TEXAS HIGHWAY DEPARTMENT

SHOULDER DESIGN AND CONSTRUCTION PRACTICES

ROAD DESIGN DIVISION

SEPTEMBER 1955

Discussion of Shoulder Design and Construction Practices in Texas

Planning Instructors School
Austin-September 28,29 & 30, 1955

Definition and Purpose of Shoulders

Under approved nomenclature a shoulder is defined by the American Association of State Highway Officials as "The portion of the roadway contigous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support and surface courses". Thus the shoulder serves two major purposes, (1) to provide a stable area for off road parking or stopping of all vehicles and (2) to provide lateral support for pavement in the traveled way. The proper width and stability of a shoulder is dependent upon two principle factors (1) the volume and character of traffic using the road and (2) the cost of material to construct the shoulder.

Modern design practice has created other uses for the shoulder which are incidental to this discussion but are mentioned in passing. By proper design a shoulder can be used for a speed change lane for traffic interchanging between high speed highways and local roads and streets. In many cases the shoulders on two lane roads are being converted to climbing lanes on hills to accommodate slow moving heavily loaded trucks.

A complete discussion on shoulder warrants and design is included in "A Policy on Geometric Design of Rural Highways", AASHO 1954. This publication has been furnished every Resident Engineers' office in Texas and is available to all the members of this school. The discussion is of such general nature that i t adequately covers practically all possible types of shoulders. It is believed to be of such general nature that it will adequately cover the variety of practices as they now exist in Texas.

Legal Requirements for Vehicles Using Texas Highways

In recognition of the many accidents caused by vehicles running into stopped vehicles on the highways the motor vehicle laws include a provision that "no person shall stop, park, or leave standing any vehicle, whether attended or unattended upon the paved or main traveled part of the highway when it is possible to stop, park, or so leave vehicle off such part of said highway but in every event the unobstructed width of the highway opposite a standing vehicle shall be left for the free passage of other vehicles, etc." In the interest of safety and to cooperate with the traffic laws it is the Department's policy to provide a place for stopped vehicles wherever it is possible. Where shoulder materials are relatively inexpensive they should be constructed for low traffic highways. On the other hand there may be cases where suitable shoulder materials are not available locally and parking shoulders can be justified only for through highways. In the latter case it is often necessary to ship materials in from other counties or districts.

Shoulder Practices in Texas

All of us who have traveled over Texas highways realize that there is a wide variety of shoulder types in this State. If you have traveled outside of Texas the variety increases with every State and sub-division thereof. Considerable criticism is being expressed by the layman because of the variety of practices. There is also criticism among those of us in the highway engineering profession. It is usually being levelled at those who disagree with an individual's particular philosophy of design. I would like for you to take note of the fact that the Road Design Division has, up until this time, remained neutral on the subject. This traditional neutrality of the Design Division is deep rooted and goes back into the formitive years of the Department. Shoulder design has always been looked upon as a maintenance operation.

The appearance of the road, the desires of the public, the effects of wind and rain erosion, the cost of materials and other variables are best judged by the personnel of the several districts. Only when sharply different shoulder designs appear at a district line do we in the Headquarters Office become concerned. It is not wholly a matter of disagreement between the Headquarters Office and a district nor between districts. It is becoming a matter of concern with the traveling public, our employers, and it is well that we take inventory of our practices.

The following series of slides will demonstrate most of the practices which exist in Texas today. It should be understood that this discussion pertains to two lane highways carring traffic volumes above about 1,000 v.p.d. Cost of materials and climatic conditions may cause this figure to vary between 500 v.p.d. and 1500 v.p.d.

<u>Slide 1</u> (Flexible Base, Asphalt Concrete Pavement, Surfaced Shoulders).

Shoulders of this type will carry approximately the same weight load as the adjacent traveled way. A slight reduction in the depth due to slope correction will not materially affect the load carrying capacity because of the lower frequency of load application. According to conclusions reached in the WASHO Road Test the load carrying capacity of a roadway is increased when the shoulders are sealed. For the particular conditions existing under that series of test it was found that a 14" depth flexible pavement with paved shoulders had a load carrying capacity equal to 18" depth pavement with unsurfaced shoulders. There are many proponents of this design and the majority of the projects being submitted into the Austin office are of this type. The advantages are listed as follows:

(1) Maintenance costs are less.

(2) Strength of base is greater.

(3) Truck traffic on the roadway travels further apart laterally because of the feeling of safety when nearing the outer edge of pavement. (A recent study on the Effect of Lane Widths supports this statement.

Compare Figures 1 and 4 in that publication.)

(4) Under emergency conditions traffic can use the shoulder as part of the traveled way, at least on short sections. Examples: for climbing lanes and for channelization at intersections or for passing bays over hill crests.

Disadvantages are:

(1) For extremely high volumes, traffic may use the facility as an undivided four lane road on all sections of the highway.

(2) All bridges should be crown width unless expensive channelization devices are employed.

(3) Unless the depth of pavement is at or near wheel load design requirements structural failures will result.

(4) It may be difficult to maintain the color differential.

Slide 2 (Portland Cement Concrete Pavement, Flexible Base Shoulders with Asphalt surface).

The advantages and disadvantages of this type of section are similar to those in Slide 1. This section is shown in order to show the relation between the shoulder base depth and the subgrade treatment under the concrete pavement. It is suggested that the 4" minimum be adhered to only where base material is extremely expensive. It is recommended that the usual depth of subgrade treatment be approximately 6 inches, and the shoulders be made a depth necessary to support design wheel loods. It should be noted that one additional problem will be encountered in the maintenace of this kind of section, namely, there is danger of a slight opening between the concrete pavement and flexible pavement after a few years have passed. Such opening will permit excess moisture and result in seasonal expansion of subgrade soils.

Slide 3 (Flexible Base, Asphaltic Concrete Pavement and Combination of paved and open shoulders)

The section shown on Slide 3 is believed to have originated as a device to widen substandard 18 and 20 foot pavements. In recent years it has been proposed on shoulder rehabilitation projects where rather high traffic volumes have a wearing away effect on unsurfaced shoulders. The advantages are listed as follows:

(1) Maintenance costs are reduced some but not as great as for the section shown in Slide 1.

(2) Lateral support is afforded the pavement at the roadway edge.

(3) Traffic on the traveled way will travel further apart transversaly because of the feeling of safety when nearing the outer edge of pavement.

Disadvantages are:

(1) Maintenance costs are greater, because of the unsurfaced areas.

(2) The traveling public will attempt to stop on the narrow unpaved portions of the shoulder not knowing that the narrow paved strip is not part of the pavement. For a great part of the State such shoulder will not be stable unless expensive materials are used and if expensive materials are used good economics dictate surfacing to preserve and retain materials.

Slide 4 (Trenched Flexible Base, Asphalt Concrete Pavement and Combination sod and Paved Shoulders).

This section has been used primarily in an area where flexible materials are scarce and where climatic conditions are such as to encourage the growth of sod. The advantages are listed as follows:

(1) The pavement is sufficiently wide to accommodate ordinary two lane traffic volumes.

(2) It is less expensive because sod shoulders can be maintained on select material usually obtained from roadway excavation.

Disadvantages are:

(1) For large traffic volumes the wearing away of the sod edges often makes it desirable or necessary to widen the base.

(2) The sod part of the shoulder is too narrow to accommodate stopped vehicles.

(3) The sod shoulder will not support heavily loaded trucks during wet weather and for present loads is not always stable in dry weather.

Slide 5 (Flexible Base, Asphaltic Concrete Pavement and open Shoulders).

In recent years this section has been predominate throughout most of West Texas particularly the Edwards Plateau area. It has been constructed of relatively cheap material and losses through erosion have been easy to replace. However, in recent years many District Engineers have found it economical to surface the shoulders and convert to a section identical as shown in Slide 1. Where base depths are adequate a single surface treatment is all that is necessary to convert to the Slide 1 section. The cost is approximately $1500 per mile. The advantages are listed as follows:

(1) The first cost is more economical as compared to any other types of shoulder treatment when full width is provided.

(2) It keeps all traffic channelized on the traveled way and makes it possible to build shoulders of minimum depth.

(3) It is possible to construct minimum width bridge structures.

Disadvantages are:

(1) According to many District Engineers the added cost of shoulder maintenance will more than offset the cheaper construction cost.

(2) Inadequate lateral support is provided at the edges particularly where previous materials are used. Frost damage is general heavy where the base materials are pervious.

(3) A seeming narrowness of the 24 foot roadway is felt because traffic will not travel near the outer edges.

(4) Unless stable and impervious materials are used it is difficult to provide for stopping and parking of extremely heavy loads during wet weather.

Slide 6 (Flexible Base, Asphaltic Concrete Pavement, open shoulders).

A few sections of this type have appeared in designs during the past few years. The proponents of this section claim the following advantages:

(1) A spacious width roadway is provided and accidents are reduced. Limited statistics bear this out. (Analysis by D-18 covering period between July 1, 1954 and January 1, 1955)

(2) Since the advent of the modern automobile and truck and taking into account their near mechanical perfection stopping and parking places are no longer needed.

(3) The maintenance of a pavement of the same color is less burdensome as compared to maintaining pavement and shoulders of contrasting colors.

Disadvantages are:

(1) Since recent studies on Effect of Lane Width prove that traffic follows a path near the middle of a lane, whatever the width, there would be no effective shoulder for stopped vehicles. (See Figure 11 of that publication)

(2) For high volumes, traffic may use the facility as a three or four lane road.

ACCIDENT ANALYSIS
BY WIDTHS OF RURAL TWO-LANE HIGHWAYS

ACCIDENTS FROM 7-1-54 THROUGH 12-31-54

WIDTH OF 2 LANE PVT.	14-15 Feet				16-17 Feet				18-19 Feet			
	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total
TOTAL ACCIDENTS	1		5	6	10	64	114	188	131	747	1379	2257
NON-COLLISION					6	28	24	58	59	276	321	656
RIGHT ANGLE						6	6	12	11	43	42	96
HEAD ON						1	3	4	9	23	15	47
SIDESWIPE SAME						1	8	9	5	27	98	130
SIDESWIPE OPPOSITE			1	1	2	7	17	26	7	88	181	276
LEFT TURN			2	2		2	16	18	3	70	192	265
RIGHT TURN						1	4	5		9	31	40
REAR END			2	2		3	12	15	4	68	161	233
PARKING ACCIDENT										1	1	2
FIXED OBJECT					1	11	14	26	23	117	179	319
OTHER	1				1	4	10	15	10	25	158	193

WIDTH OF 2 LANE PVT.	20-21 Feet				22 Feet				23-26 Feet			
	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total
TOTAL ACCIDENTS	153	1002	1846	3001	81	511	999	1591	152	868	1701	2721
NON-COLLISION	53	270	362	685	30	130	181	341	38	212	299	549
RIGHT ANGLE	11	53	83	147	2	31	36	69	5	43	75	123
HEAD ON	19	39	10	68	11	21	3	35	28	30	8	66
SIDESWIPE SAME	2	45	144	191		31	79	110	10	40	151	201
SIDESWIPE OPPOSITE	14	122	204	340	12	57	98	167	31	126	165	322
LEFT TURN	8	111	235	354	2	58	127	187	3	94	249	346
RIGHT TURN	1	11	39	51	1	4	28	33		11	47	58
REAR END	8	141	316	465	5	80	182	267	8	155	325	488
PARKING ACCIDENT		1		1	1	1	1	3			2	2
FIXED OBJECT	26	159	210	395	10	71	113	194	12	115	174	301
OTHER	11	50	243	304	7	27	151	185	17	42	206	265

WIDTH OF 2 LANE PVT.	27-29 Feet				30-32 Feet				33-35 Feet			
	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total
TOTAL ACCIDENTS	6	24	28	58	6	25	40	71	0	8	11	19
NON-COLLISION	1	5	5	11		8	11	19		1		1
RIGHT ANGLE					2			2			1	1
HEAD ON	1	1		2	1			1				
SIDESWIPE SAME		4	5	9		1	3	4				
SIDESWIPE OPPOSITE		4	4	8	1	1	5	7		1	1	2
LEFT TURN		2		2		4	4	8			1	1
RIGHT TURN			1	1			1	1				
REAR END	1	5	6	12		4	6	10		2	5	7
PARKING ACCIDENT												
FIXED OBJECT	1	3	3	7		6	7	13		3	2	5
OTHER	2		4	6	2	1	3	6		1	1	2

WIDTH OF 2 LANE PVT.	36-39 Feet				40-43 Feet				44 Feet				45 Feet & Over				Totals			
	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total	Fat.	P.I.	P.D.	Total
TOTAL ACCIDENTS	1	2	11	14	0	2	4	6	0	0	0	0	0	0	1	1	541	3253	6139	9933
NON-COLLISION	1	1	3	5		1		1												
RIGHT ANGLE		1		1																
HEAD ON						1		1												
SIDESWIPE SAME																				
SIDESWIPE OPPOSITE			2	2			1	1												
LEFT TURN			2	2																
RIGHT TURN																				
REAR END			2	2			2	2												
PARKING ACCIDENT																				
FIXED OBJECT																				
OTHER			2	2			1	1												

WIDTH OF 2 LANE PVT.	14-15 Feet	16-17 Feet	18-19 Feet	20-21 Feet	22 Feet	23-26 Feet	27-29 Feet	30-32 Feet	33-35 Feet	36-39 Feet	40-43 Feet	44 Feet	45 Feet & Over	Totals
TOTAL MILES OF ROAD	45	1643	18252	10831	5331	6075	229	588	85	167	116	22	73	
DAILY VEHICLE MILES	15,759	625,879	7,427,239	10,700,627	6,659,270	13,578,097	364,224	1,230,554	337,730	698,487	519,079	82,816	279,447	
FATAL ACCIDENT RATE	34.8	8.77	9.66	7.83	6.67	6.10	9.03	2.68	0	0.79	2.11	0	0	
TOTAL ACCIDENT RATE	209	165	166	154	131	109	87.5	31.7	30.8	11	6.32	0	1.96	

ACCIDENT RATES ARE NUMBER OF ACCIDENTS PER 100,000,000 VEHICLE MILES   Fat. = FATAL ACCIDENT   P.I. = INJURY ACCIDENT   P.D. = PROPERTY DAMAGE ACCIDENT

(3) All bridges should be crown width unless expensive channelization devices are used.

Conclusions

Various shoulder types have been shown as a means of acquainting you with what the several districts are doing. It is doubtful whether the Department can or should ever attempt standardization of shoulder design. The great variety of natural conditions would make it impossible to duplicate designs in the extremes of Texas geography and climate.

However it can be argued that traffic needs as regards shoulders remain constant. These basic needs are considered to be:

(1) On the arterial routes a continuous shoulder type is desirable. Also, uniform signs specifying the permitted use of the shoulder are necessary for intelligent guidance of the public.

(2) The shoulder area should be readily identified by use of color or texture differing from that of the traveled way pavement. Otherwise traffic will use the shoulder area as part of the traveled way and no space would be available for stopped traffic except in the traveled way.

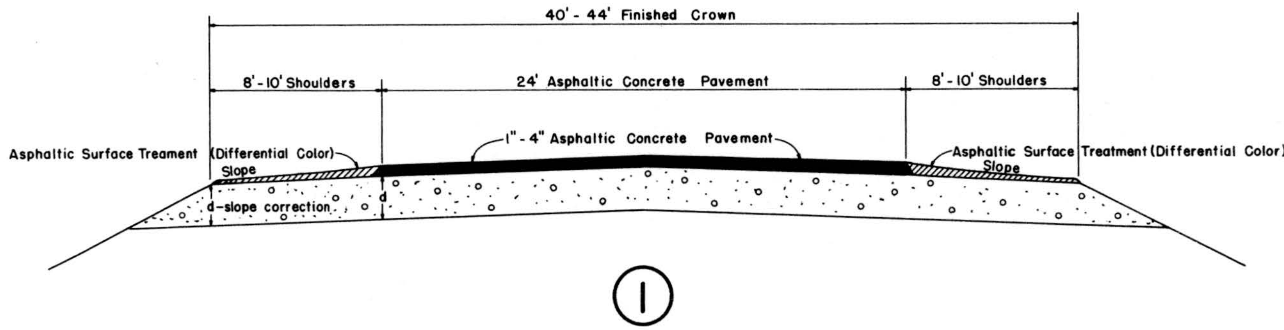
(3) All shoulders should be stable nearly all the time. The structural design of the stable shoulder should provide for the same load which will use the contiguous traveled way with allowance for reduced frequency of application.

(4) In areas of the State where economic conditions preclude construction of shoulder types outlined above it is considered desirable to provide traveled ways 26 or 28 feet, in width constructed on bases two to four feet wider than the traveled way. For this condition all sod shoulders

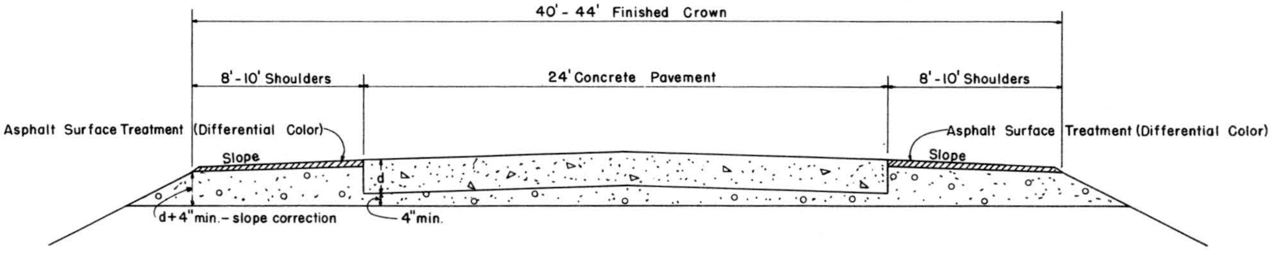
and substandard depth flexible shoulders should be constructed as narrow as standards will permit and marked as unstable and not for use except for emergency conditions.

(5) Roadway sections recommended by D-8 are shown on Slides 7 and 8.

Research should be continued in order to ascertain the advantages and disadvantages of various width shoulders in combination with traveled way of the 26, 28 and 30 foot widths. It is expected that such information may be available when the Bureau of Public Roads completes placement studies being made on the rural roads of some of the western states.



FLEXIBLE BASE
ASPHALTIC CONCRETE PAVEMENT
SURFACED SHOULDERS



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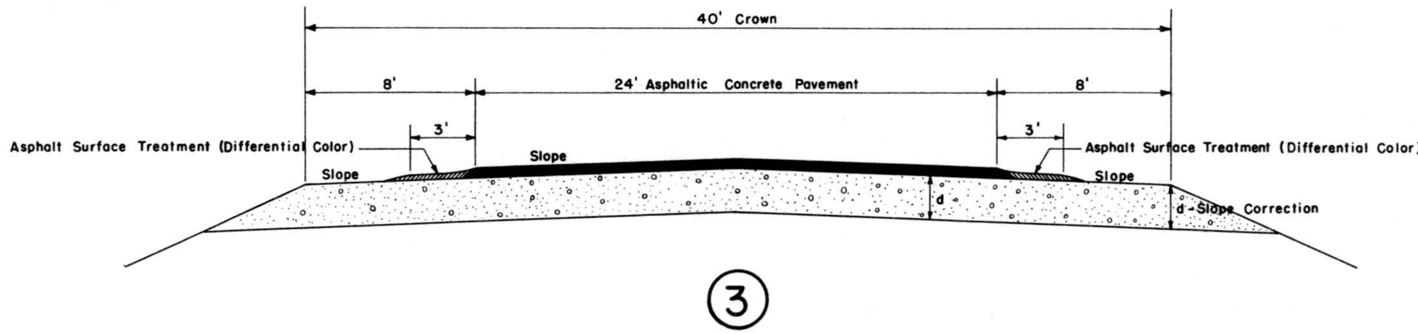
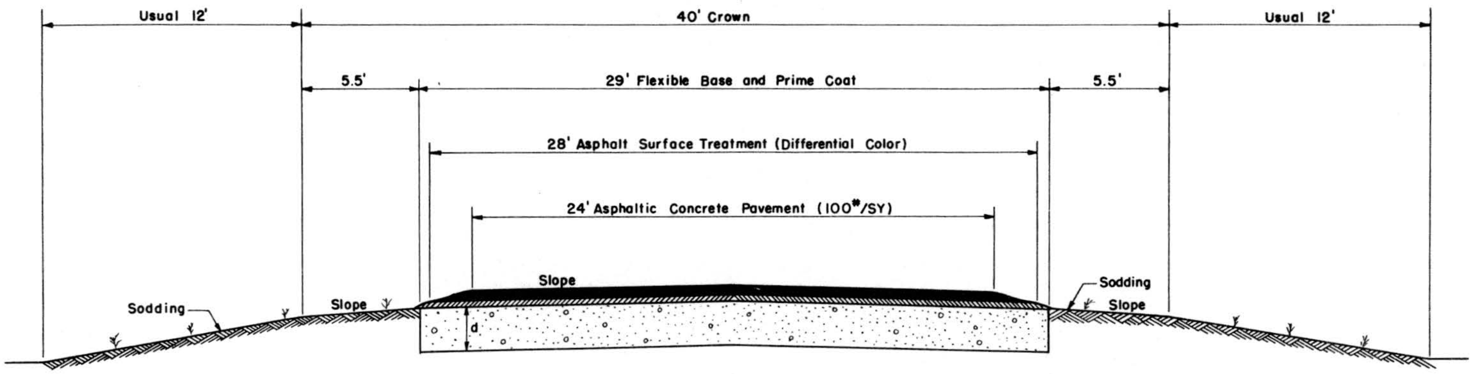
PORTLAND CEMENT CONCRETE PAVEMENT
FLEXIBLE BASE SHOULDERS
SURFACED SHOULDERS



FLEXIBLE BASE

ASPHALTIC CONCRETE PAVEMENT

COMBINATION PAVED AND OPEN SHOULDERS



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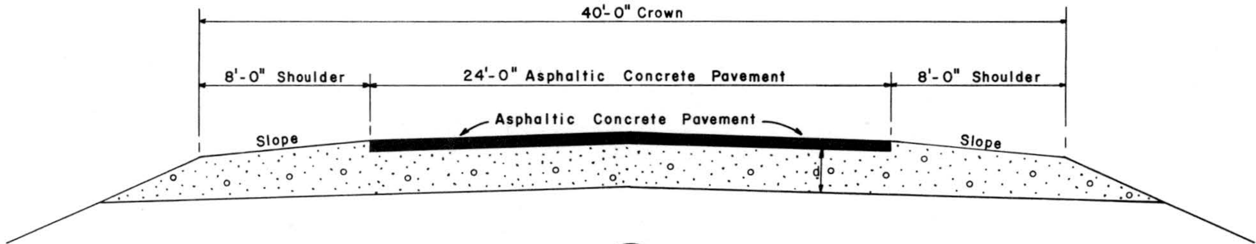
TRENCHED FLEXIBLE BASE
ASPHALTIC CONCRETE PAVEMENT
COMBINATION SOD AND PAVED SHOULDERS



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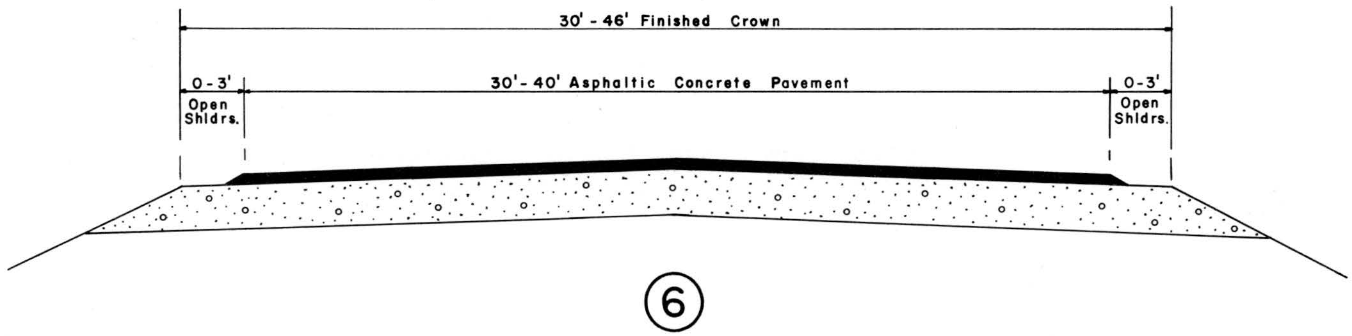
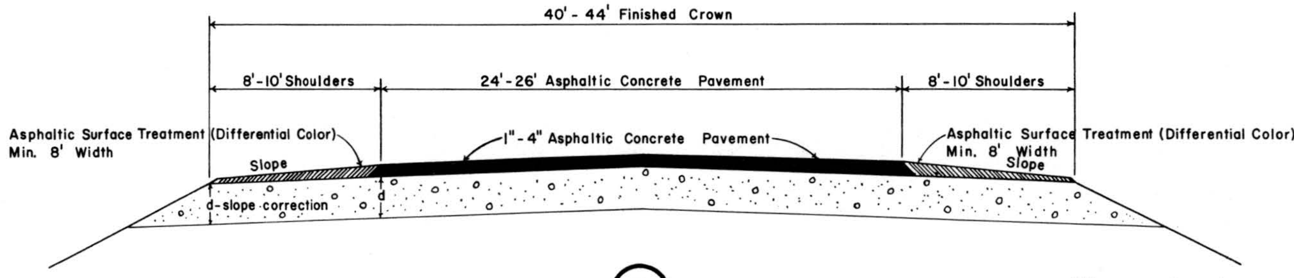
FLEXIBLE BASE
ASPHALTIC CONCRETE PAVEMENT
OPEN SHOULDERS



FLEXIBLE BASE
ASPHALTIC CONCRETE PAVEMENT
OPEN SHOULDERS



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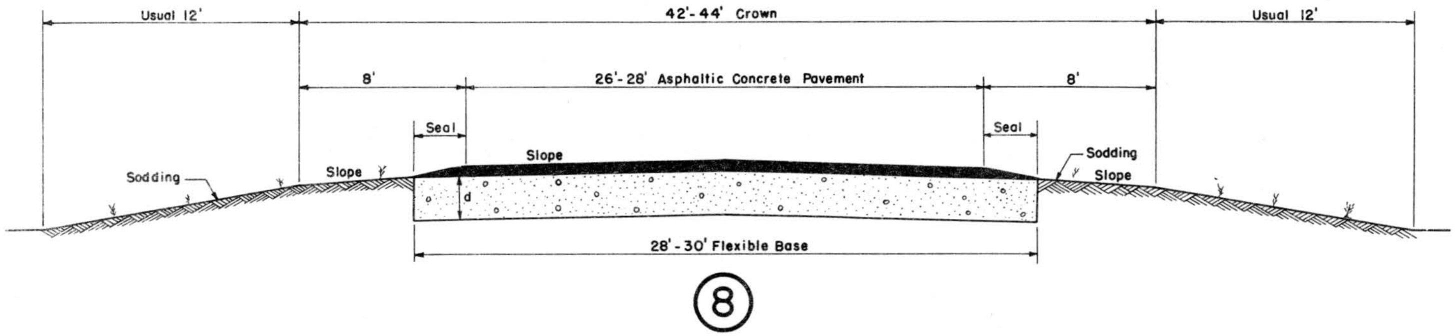
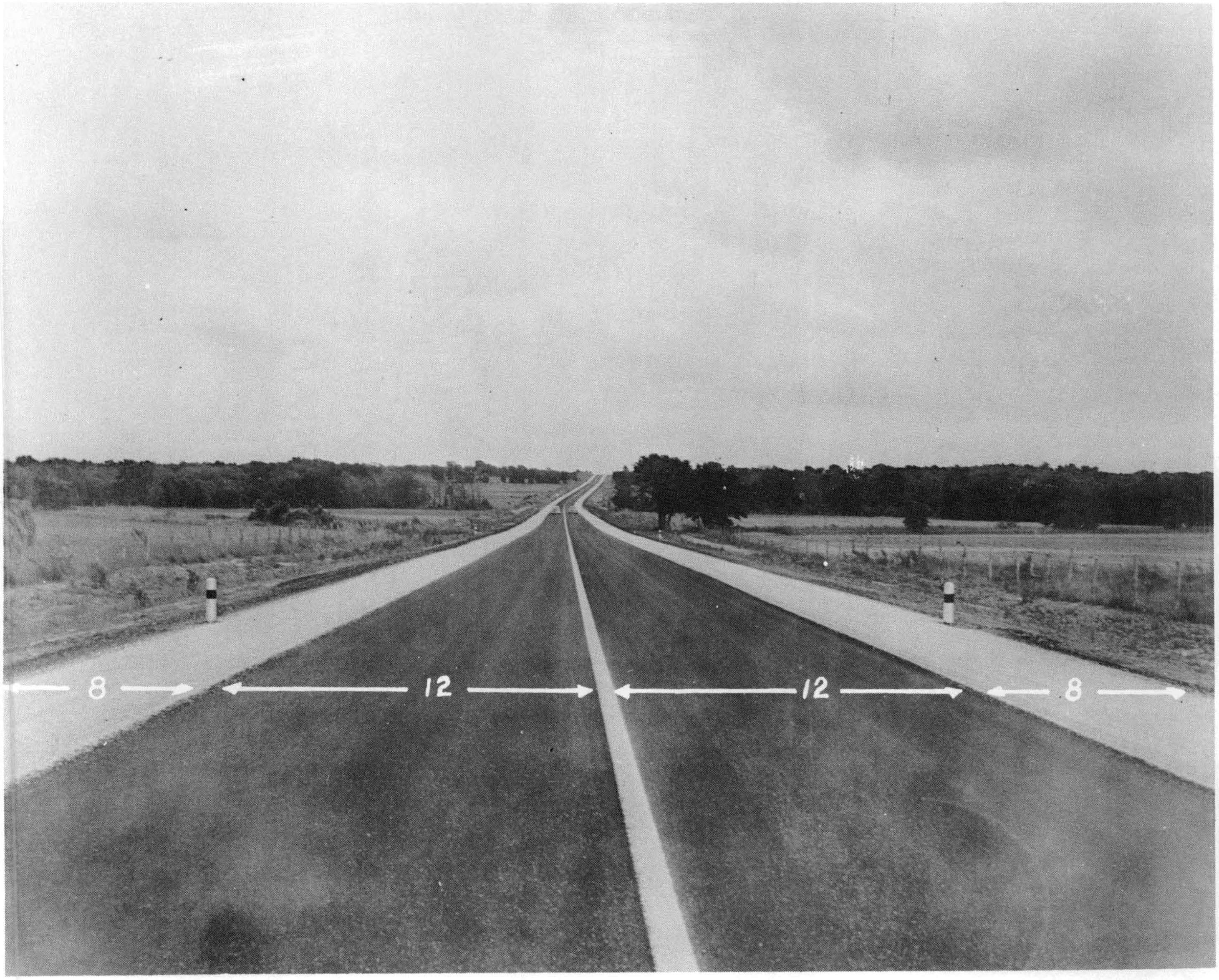
Where structure widths will permit the recommended section is:
26' Roadway with 8' Shoulders

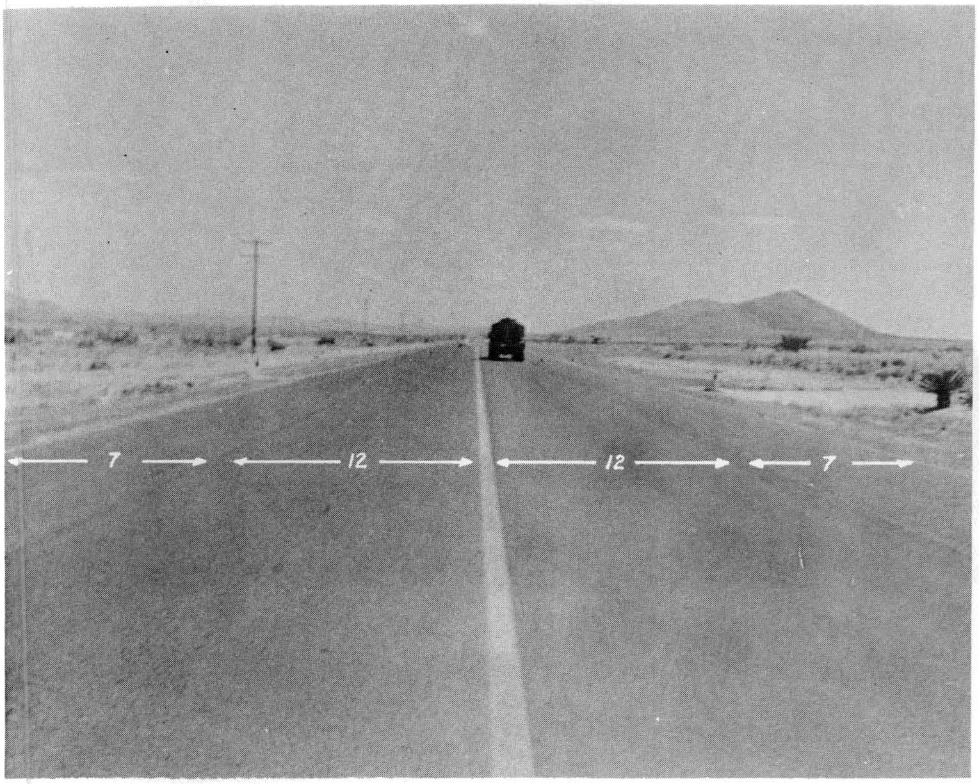
RECOMMENDED SECTION
CLASS B&C HIGHWAYS



RECOMMENDED SECTION
WHERE CONDITIONS REQUIRE OR JUSTIFY
A TRENCHED SECTION
CLASS B & C HIGHWAYS

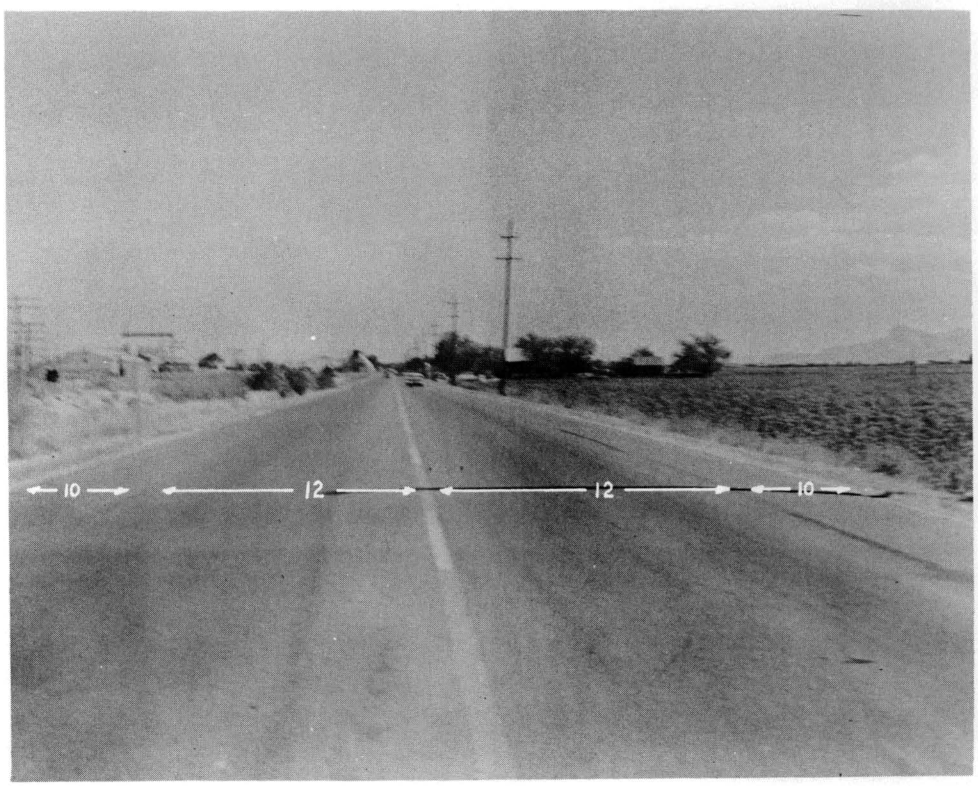


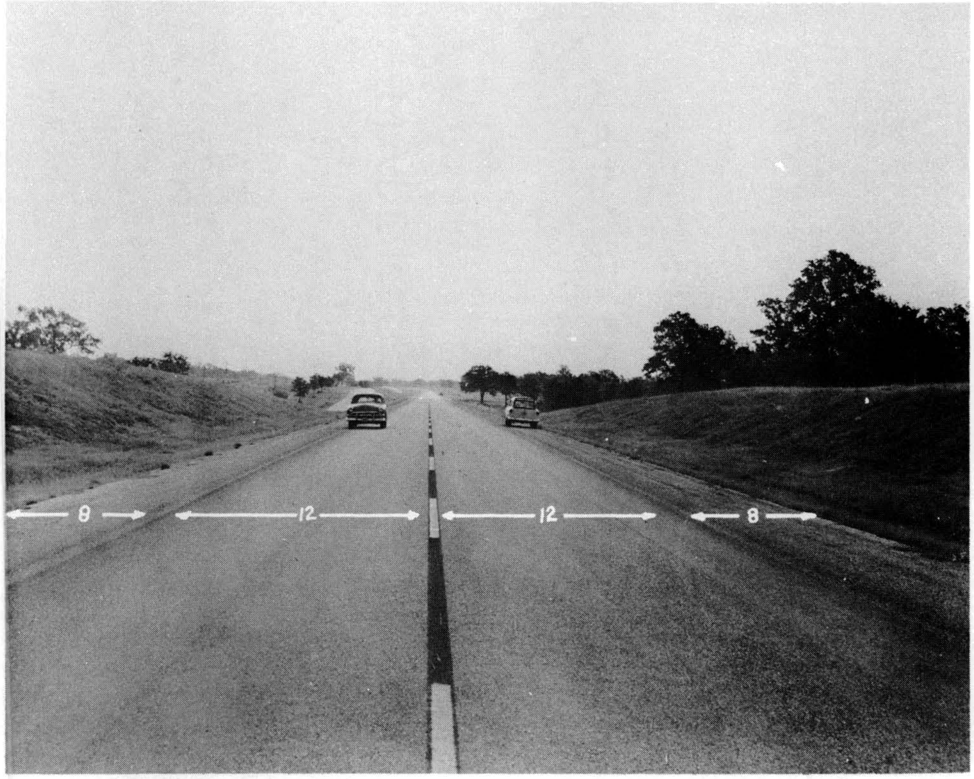
U.S. 290 Average traffic 1,600 vehicles daily. Bastrop Co. between Jct. S.H. 21 and Lee Co. Line.



U.S. 80 Average traffic 4,200 vehicles daily. El Paso Co. 34 miles southeast El Paso.

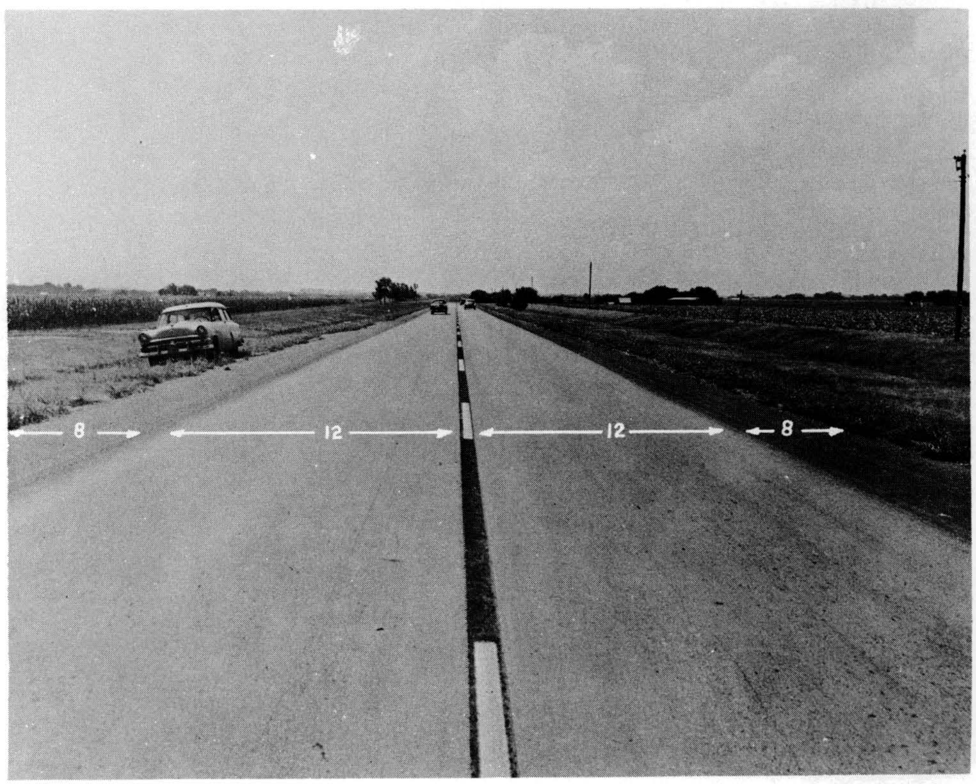
U.S. 80 Average traffic 2,860 vehicles daily. Hudspeth Co. 5 miles west Sierra Blanca.





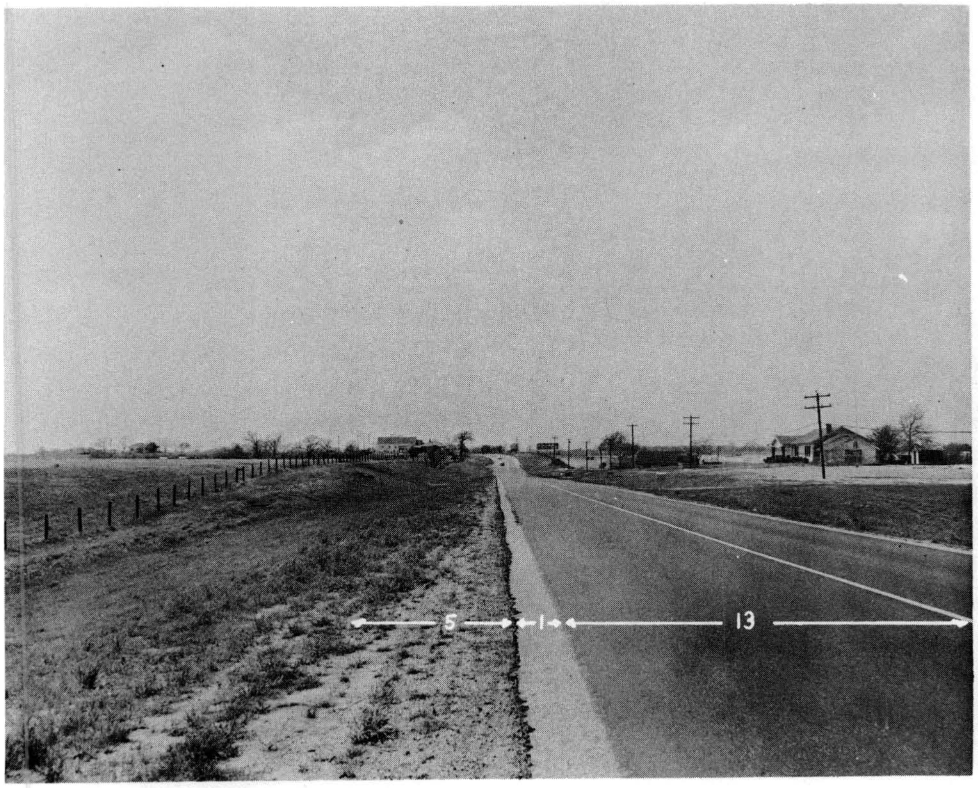
U.S. 290 Average traffic 1,500 vehicles daily. Lee Co. between Giddings and Bastrop Co. Line.

S.H. 95 Average traffic 1,820 vehicles daily. Williamson Co. between Taylor and Granger. Today there are 1,450 miles of this type on Texas Highway System carrying more than 1,000 vehicles daily.



S.H. 359 Average traffic 5,700 vehicles daily. Jim Wells Co. west of Alice.

U.S. 80 Average traffic 2,640 vehicles daily. Hudspeth Co. 10 miles west of Sierra Blanca.

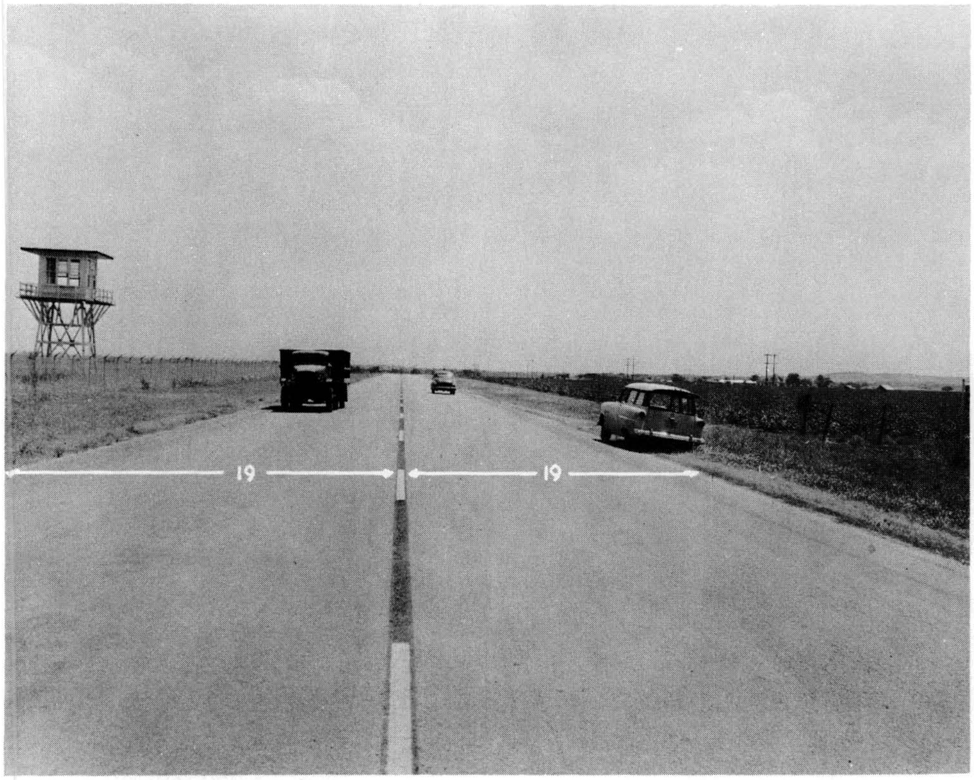


S.H. 64 Average traffic 3,480 vehicles daily. Smith Co. west of Tyler.

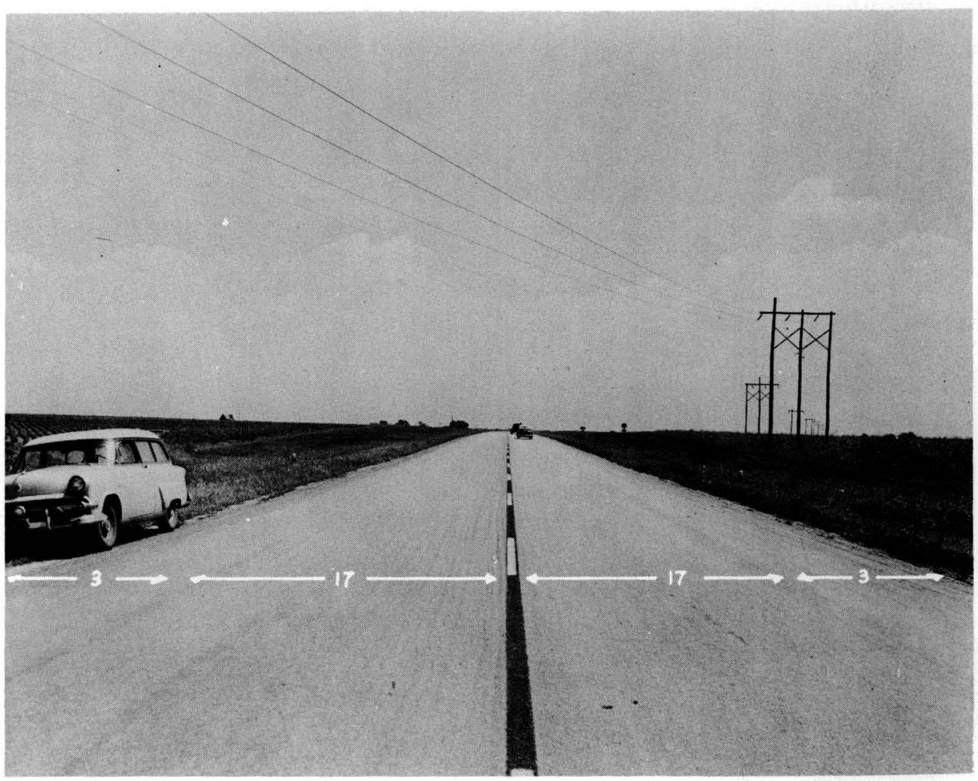
U.S. 80 Average traffic 2,550 vehicles daily. Hudspeth Co. 8 miles southeast McNary.

S.H. 26 Average traffic 1,670 vehicles daily. Nacogdoches Co. between Nacogdoches and Rusk Co. Line.

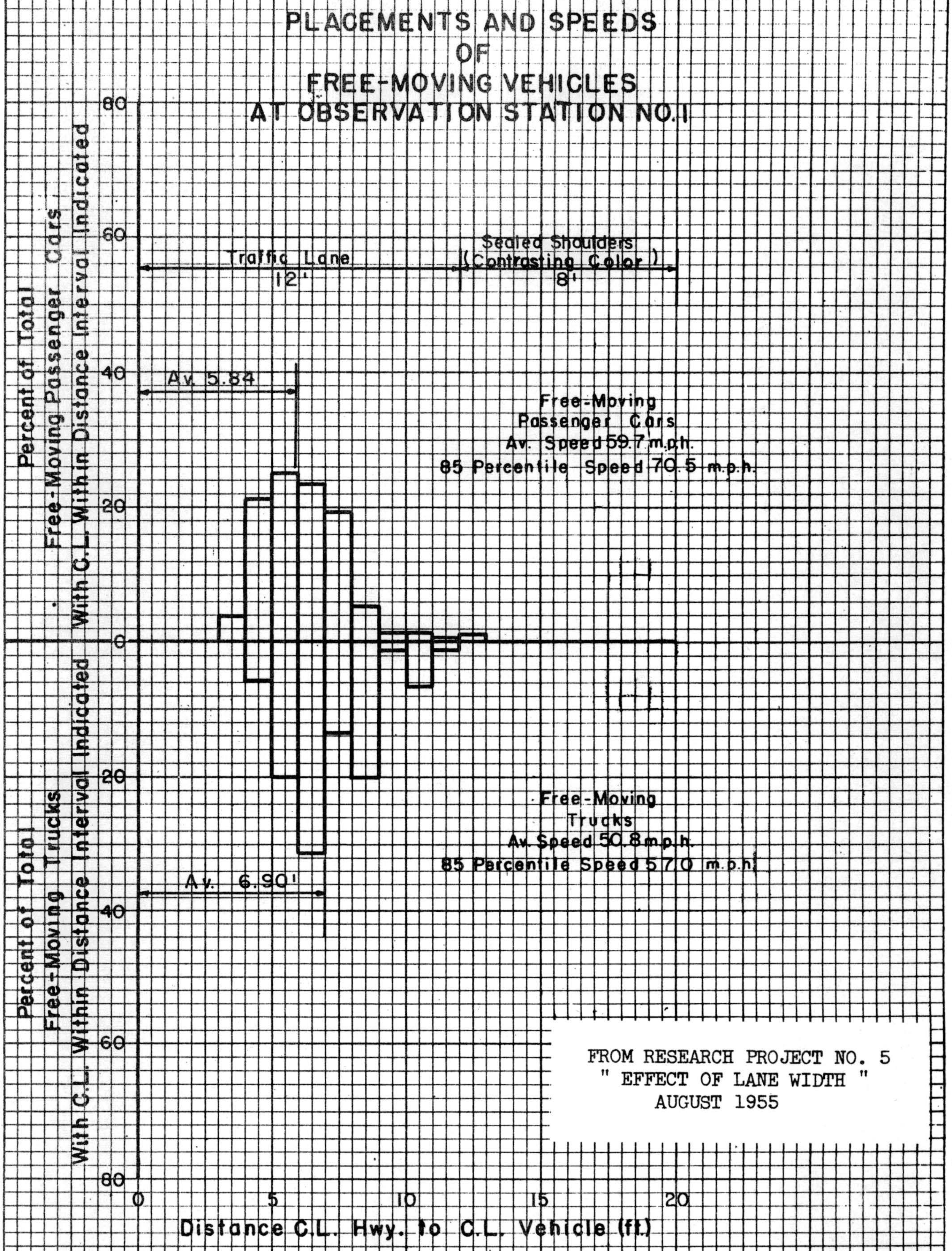
U.S. 183 Average traffic 1,310 daily. Lampasas Co. near Lampasas.



U.S. 183 Average traffic 2,840 vehicles daily. Travis Co. between Austin and Jct. S.H. 21.

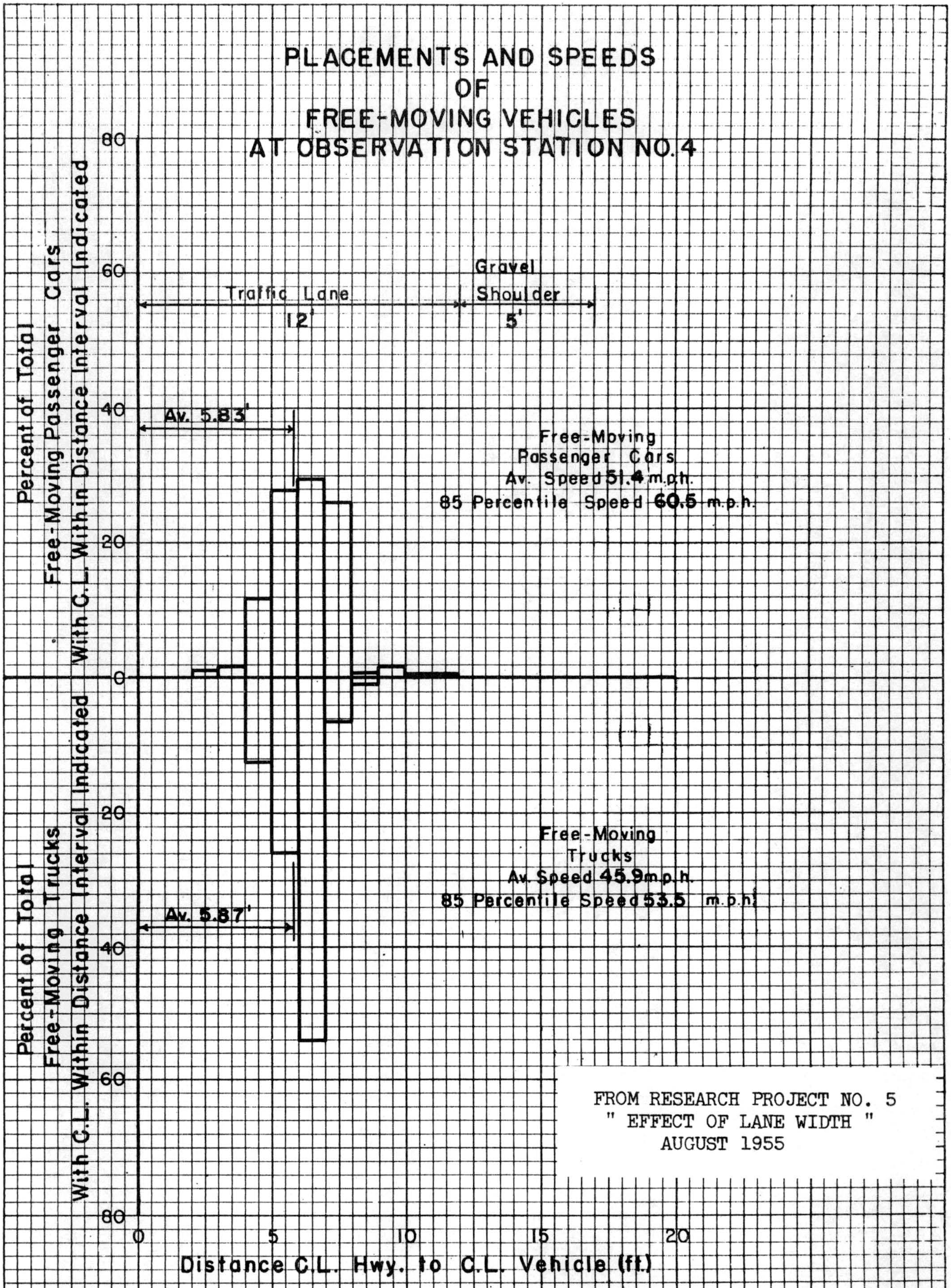


U.S. 79 Average traffic 3,000 vehicles daily. Williamson Co. between Taylor and Hutto.



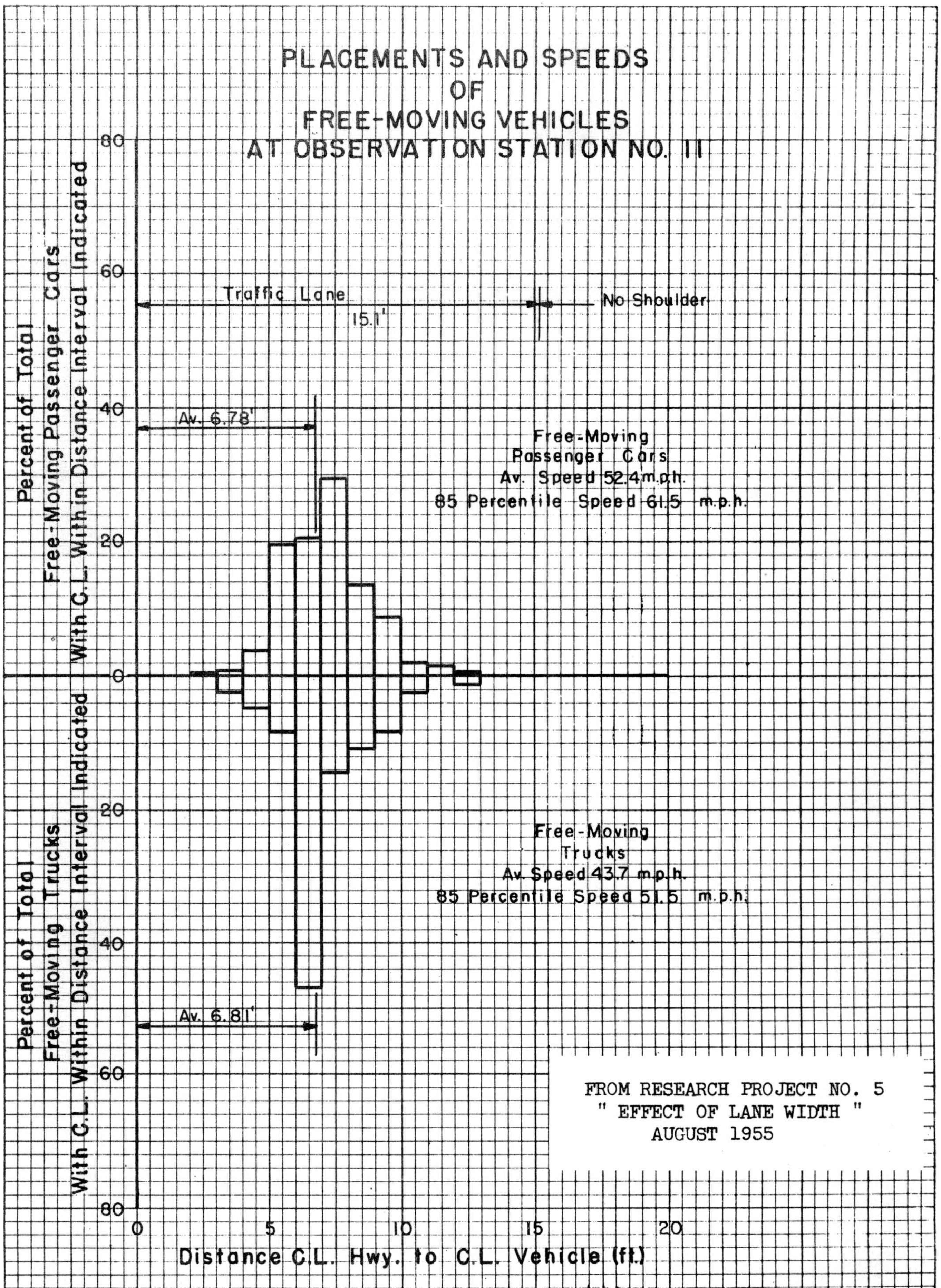
FROM RESEARCH PROJECT NO. 5
" EFFECT OF LANE WIDTH "
AUGUST 1955

FIG. I



FROM RESEARCH PROJECT NO. 5
" EFFECT OF LANE WIDTH "
AUGUST 1955

FIG. 4



FROM RESEARCH PROJECT NO. 5
" EFFECT OF LANE WIDTH "
AUGUST 1955

FIG. 11