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Rumble Pavements

State of California
Department of Public Works
Division of Highways
Materials and Research Department

July 1961

W.O. - 13U51H13
Lab. 100-R-6235

Mr. W. L. Warren
Engineer of Design
Division of Highways
Sacramento, California

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Dear Sir:

Submitted for your consideration is:

A REPORT ON

THE EFFECT OF SCORED CONCRETE SHOULDER STRIPS

ON THE STEERING AND BRAKING OF A VEHICLE

Study made by . . . . . Structural Materials Section
Under direction of . . . . . J. L. Beaton
Work supervised by . . . . . R. N. Field
Report prepared by . . . . R. N. Field, K. Leutner, R. Hamilton

Very truly yours,

F. N. Hveem

F. N. Hveem
Materials and Research Engineer

RNF/KL/RH:mw
cc: LRGillis
GMWebb
FMReynolds (Attn: DHAlderson (2)

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INTRODUCTION

In accordance with a request dated April 19, 1960, from the Design Department, full scale dynamic skid tests were conducted on two designs (Exhibit 1) of scored concrete shoulder strips submitted to this department for study. The strips are each 24" wide and 6" deep with transverse serrations across the top surface. On one strip the raised serrations are spaced at 4" centers and on the other at 8" centers. The purpose of the serrations is to warn a motorist that his vehicle is contacting the strip.

This report describes the procedures used in evaluating the strips for any adverse effects on the control of a vehicle as well as a discussion on the relative merits of the two designs in alerting the motorist to hazardous conditions.

It is the purpose of this report to evaluate the reaction of a vehicle contacting a scored concrete shoulder strip in light of the available test data and observations.

It was suggested by the Design Department in a letter from Mr. Langsner to Mr. Hveem dated April 19, 1960, that the following items would be indicative of the efficiency of the two designs in warning a motorist without being hazardous under any normal driving conditions:

1. At high speeds does the tire contact only the tops of the ridges?

2. Does the car "pull" when riding over the scoring?

3. Is braking distance increased?

4. Does the car swerve when braking on the scored strip?

5. Is there any bouncing when riding on the scored strip?

In addition to the above items, the efficiency of each design was evaluated as to providing an audial indication that would serve to alert the driver of a vehicle.

The above five items were to be tested at high and low speeds on wet and dry pavements for each design. (No high speed or wet pavement tests were conducted at the Loomis test site on the 4" design because of the limited tangent section available and also the traffic conditions.)

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FINDINGS

TIRE CONTACT

1. The measured length of tire contact transverse to the serrations of the 8" design under locked wheel braking and unlocked wheel braking conditions averaged approximately 7 lineal inches. Tire contact patterns were similar for all speeds from 35 mph to 75 mph. Static and dynamic measurements of the length of tire contact under conditions of no braking were also approximately seven lineal inches.

The length of tire contact between the serrations on the 4" design was approximately 3 inches under similar conditions.

STEERING EFFECT

2. As indicated in Exhibit 2, there is no measurable increase or decrease in torque or "pull" in the steering system when driving from normal pavement to the 8" scored strip at speeds from 30 mph to 70 mph. Observations from repeated test runs on the 4" design indicate that there is no apparent change in torque in the steering system under normal driving conditions on curved or tangent sections of the scored shoulder strip.

BRAKING DISTANCE

3. The following tabulation indicates that there is no significant difference in braking distance under locked-wheel skid conditions between asphalt pavement and the scored shoulder strip.

Speed	Approximate Stopping Distance	Conditions
	4" Scored Strip	
35	50 ft.	Dry Scored Strip
40	55 ft.	Dry Asphalt Pavement
	8" Scored Strip	
55	125 ft.	Dry Asphalt Pavement
55	125 ft.	Dry Scored Strip
55	100 ft.	Wet Scored Strip
65	150 ft.	Wet Asphalt Pavement
65	150 ft.	Wet Scored Strip
65	150 ft.	Dry Scored Strip

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In the above tests on the 4" scored strips, the right front and rear tires were in contact with the strip for the full stopping distance. On the 8" scored strip, the right front and rear tires were in contact for the first 100 feet only.

The coefficient of friction on the dry asphalt pavement adjacent to the 8" test strip was determined to be 0.36 by calculations from the wheel tracks and 0.36 to 0.40 by actual skid resistance tests with a smooth tire on wet pavement at 50 mph. The coefficient of friction of the concrete surface of the strip transversely to line of travel was determined to be 0.22.

BRAKING SWERVE

4. There was no swerving or drifting of the vehicle on any of the locked-wheel skid tests while the vehicle tires were in contact with the strips. All recorded swerving or spinning occurred after the vehicle had passed beyond the limits of the test strips. No apparent difference in vehicle reaction was noted between tests on wet or dry strips.

WHEEL BOUNCE

5. High speed film records of the vehicle wheels passing over the 4" and 8" scored strips show there is no measurable wheel bounce under any of the test conditions.

AUDIBILITY

6. Vibration tests conducted on the 8" design with a 1958 Chevrolet sedan indicate that the natural frequency of the wheel and suspension system is approximately 13 cycles/sec. The oscillograph records show that this natural or resonant frequency is independent of speeds over 30 mph. It can therefore be deduced from measurements and observations that the vehicle wheels will not follow the contour of the 8" serration at speeds of more than 10 mph. Thus the transition from vibrations which may be felt by the driver to sound emanating from the contact of the tires on the 8" strip will occur at a speed of over 10 mph. The pitch or frequency of the sound reaching the driver therefore becomes the important factor in warning the motorist of a hazardous condition.

In comparing the two designs for effectiveness in alerting the motorist, the higher pitched sound produced by the 4" strip at speeds of 40 to 60 mph is more audible than the low pitched sound produced by the 8" design. Sound level measurements verify that the higher pitch of the 4" design produces a greater decibel rise in noise level over the random background noise from the wind and engine (see Exhibit 3).

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TEST PROCEDURES AND INSTRUMENTATION

A 100 foot test section of the 8" scored strip was constructed at the Franklin Airport for the purpose of conducting high speed, locked wheel skid tests. The concrete section was placed on an asphalt pavement excavated to the depth and width shown on the plans (see Exhibit 1). The test site provided adequate space for controlled locked wheel skids up to 107 mph.

Each test was recorded with a 16 mm cine camera running at 24 frames/sec. For data on the wheel bounce, a 2000 frame/sec camera recorded 3 high speed and 3 low speed tests. The camera was placed adjacent to the strip shooting through a 2" square grid to a close-up of the vehicle wheel passing over the strips. The center of the hub caps was targeted under dynamic conditions by spinning the wheels while indicating the center.

Three tests were conducted at each speed, one on the pavement adjacent to the strip, one with the right wheels contacting a dry strip, and a third with the right wheels contacting a wet strip.

Torque measurements of loading transmitted to the periphery of the steering wheel when riding on the strip and on the pavement were made with an SR-4 strain gage attachment and recorded on a Brush Oscillograph for speeds from 30 to 70 mph.

For tests on the 4" design, the Loomis south bound on-ramp was selected. The geometry of the ramp restricted the speeds to 40 mph for the locked wheel braking tests; therefore no data is available at the higher speeds on this design. A 2000 frames/sec camera recorded the wheel reaction during three locked wheel skid tests and one non-locked wheel braking.

For direct measurements of tire contact transverse to the serrations, a thin layer of steel sash putty was troweled on the surface of the 4" strip. A thin calcimine coating was applied to the 8" strip for recording tire contact patterns.

The test vehicles for locked-wheel skid tests on the 8" design at the Franklin Airport were 1959 Dodge Coronet sedans equipped with 7.60 x 15 - 6 ply tires inflated to approximately 32 psi. Test drivers and vehicles were furnished by the California Highway Patrol. The test vehicle used for the low speed locked wheel skid tests on the 4" design at the Loomis Interchange was a 1958 Chevrolet sedan equipped with 7.50 x 14 - 4 ply tires inflated to approximately 32 psi. The vehicle was driven by Materials and Research Department personnel.

Sound pressure level measurements were made with a Rudmose Sound Analyzer Model RA-100, in the "A" scale position.

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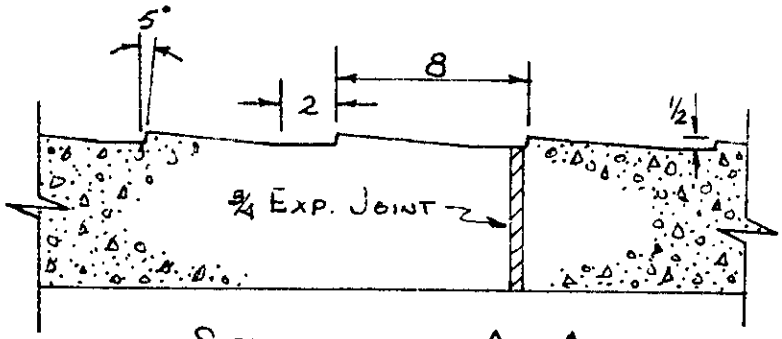

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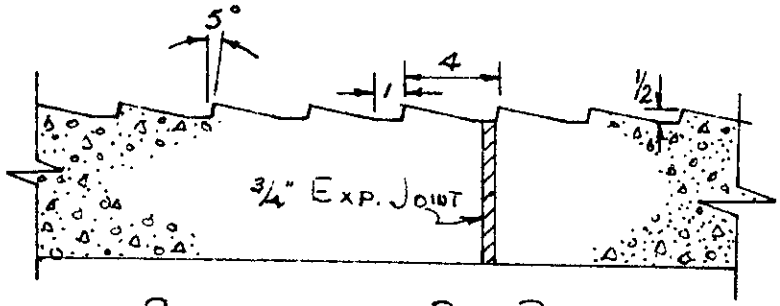

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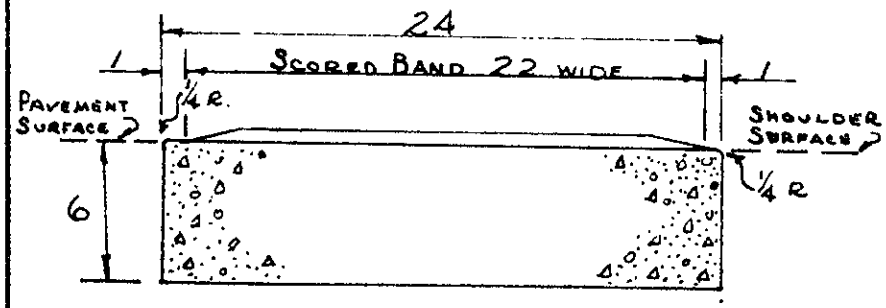
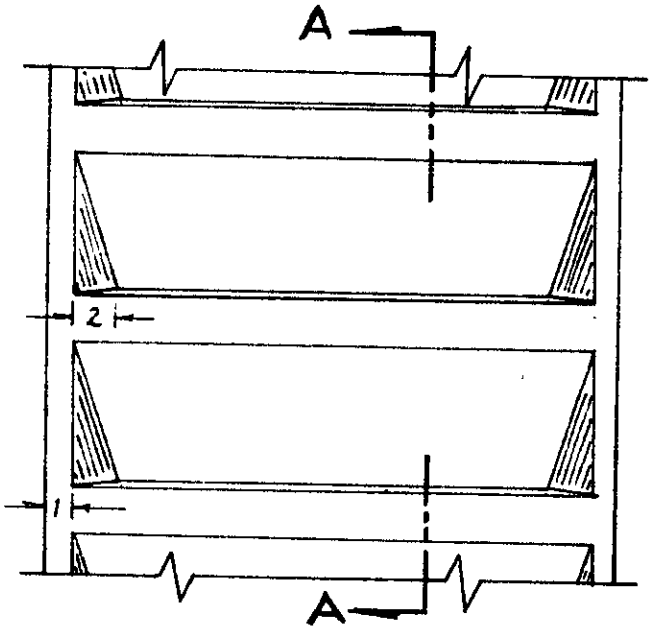
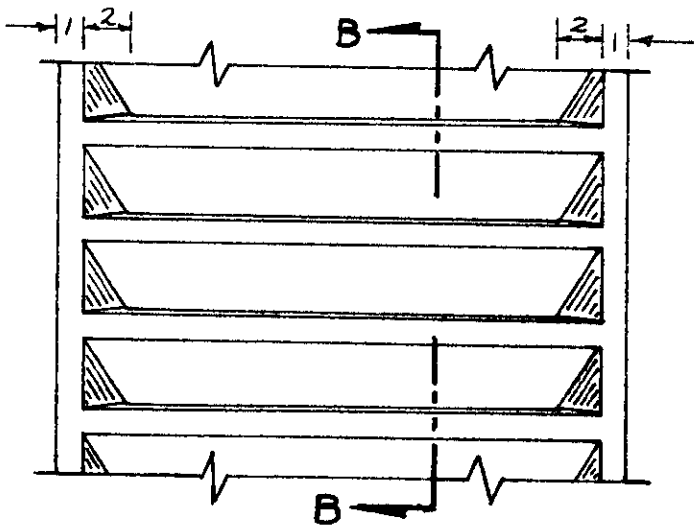


ELEVATION ~ TYP.



8" DESIGN ~ PLAN



4" DESIGN ~ PLAN

SCORED CONCRETE
SHOULDER STRIP
8" & 4" DESIGNS

SCALE: 1/8" = 1'-0"

EXHIBIT 1

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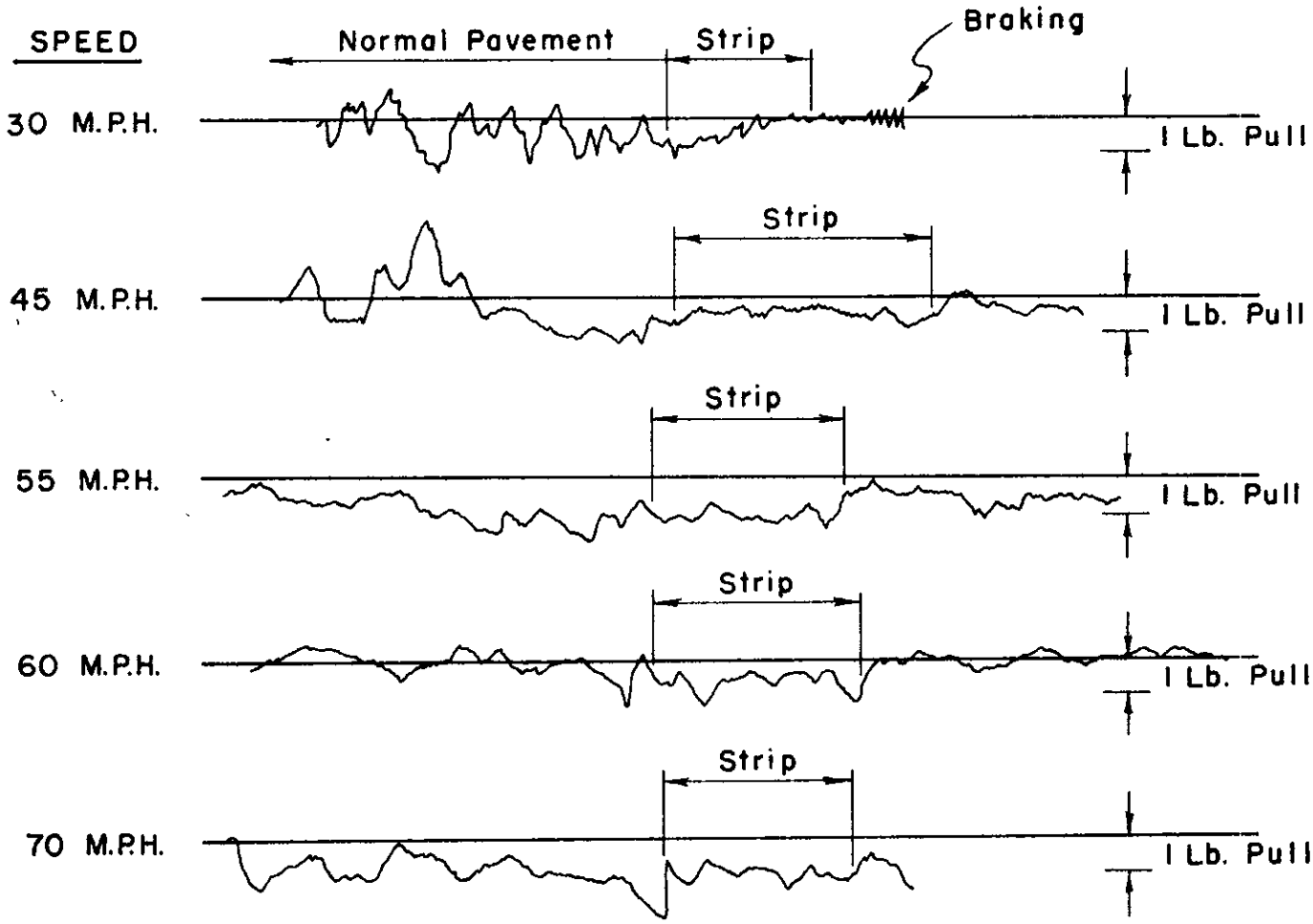

8" SPACING - SCORED CONCRETE SHOULDER STRIP

Load Transmitted to Periphery of Steering Wheel

Vehicle: 1961 Chevrolet Station Wagon

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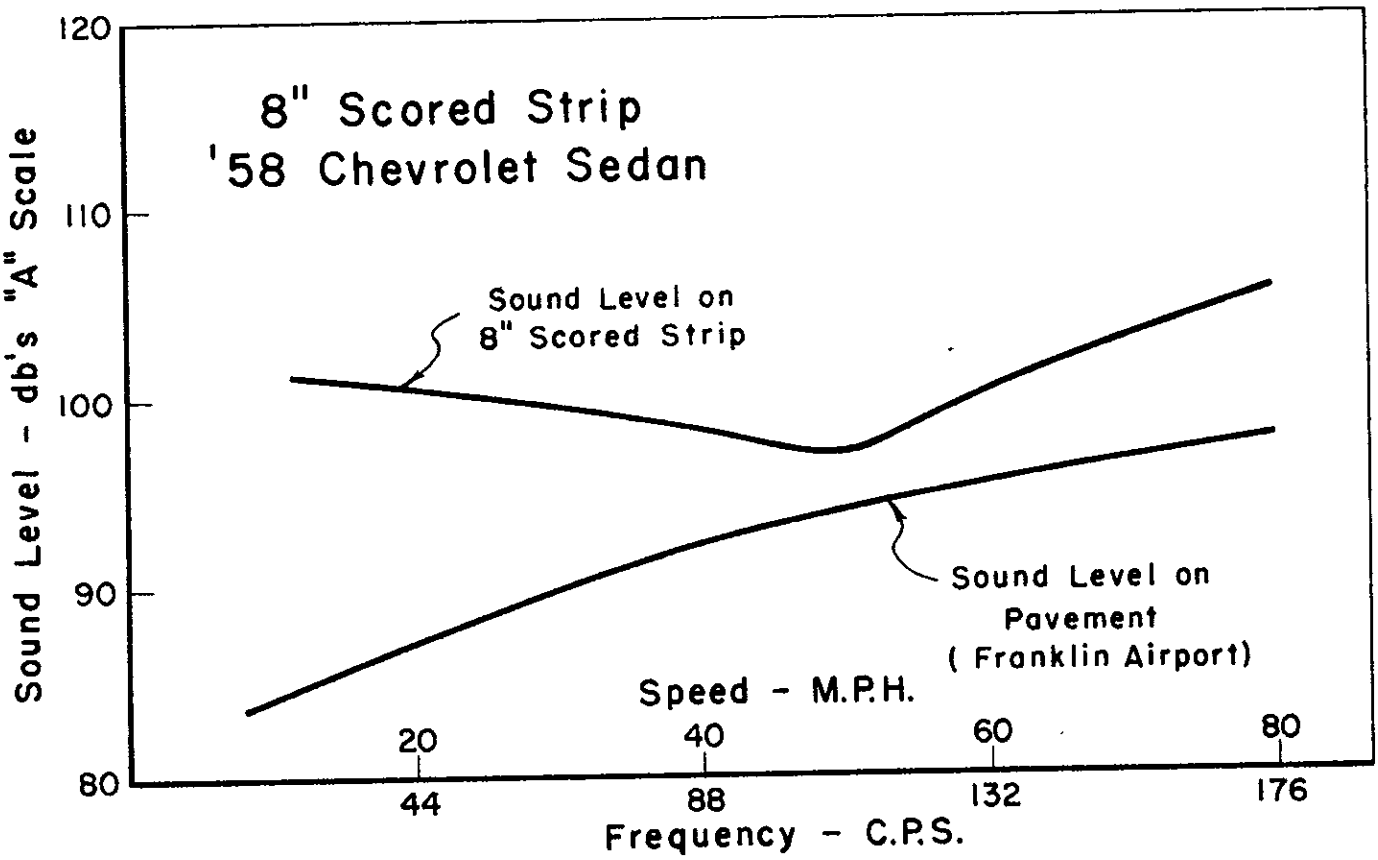
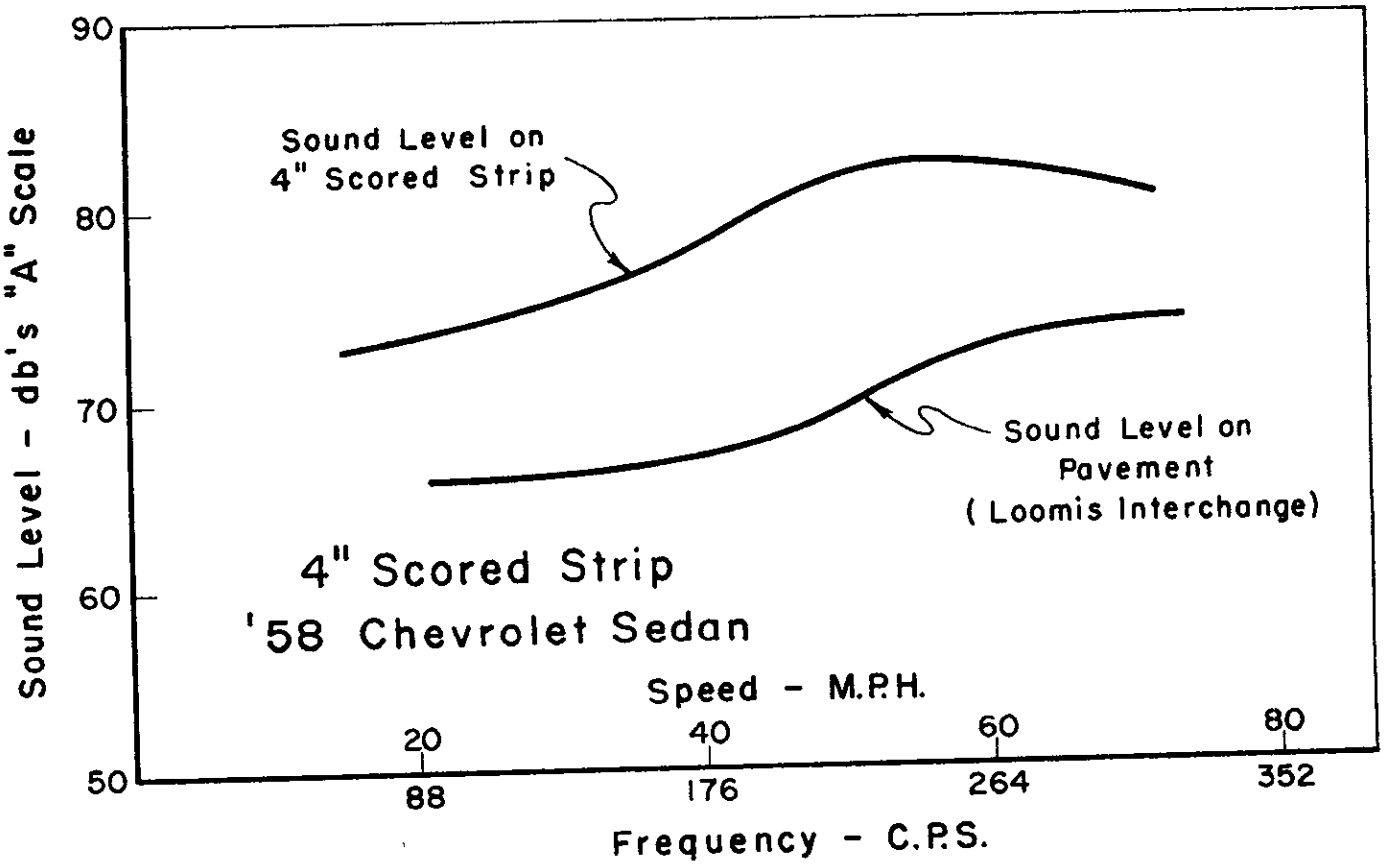
AVERAGE SOUND LEVEL





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