Research Report No. R-1338

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This report, authorized by the transportation director, has been prepared to provide technical information and guidance for personnel in the Michigan Department of Transportation, the FHWA, and other reciprocating agencies. The cost of publishing 60 copies of this report at $0.76 per copy is $45.42 and it is printed in accordance with Executive Directive 1991-6.

INTRODUCTION

This report describes the performance of the I-75 European concrete pavement reconstruction project approximately one year after construction. The design and construction attributes of the project are documented in Research Report No. 1333, which was published in September 1994 as part of Research Project No. 92 B-105. The experimental features of the pavement design were assimilated from designs used in Germany and Austria. The construction project is identified as federal project IM 75-1(420) and Michigan project IM 82251-30613A.

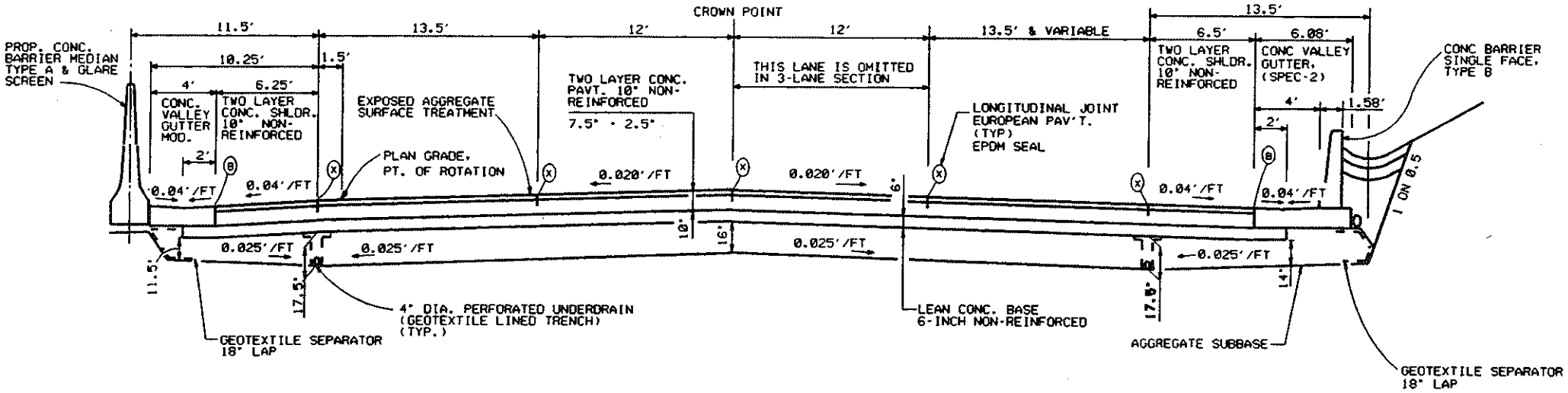
The objective of this project is to determine whether innovative features of typical rigid pavement designs used in European countries can be applied cost effectively to conventional design and construction methods used for rigid pavements in the United States. Two concerns that currently prohibit their use in American designs are: (1) their relatively high initial costs and (2) their unknown effect on life cycle costs over the pavement's service life. Their adoption within Michigan rigid pavement designs depends upon answering point two as applied to Michigan's pavement selection process. This postulate will be examined in the final report after the completion of the five year evaluation period in 1998.

The approximately one mile long European pavement is located on northbound I-75 between the Warren Avenue exit ramp northerly to Picquette Avenue, which is just north of I-94. Construction began in July 1993 and the pavement was opened to traffic on November 23, 1993. During the 1994 construction season, southbound I-75 traffic was detoured onto northbound I-75, while it was reconstructed. Southbound traffic was restricted to the two inner lanes (median side) on northbound I-75. The entire I-75 reconstruction project was completed and both directions resumed normal traffic operation on October 5, 1994.

The European pavement was part of a major Michigan project to reconstruct 2.3 miles of the I-75 (Chrysler) freeway in downtown Detroit between I-375 and the I-94 (Edsel Ford) freeway. I-75 is six to eight lanes wide and carries about 111,000 vehicles a day that includes 11 percent trucks. The remaining portions of northbound I-75 and southbound I-75 are a conventional Michigan concrete pavement design that serve as a control section to the European design. Typical cross-sections of the European and Michigan pavements are shown in Figures 1 and 2, respectively.

PROJECT EVALUATION

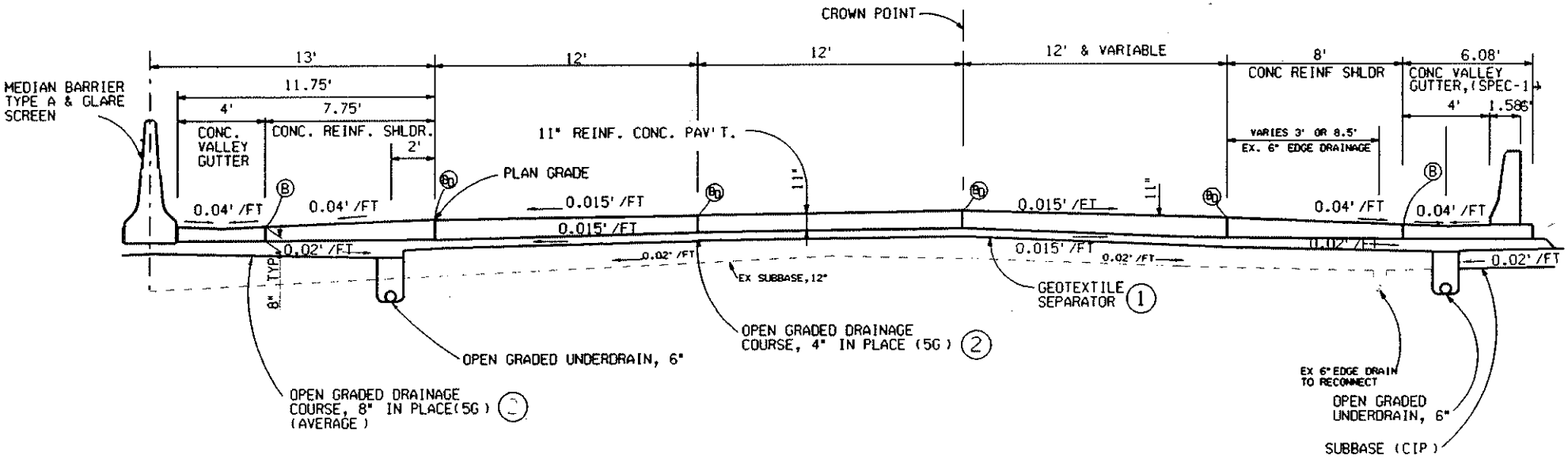
The parameters to determine long term performance of the European pavement were defined in Michigan Work Plan No. 130, dated February 1993. The project agreement with the FHWA specifies a five year monitoring period



EUROPEAN PAVEMENT SECTION

NBD I-75

Figure 1



MICHIGAN CONVENTIONAL SECTION
NB I-75

NOTES:

(1) GEOTEXTILE SEPARATOR WAS INADVERTENTLY SHOWN TO BE PLACED ACROSS TRENCH OPENING FOR OPEN-GRADED UNDERDRAIN.

(2) CONTRACTOR HAS OPTION BY SPECIFICATION TO COAT 5G AGGREGATE WITH EITHER CEMENT OR ASPHALT.

Figure 2

with the final report due by December 31, 1998. This report is the first performance evaluation study of the project.

Performance criteria to be evaluated for both the European and Michigan sections are ride quality, surface distress characteristics, surface friction levels, and tire noise levels. Seasonal pavement deflection measurements are to be taken occasionally during the five year monitoring period to identify any structural inadequacies that may develop in either pavement section.

The reconstruction of southbound I-75 during most of 1994 and the resulting traffic detour onto northbound prevented performance data collection for ride quality and deflection measurements. The remaining performance parameters are discussed as follows, including the performance of the unique design features of the European pavement.

Surface Distress

A walking visual inspection was made of the entire European section just prior to the pavement being opened to normal traffic operation in October 1994. The only distress features found were one transverse crack in one 15' long pavement panel in the driving lane and occasional surface popouts that were normally 1"-2" in diameter. The crack was cored to determine its probable cause. The core was honeycombed, which indicated the concrete was poorly consolidated. The top layer of the two-layer 10" pavement was approximately eight inches thick versus a 2 1/2" thick plan specification. A considerable amount of dirt had infiltrated the crack, which had poor aggregate interlock. The underlying six inch lean concrete base directly below the crack was also cored and found to be sound with no cracking.

After coring was completed, a discussion with construction project staff indicated that the crack was likely caused from damage by contractor equipment during the paving operation for the 10" two-layer pavement. The construction staff believes the crack is a cold joint between older concrete and a botched attempt to patch damaged fresh concrete. The cracked panel is part of a gapped portion of the outside driving lane that was subsequently poured after mainline production paving was completed several days earlier. The gap was poured properly early in the day, but was damaged at the day's end when paving equipment was crossing the area from paving the adjacent lane. The crack later formed as a cold joint between concrete that had initially set and a patch made of top layer concrete mix, which explains why the top layer greatly exceeds plan thickness. The contractor was directed to clean and epoxy inject the crack prior to opening for traffic. The condition of the repair effort is not known at this time.

The Michigan control section on northbound was also visually inspected in October 1994 by car before it was opened to traffic. The only noticeable distress type was transverse cracks. Approximately 50 percent of the 41' long

panels usually had one, and occasionally two, transverse cracks. The cracks were tight and typically irregular in direction. They were usually in only one lane and had not propagated across an adjacent lane. This initial crack pattern is typical of Michigan's 41' long reinforced pavement panels.

It was intended in the project work plan to use Michigan's Pavement Management System (PMS) to identify the type and severity of surface distress features for both pavement sections. However, it was not possible during 1994 to include this portion of I-75 in the video tape survey to collect distress data and complete the necessary data processing in time for inclusion in this report. Future performance reports will include more detailed information from Michigan's PMS.

Exposed Aggregate Surface

Although surface texture is not a specific performance parameter for this project, it deserves special attention because of the unique exposed aggregate surface used on the European pavement. The construction procedure detailed in the construction report is a patented process (International Patent No. 0086188) developed by Robuco, Ltd. of Belgium. Its stated advantages, to be evaluated with this project versus typical surface drag and transverse tinning on the Michigan pavement, are less tire noise levels and higher skid resistance (friction values), which will be discussed later in this report.

The perception of participants in the walking inspection was that the two inner left lanes had a noticeable reduction in macro-texture from the outer lanes, where traffic had been restricted for most of 1994 when the southbound traffic was detoured to the northbound side in May 1994. All lanes on northbound I-75 were open to traffic during the period between November 1993 and May 1994.

The reasons for this perception are difficult to quantify. There were more noticeable "popouts" of dark colored larger sand particles (2NS gradation) that gave the appearance of more paste volume between the coarse dark gray exposed stone in the two left lanes than appeared in the right lanes. No loss of coarse dark stone was evident on the surface, however, some stone particles were found in the joint cavities and gutter. Robert Felter, who supervises the department's friction program, commented during the inspection that friction levels would not likely be significantly different from previous spring testing levels, which are listed in Table 1.

Overall, the walking inspection provided a much closer view of the surface than was previously possible by viewing the surface from a car window on the outside shoulder. Under closer inspection, the surface appeared not as uniform in color and texture, as compared to a spring inspection by car. Unfortunately, there was insufficient time to perform sand patch testing prior to traffic opening to confirm the appearance of lost macro-texture and

compare those results with testing during construction. Sand patch testing will be conducted in 1995 and included in the next report.

TABLE 1 - PAVEMENT FRICTION ANALYSIS							
Michigan Design				European Design			
Nov. 1993 Results		April 1994 Results		Nov. 1993 Results		April 1994 Results	
Sta. of Test	FN	Sta. of Test	FN	Sta. of Test	FN	Sta. of Test	FN
NB #3							
64+60	45.4	63+14	53.7	123+15	42.1	122+39	44.0
72+67	43.7	66+42	52.3	131+12	36.1	125+56	44.5
89+25	46.0	87+85	51.3	137+41	35.3	140+34	41.0
93+95	44.6	91+55	50.4	143+53	36.0	144+04	40.2
103+19	39.4	118+06	51.9	150+98	31.3	146+68	38.7
111+27	42.0	--	--	157+47	32.0	149+85	35.7
--	--	--	--	164+86	33.9	153+01	35.8
--	--	--	--	169+61	33.9	157+24	40.5
Average 43.5		Average 51.9		Average 35.1		Average 40.1	
NB #2							
68+13	38.3	63+15	47.1	122+41	43.3	121+23	46.7
81+97	45.8	66+31	50.7	132+39*	34.9	124+40	43.4
94+11	44.5	77+40	53.6	141+00	35.1	128+62	40.4
105+94	50.7	80+57	52.9	149+45	41.7	139+71	41.6
114+23	52.0	96+94	53.7	164+49	39.7	143+40	40.4
--	--	102+22	54.8	169+51	33.3	150+27*	41.0
--	--	110+67	56.0	--	--	160+30	45.1
--	--	115+95	56.0	--	--	164+00	41.7
--	--	--	--	--	--	167+16	40.1
Average 46.3		Average 53.1		Average 38.0		Average 42.3	
NBIL							
62+43	43.4	62+72	46.2	123+78	36.0	121+33	46.2
78+43	44.0	65+36	52.9	131+02	36.1	125+56	43.4
91+37	56.7	68+53	54.5	142+79*	44.8	129+78	43.6

TABLE 1 - PAVEMENT FRICTION ANALYSIS							
Michigan Design				European Design			
Nov. 1993 Results		April 1994 Results		Nov. 1993 Results		April 1994 Results	
Sta. of Test	FN	Sta. of Test	FN	Sta. of Test	FN	Sta. of Test	FN
105+83	48.9	81+73	52.7	153+88*	43.0	133+48	41.2
115+60	50.2	86+48	57.3	164+97	46.6	141+40	44.3
--	--	95+98	54.8	--	--	147+21	43.1
--	--	105+49	56.3	--	--	157+77	45.4
--	--	113+41	58.3	--	--	165+16*	43.5
Average 48.6		Average 54.1		Average 41.3		Average 43.8	
Overall Averages							
46.0		53.2		37.6		42.1	

NBIL - Lane closest to median.
NB #2 - Second lane from median.
NB #3 - Third land from median.

* Test location within area of low texture values that were abrasive blasted during construction.

Joint Seals

The longitudinal and transverse joints were sealed with an Ethylene Propylene Diene Terpolymer (EPDM) seal, as shown in Figure 3, and inspected during the October walking inspection. The transverse seals showed occasional evidence of "camelback humping", but there was no seal protrusion above the pavement surface. The EPDM material appeared to be in very good condition. The longitudinal seals showed no defects. The lap joint at the intersection of the transverse and longitudinal joint appeared fine. The seal supplier, Phoenix North America, Inc., reports the EPDM seal has an expected 10-12 year service life.

During installation, a modification was made to increase the transverse joint cavity width from 10 mm to 11 mm. Resawing caused occasional minor edge spalling of less than two inches along the joint face that was repaired with Akemi PM802 Type II epoxy, which is performing satisfactorily.

Expansion joints were only placed in the European pavement at the beginning and ending points, which are about 4600' apart, in contrast to Michigan's standard practice of using expansion joints throughout the project

length. There was no compression of the preformed joint filler evident at the south end, while there was approximate 30 percent filler compression at the north end joint.

Surface Friction

Friction Numbers (FN) are Michigan's measurement unit for available wet sliding friction on pavement surfaces. The values are acquired by field testing using a full scale locked wheel trailer under controlled test parameters according to ASTM E-274. The field values are converted to equivalent standard FN units by use of a correlation equation developed at the Field Test and Evaluation Center for Eastern States near East Liberty, Ohio. Table 1 shows a comparison between the initial FN test results, taken just prior to opening to traffic, and the following spring test results, taken prior to detouring traffic for southbound I-75 construction. The initial November 1993 FN values were calculated from testing prior to opening to traffic, when the curing compound was still present on both pavement surfaces.

Over the five month period between tests, the FN values increased for both the Michigan and European pavement sections. The Michigan section still retains higher values, though both have acceptable FN values. The testing in April 1994 on the European section included two locations where the exposed aggregate surface was abrasive blasted during construction to increase texture depth. The abrasive blasting only increased texture values slightly, which remained near 1.1 mm versus the desired specification requirement of 1.3 mm. The sample FN values indicate these small differences in texture depth do not appreciably effect friction numbers.

Traffic/Tire Noise Study

An exposed aggregate surface has been used successfully in Europe for several years to reduce the annoying affects of traffic vehicle noise resulting from tire contact with the pavement surface. The exposed aggregate surface on this project was expected to provide similar results.

A traffic noise study was made in June 1994 by the Materials and Technology Division's Instrumentation and Data Systems Unit, while southbound traffic was detoured to the northbound side of I-75. The noise testing was done after the detour went into effect to avoid background vehicle noise from southbound I-75. The complete report of the noise study is contained in Appendix A.

Separate noise measurements of mixed traffic were made simultaneously at locations adjacent to the European pavement and the Michigan pavement using a General Radio and B & K Type I noise level meters, and a Nagra IV SJ tape recorder. The magnetic tape was later used to analyze the spectral composition of the noise. The time period for each measurement was ten

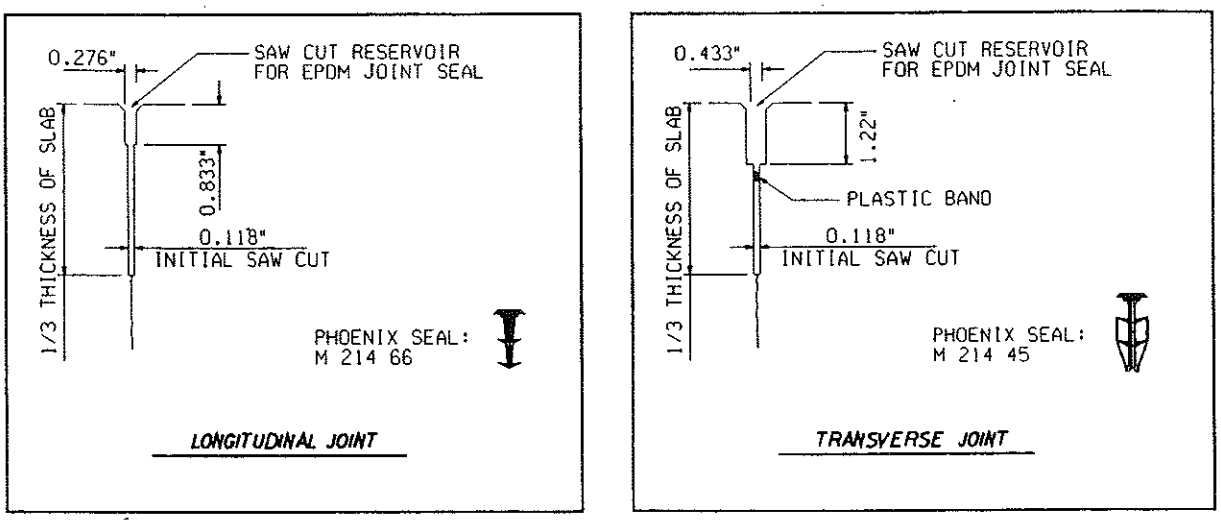

0.276"
SAW CUT RESERVOIR
FOR EPDM JOINT SEAL
1/3 THICKNESS OF SLAB
0.833"
0.118"
INITIAL SAW CUT
PHOENIX SEAL:
M 214 66
LONGITUDINAL JOINT
0.433"
SAW CUT RESERVOIR
FOR EPDM JOINT SEAL
1.22"
PLASTIC BAND
1/3 THICKNESS OF SLAB
0.118"
INITIAL SAW CUT
PHOENIX SEAL:
M 214 45
TRANSVERSE JOINT

Figure 3.

minutes. The Leq noise levels for the European pavement were 0.4 dBA quieter (76.0 vs. 76.4) than the Michigan pavement. The magnetic tape analysis at one octave band intervals showed the European pavement produced slightly more energy at 63 and 16K Hz, but produced less noise at 250, 2K, 4K, and 8K Hz. There was no significant difference for other octave bands.

Noise measurements were also made inside a 1991 Dodge Dynasty traveling at 50 mph with the windows closed and open. With the windows closed, the Leq noise level for the European pavement was 64.5 dBA versus 65.2 dBA for the Michigan pavement. With the windows open, the Leq noise level for the European pavement was 66.8 dBA versus 67.4 dBA for the Michigan pavement. The magnetic tape analysis showed only slight differences between the pavement types.

The study results indicate the exposed aggregate surface does not produce the expected reduction in noise levels that are perceptible to persons residing adjacent to the project or when traveling by car.

The results of the department's noise study were reviewed by Romain Buys, President of Robuco, Ltd. The following comments on the study were provided by Mr. Buys in a letter to Earl Knott, who is the United States representative for Robuco, Ltd.

- The exposed aggregate surface reduces noise levels most effectively between vehicle speeds of 56 mph and 75 mph.

- To reach optimal effectiveness, the longitudinal pavement profile should be as smooth (flat) as possible.

- Concrete safety barriers, like the New Jersey type used on I-75, have a tendency to reflect noise which skews test results, especially if barrier conditions on both sides of the pavement are not equal.

- Varying mix proportions of trucks and cars provide different noise levels, as trucks produce more noise than cars, especially on concrete pavements within a certain maximum volume of trucks.

CONCLUSIONS

Comparisons between first year and initial performance testing are limited, but the European pavement appears to be performing as expected, except for the disappointing results pertaining to the exposed aggregate surface as a means to reduce traffic noise levels. Specific points of interest about the project are summarized as follows:

- No surface distress features, except for minor popouts, have developed on the European pavement, in contrast to the Michigan pavement, where 50 percent of the pavement panels have one or two transverse cracks. No other surface distress features are evident on the Michigan pavement.

- The EPDM joint seals are performing satisfactorily. There is occasional "camelback humping" of the seal material indicating that the seal is compressing after installation.

- From visual observation, the exposed aggregate surface appears to have lost macro-texture in the two inner lanes of northbound I-75, where traffic was during most of 1994 while southbound I-75 was being reconstructed. This perception will be verified by sand patch testing in 1995.

- Over an approximate five month period, surface friction numbers increased, as expected, from an average 37.6 to 42.1 on the European exposed aggregate surface, and from 46.0 to 53.2 on the Michigan tinned surface.

- The exposed aggregate surface provides only a slight reduction (0.4 dBA) in exterior Leq noise levels, as compared to a reported (in Robuco, Ltd. literature) 4 to 5 dBA reductions with similar European projects. Interior car Leq noise levels are only reduced by similar levels, while reported reductions in Europe range from 3.5 to 4.5 dBA.

APPENDIX A

OFFICE MEMORANDUM

DATE: July 7, 1994

TO: Jon W. Reincke
Engineer of Research

FROM: Leo DeFrain
Supervising Engineer
Instrumentation & Data Systems Unit

SUBJECT: Noise Analysis of European Concrete
Research Project 72 G-189

This is in response to your request to analyze noise levels of traffic on the European Concrete on I-75 in Detroit.

Measurements were made at two locations using a General Radio and a B & K Type I noise level meters, and a Nagra IV SJ tape recorder. Figure 1 is a plan-view sketch of the measurement site. Measurement locations M_1 and M_2 were 56 ft from the near lane of I-75 traffic, approximately 1,400 ft apart. Location M_1 was used to measure the sound generated by the European pavement, and location M_2 was used to measure the sound produced by conventional rigid pavement. The first measurement was taken using a sound level meter and the Nagra tape recorder. A simultaneous measurement was made at location M_2 using the another meter. For the second measurement the meters remained in the same location, but the tape recorder was move to M_2. The time period for each of the two measurements was ten minutes. The following Leq noise levels were measured:

Measurement	Site	Noise Level, dBA Leq	Tape Level dBA Leq
1	Euro. M_1	75.9	76.0
	Standard M_2	75.7	
2	Euro. M_1	76.7	
	Standard M_2	76.1	76.4

The magnetic tape was analyzed to obtain the spectral composition of the noise. As shown in the table above, the overall noise level (Leq) of the European pavement was nearly the same (0.4 dBA difference). Figure 2 is a comparison of the frequencies at one

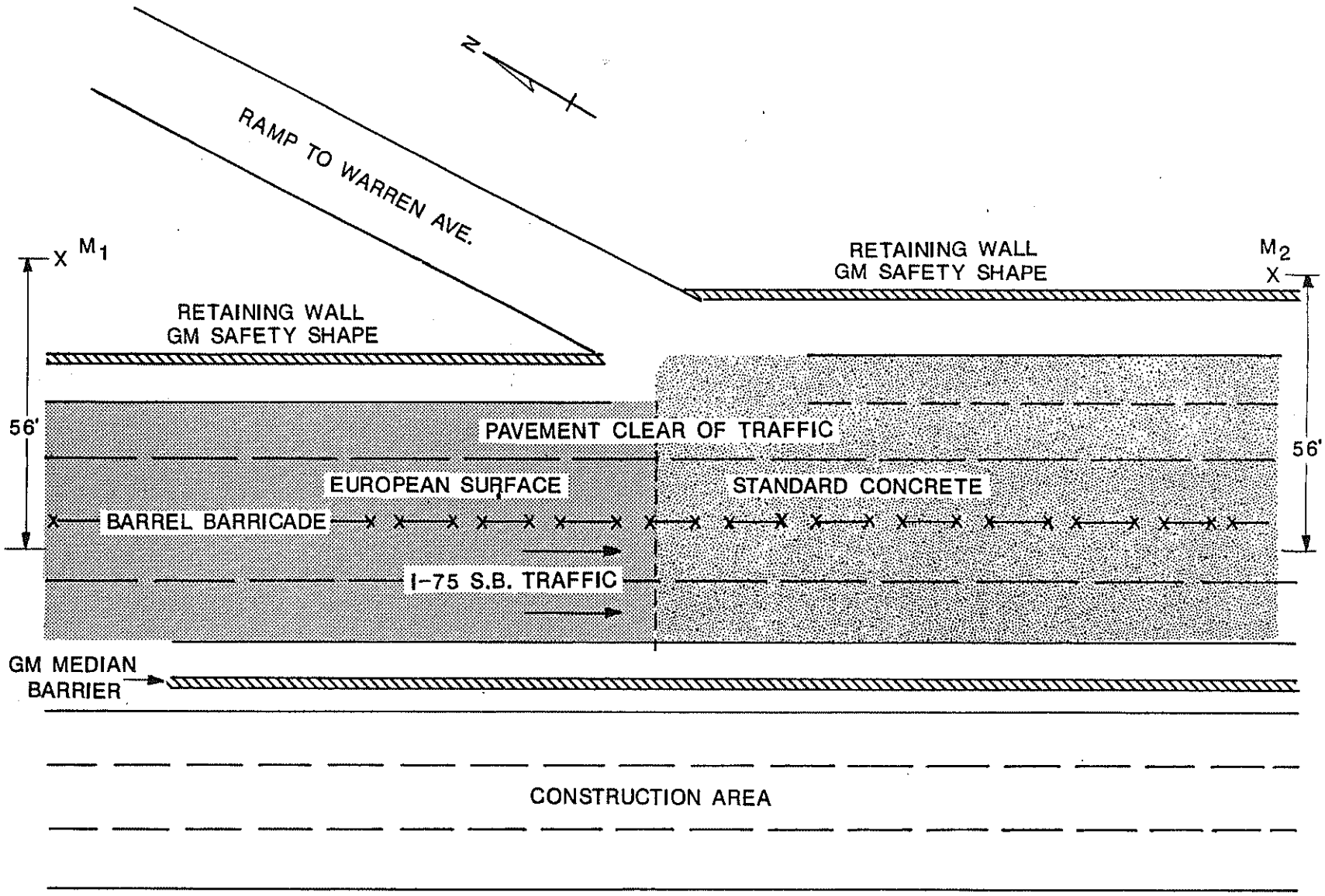


Figure 1. Noise analysis site of European Concrete and Standard Concrete.

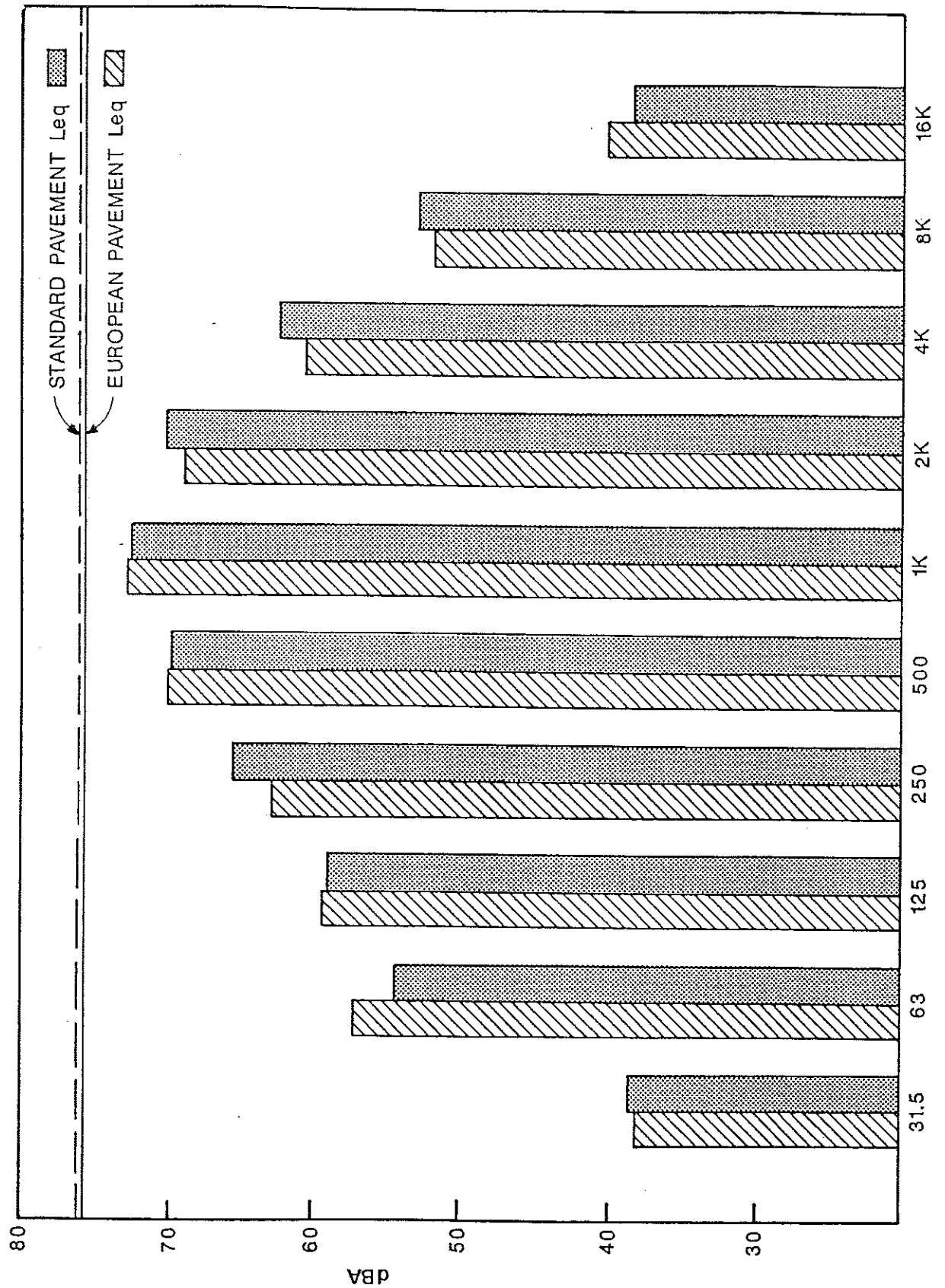


Figure 2. European Pavement study vehicle passby noise at 56 feet.

octave band intervals. The European pavement surface produced slightly more energy at 63, and 16K Hz, but produced less noise at 250, 2K, 4K and 8K Hz. The other four octave bands were nearly at the same noise level.

Noise measurements were also made inside a Dodge Dynasty traveling at 50 mph, with windows closed and windows open. The following Leq noise levels were measured.

Window Position	Noise Level, Leq		Nagra Tape Level, Leq	
	Euro.	Standard	Euro.	Standard
Closed	64.5	65.2	66.3	65.9
Open	66.8	67.4	66.7	67.4

The tape analysis showed that the European pavement produced less noise at 2K Hz when the windows were closed (see Figure 3). The noise level of the other nine frequencies were nearly the same. When the rear windows were open 3/4 inch, the European pavement produced less noise at 125, 250, and 2K Hz. The other seven frequencies were nearly at the same level (see Figure 4).

The noise level differences indicated above would not be perceptible to a person either inside or outside a vehicle located near the roadway. Our results show that the European pavement surface does not reduce the noise level produced by vehicles as compared to standard rigid pavement.

MATERIALS & TECHNOLOGY DIVISION

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Attachments

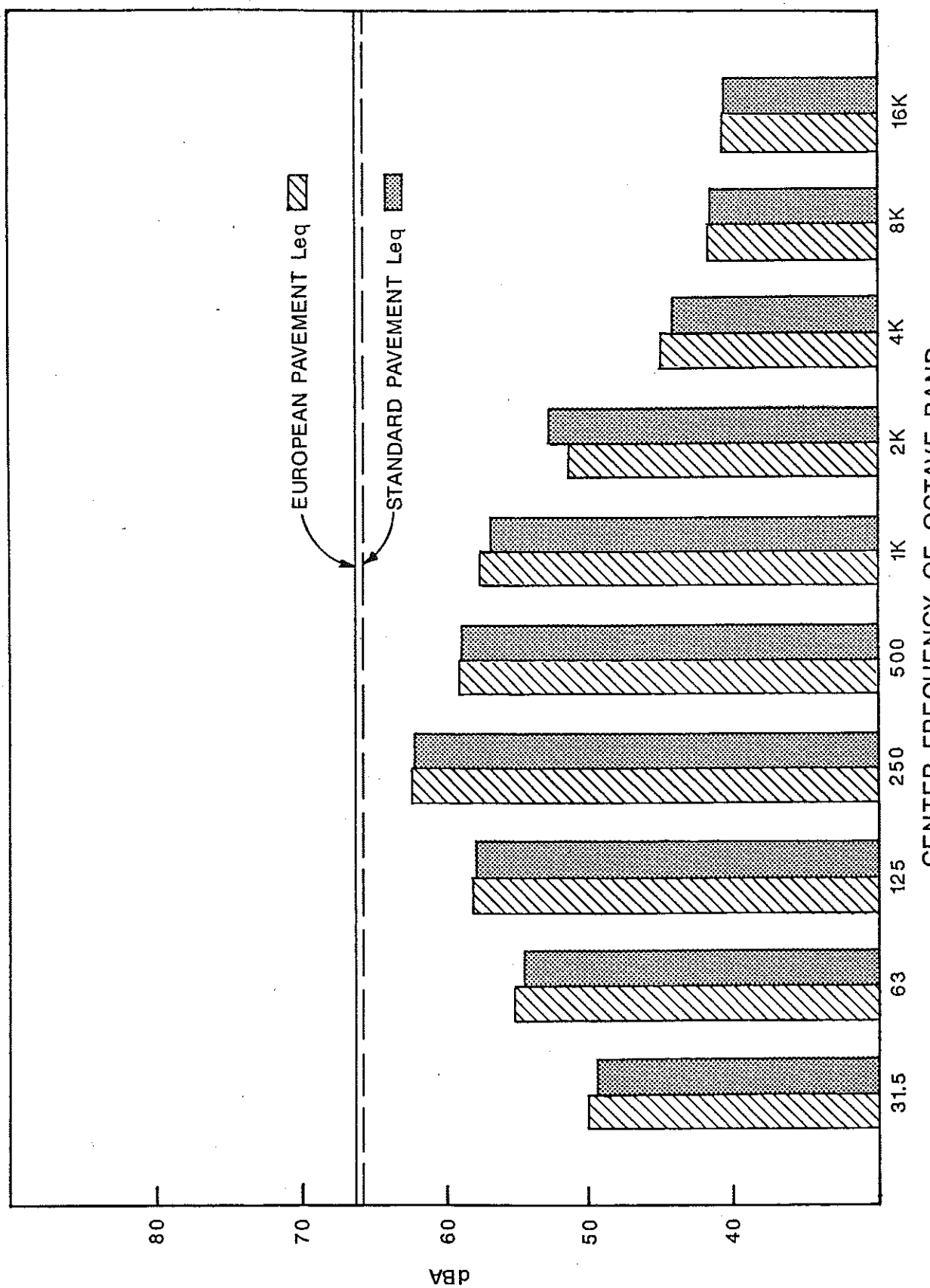

Figure 3. European Pavement study vehicle interior noise windows closed.

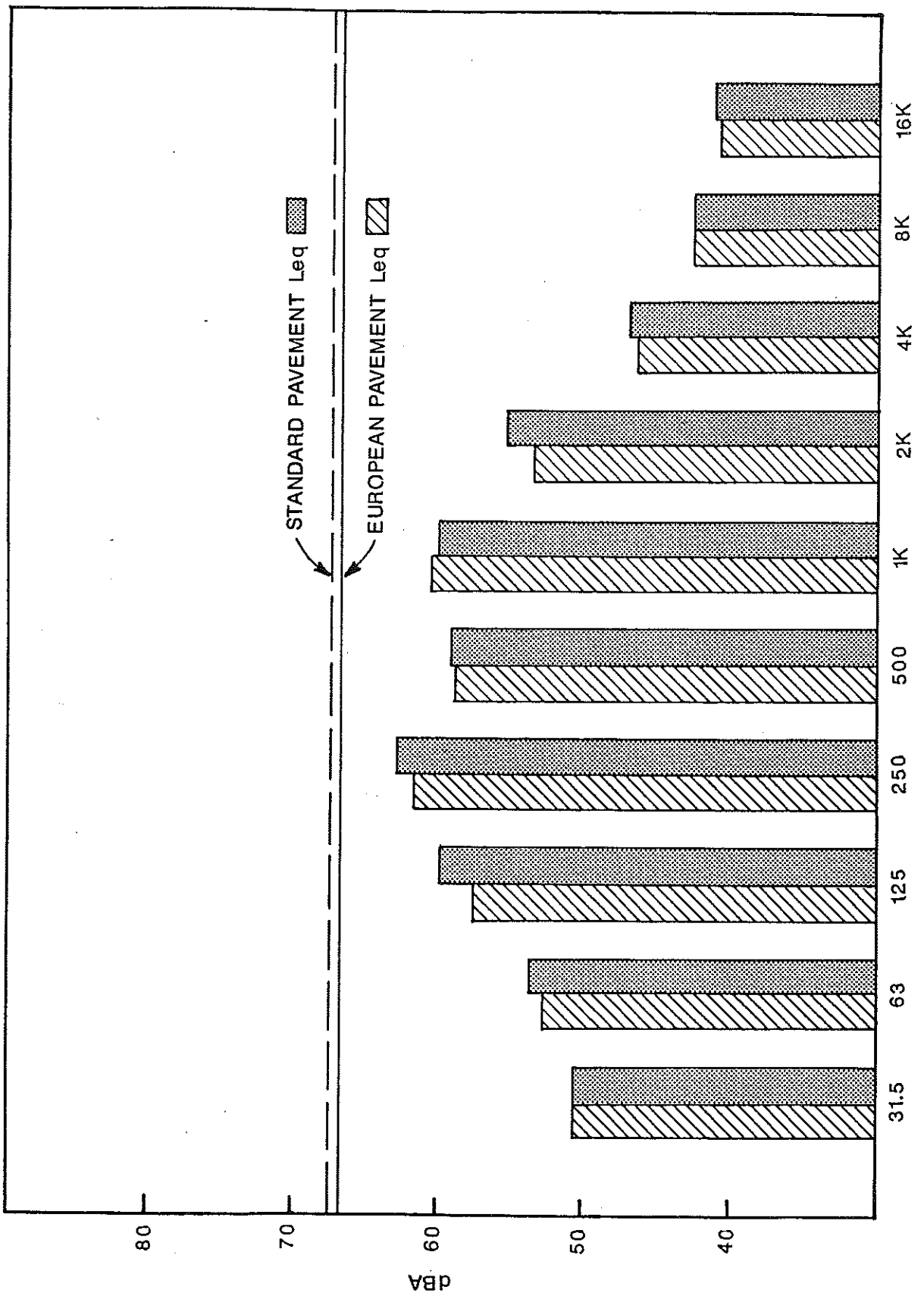

Figure 4. European Pavement study vehicle interior noise windows open.