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Deflection measurements were made using linear variable differential transformer gage installations and the Benkelman beam. Pavement strain measurements were made using SR4 strain gages attached to the top and bottom of the AC surfacing. Test sites with widely varying structural sections were selected for this study. Analysis of strain and deflection data indicates that the destructive effect of a flotation tire with a single axle loading of 12,000 pounds equals or exceeds that of the dual wheel configuration at an axle loading of 18,000 pounds.

Relationships between tire pressure, pavement temperature, axle loading, pavement deflection, surface tensile strain, and type of wheel loading are presented.

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DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

AN INVESTIGATION OF THE DESTRUCTIVE EFFECT OF FLOTATION TIRES ON FLEXIBLE PAVEMENT

BY
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Presented at the 44th Annual Meeting of the
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INTRODUCTION

In the last two years, the use of flotation or "wide base" tires in lieu of the normal dual wheel configuration has become increasingly commonplace, particularly on transit mix concrete trucks. The reasons advanced by the tire manufacturers for the increased popularity of these tires include: (1) lower rolling resistance, (2) reduced dead weight, (3) improved riding qualities, (4) off the road mobility, and (5) a high load front axle capacity. With the increased usage of these tires, it was apparent that a comparison should be made of the destructive effect of trucks utilizing this type tire with that induced by the normal single axle dual wheel configuration at its maximum legal load limit of 18,000 pounds.

An investigation of a similar nature was included and reported on during the AASHO road test (1). In this investigation various test sections of Loop 2 were subjected to 32,000 pounds tandem axle loads with conventional

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and low pressure-low silhouette (LPLS) tires. The results of this study indicated that loss of pavement serviceability was slightly less over those sections on which the LPLS tires were utilized. However, it is believed that these results are not significant to this investigation since the tires involved were of a military type. An examination of the contact prints shown by Figure 9 (page 11) of the final report (1) reveals an entirely different dual and flotation tire configuration than that resulting from standard commercial truck tires of both types. In fact, the over-all width of the two military duals is equal to or less than that of the military LPLS tire. The reverse holds true in the case of the commercial flotation and dual truck tires used in this investigation.

CRITERIA OF DESTRUCTIVE EFFECT

The first and most important decision to be made for a comparison of the destructive effects of two types of truck tire configuration is the selection of criteria upon which rational judgments may be based. Certainly destructive effect of wheel loads on flexible pavements may be evaluated in many different ways. In this particular case, however, the difference between the wheel configurations are relatively minor so that a valid appraisal requires sensitive criteria. In addition, it is necessary that these criteria be related to flexible pavement performance. It is believed these requirements are effectively fulfilled by measurements of AC surfacing tensile strain and transient pavement deflection.

The choice of AC surfacing tensile strain was based on the preliminary findings of Pell (2) and others, who observed that the fatigue life of an AC surfacing is primarily a function of tensile strain and independent of surfacing temperature or speed of loading. Application of the layer theory and the limited data available indicates that tensile strain at the bottom of the AC surfacing is substantially greater than that which occurs on the surface.

Unfortunately, the time available for this investigation did not permit the installation of strain gages at the bottom of the AC surfacing except for the one project installation at the Shell Avenue test road. It is reasonable to assume, however, that surface tensile strain measurements, if not as large in an absolute sense as the bottom strain measurements, are at least directly proportional so that for the purpose of comparison they may be considered as valid criteria.

The selection of pavement deflection was made with considerable confidence in view of the amounts of very productive pavement deflection research of the last twenty years. In addition to the extensive deflection work done on the two major test roads (AASHO and WASHO), the State of California and other agencies have, with some success, related allowable levels of transient pavement deflection to fatigue cracking of AC surfacing. The California Division of Highways has, in fact, for some years utilized deflection measurements in the design of reconstruction of distressed roadways. There can be little doubt that transient pavement deflection provides an excellent indicator of the in-place strength of an existing roadway and a reasonably accurate forecast of future fatigue cracking.

Considerations of plastic deformation or lateral displacement have not been taken into consideration since, as will be shown in a subsequent section of this report, for a given axle load the pressures induced by both wheel configurations at depths greater than 6 inches are, for all practical purposes, the same.

TEST EQUIPMENT AND INSTRUMENTATION

This study, undertaken in April, 1963, was accomplished using pavement deflection and strain measurements taken over several different structural sections in Northern California. Two trucks, both with single rear axles, were used as test vehicles. In one case, the axle was loaded to California's legal limit of 18,000 pounds and supported with dual wheels using 10.00-20 truck tires with the 12 ply casings inflated to a pressure of 70 psi. The rear axle of the other truck carried a variable load and was supported by 18.00-19.5 flotation tires with the 16 ply, wide base casings inflated to 75 psi (see Figure 1).

Pavement deflection measurements were obtained with a Benkelman beam and, at three locations, with linear variable differential transformer (LVDT) gages. Strain measurements were taken at varying distances from the outside edge of the loaded tires utilizing surface set SR-4 strain gages attached to the pavement surface (see Figures 2 and 3). At one test section, the Shell Avenue test road in Martinez, prior instrumentation, in support of the test road project sponsored jointly by the University of California and Contra Costa County, made it possible to obtain pavement strain measurements at the bottom of the AC surfacing layer.

After grinding the surface to remove large irregularities, two transversely oriented SR-4 strain gages were placed at each test location. These gages, placed at 6" intervals, were cemented into place with "Duco" cement and then covered with "Gagekoat No. 5" for physical protection. During the early trials, it was noted that actual contact between the strain gage and the tire resulted in extremely erratic and obviously incorrect readings. Since unprotected gages were prone to damage by tire contact, it was found necessary to provide this protective coating.

TEST SECTIONS

It was apparent from the beginning of the investigation that a study involving the variables of load, tire configuration, structural section, pavement deflection, and pavement strain could, unless limited in scope, become extremely unwieldy, time-consuming, and expensive. The relatively few test sections were chosen, therefore, to represent the most common types of AC surfaced structural sections, and in addition, to present a large range of pavement deflection for increased sensitivity. The sites selected for this study were:

Location	Structural Section
Service & Supply Yard 60th & Folsom Blvd. Sacramento, Calif.	3" Asphalt Concrete 10" Aggregate Base
Warehouse Road (60th & Folsom Blvd.) Sacramento, Calif.	1-1/2" to 2" Asphalt Concrete 9" Aggregate Base
Pendegast St. Woodland, Calif.	2" Asphalt Concrete 6" Aggregate Base
Shell Avenue Martinez, Calif.	3" Asphalt Concrete (New) 2" Asphalt Concrete (Old) Variable Aggregate Base
State Fair Grounds Sacramento, Calif.	2" Asphalt Concrete 5" Aggregate Base
III-Sac-232-A Sta. 304+04	3-3/4" Asphalt Concrete 8" Cement Treated Base
III-Sac-232-A Sta. 405+90	6-3/4" Asphalt Concrete 6" Aggregate Base
III-Sac-232-A Sta. 354+00	3-3/4" Asphalt Concrete 12" Aggregate Base

The initial range of flotation tire loading was determined by utilizing the theoretical Boussinesq equation. With this analysis, a comparison of vertical pressure induced by twin circular disks at 75 psi carrying a gross weight of 9000# was compared to that induced by a single circular disk at 75 psi loaded from 5000# to 6000#. The results of this analysis, shown by Figure 4, correspond to calculations made earlier by personnel of the Washington State Highway Department. Examination of Figure 4 shows that at depths of from 0" to 6", the vertical pressure induced by the single circular disk would exceed that of the twin circular disks. Beyond approximately 11" the vertical pressure induced by the twin disks exceeds that of the single circular disk. Although the Boussinesq equation is purely a mathematical development of the elastic theory for an isotropic, elastic, homogenous, and infinite mass, it has been shown to be reasonably accurate for flexible sections as demonstrated by Investigators Herner (3) and Sowers (4) and the results by the Stockton test track (5). It was decided, based upon this analysis, that a single flotation tire loading range of 5000# to 6000# would provide a good starting point for the comparison of the two types of tire and wheel configuration.

It was also decided to confine both deflection and pavement strain measurements to the axis normal to the direction of travel at each test point. This selection is based upon long experience in California in which it has often been observed that the initial manifestation of alligator cracking is, in almost every case, longitudinal cracking in or close to the wheel path. The fact that transverse bending is generally more pronounced is obvious from examination of deflection contour maps resulting from the WASHO (6) and AASHO (7) test roads. The test program for each test section, therefore, consisted of applying SR-4 strain gages oriented transversely and, upon completion of instrumentation, the measurement of pavement surface strain at varying distances from the edge of the loaded wheel. At each location, strain gage measurements were determined for a dual wheel loading of 9,000 pounds and single flotation tire loaded at 5,000, 5,500, and 6,000 pounds. Where these installations were available, LVDT deflection measurements were also obtained for the aforementioned wheel loadings. At those locations where LVDT gages were not available, however, Benkelman beam deflection measurements were obtained.

During the final phase of the investigation, a series of surface strain and LVDT deflection measurements were obtained at a roadway immediately in front of the Women's Building of the California State Fair Grounds. This site offered advantages not available elsewhere, which included (1) complete freedom from traffic interference, (2) a high range of pavement deflection,

(3) availability of electric power for instrumentation, and (4) close proximity to the Headquarters Laboratory. Because of these advantages, a more comprehensive instrumentation was accomplished and the scope of the investigation increased to study the effects of two more variables. These were (1) a wider range of flotation tire single axle loadings, and (2) the effect on pavement deflection and surface tensile strain of lowered flotation tire pressures.

ANALYSIS OF DATA

During the first few trials it was observed that even relatively minor variations in pavement surface temperature resulted in very significant differences in the strain measurement induced by a given wheel load. Because the principal objective of this program was a comparison of destructive effect induced by two different vehicles with differing wheel configurations and loadings, it became apparent that the variable of pavement surface temperature had to be eliminated or minimized. This was accomplished by continuously alternating the two different trucks during every test series. Thus, for each balloon tire strain measurement, a corresponding dual wheel measurement was obtained to provide the basis of the comparison (see Figure 5).

The effect of variations in temperature on surface tensile strain is shown by Figure 6, which is a plot of surface strain versus distance to edge of loaded tire for three different pavement temperatures at one test location. Examination of these plots reveals that maximum tensile strain for the dual wheel configuration varied from 460 to 585 microinches per inch. These plots also show the very definite reversal of a surface stress from tension to compression, which generally occurs at from 2" to 5" from the edge of the loaded wheel.

Another interesting aspect of Figure 6 is that maximum tensile strain occurred, for this gage installation, at the middle pavement temperature (73°F) with the strains at 63°F and 101°F being about equal. This may indicate the existence of an optimum value of pavement temperature for a given AC surfacing insofar as surface strain is concerned. It is possible that increased cohesion at low temperatures and strain attenuation over a relatively large area due to plastic flow at high temperatures results in low strains at temperature extremes.

Over the cement treated base section on III-Sac-232-A, the data did not reveal any "peaking out" of tensile strain. It is possible that inability to attain the critical distance to the edge of the tire due to the strain gage insulation precluded the determination of this peak value. This section, however, produced extremely low strain values so that there is some doubt as to the relative importance of this section to the study.

The relationship between strains induced by both wheel configurations for all sections revealed a very noticeable lack of consistency insofar as type of structural section is concerned. This is shown by the relatively weak structural section of Pendegast Street in the City of Woodland. Here, it was found that the equivalent flotation tire axle loading, insofar as destructive effect was concerned, was 12,300 pounds as compared to the 11,000 pounds equivalency for the cement treated base overlay section at El Centro Road. Further examination of the data revealed that relative surface tensile strain is more directly relatable to pavement temperature than structural section. This is shown by Figure 7, a plot of the ratio of surface tensile strain induced by 11,000 and 12,000 pound flotation tire axle loadings, and an 18,000 pound dual wheel single axle loading versus pavement temperature. A relatively good correlation exists for the ratio involving a flotation tire axle loading of 12,000 pounds and pavement temperature. The beginning of a trend is also apparent for the 11,000 pound flotation tire axle loading. These data would indicate that, regardless of the structural section, the surface tensile strain induced by the flotation tire with a 12,000 pound single axle loading is equivalent to a dual wheel axle loading of 18,000 pounds at a pavement temperature of approximately 80°F. At lower temperatures the strain induced by the flotation tire is less and at higher temperatures the strain is greater. This general trend is also apparent for the flotation tire at an 11,000 pound axle loading, which is equivalent in surface strain to the dual wheel loading at approximately 105°F.

Leaving relative strain and discussing absolute values of surface tensile strain, Table 1 presents peak values of surface tensile strains for varying flotation tire axle loadings and the dual wheel loading at 18,000 pounds for varying structural sections and temperatures. These data show that the heavier structural sections tested on Road III-Sac-232-A produce substantially lower surface tensile strains than were obtained on the relatively weak sections at the Shell Avenue test road, City of Woodland, and the State of California Service and Supply yard. It is also interesting to note that the maximum surface tensile strains induced by the dual wheels did not occur at the maximum test temperature at any of the test sections except the asphalt treated base section on Road III-Sac-232-A. A comparison at this location was somewhat difficult due to the limited range of pavement temperature, however.

At the Shell Avenue test section, it was possible to determine both transverse and longitudinal strain measurements from the bottom of the surfacing. These results are shown by Figures 8 and 9. Because the strain gage involved was fully protected from direct approach of the loaded tire, it was possible to determine the full range of tensile and compressive strain measurements for the dual wheel configuration with an axle load of 18,000 pounds and a flotation tire single axle configuration loaded to 12,000 pounds. It was found that longitudinal strain is higher at the bottom of this pavement than is the transverse strain. Figure 8 reveals that the bottom transverse strain of the flotation tire with an axle loading of 12,000 pounds is almost equal to that induced by the dual tires. The bottom longitudinal strain induced by the flotation tire (Figure 9), however, was well in excess of that for the dual tires.

At three locations it was possible to compare pavement deflection values for both balloon and dual wheels with LVDT gage installations. The data from two of these installations are presented graphically by Figures 10 and 15. On Figure 10, the transverse deflection profile obtained at Shell Avenue reveals a higher maximum deflection value for the flotation tire axle loaded to 12,000 pounds (0.038") than the dual wheel axle configuration at 18,000 pounds (0.034").

At all three locations, however, the maximum value of pavement deflection for the flotation tire with an axle loading of 12,000 pounds exceeded that of the dual wheel axle configuration loaded to 18,000 pounds. The flotation tire axle loading at 11,000 pounds was less, however, than that of the dual wheel axle configuration at 18,000 pounds.

A plot of flotation-dual tire deflection ratios for varying flotation tire loads is presented for two gage locations at the State Fair Grounds by Figure 11. This data is considered significant due to the very minor temperature differential during the test period. At both gage locations an equivalence in pavement deflection is attained at a flotation tire single axle loading of 12,200 pounds, which is in accordance with the earlier data.

Although it was impossible to compare maximum pavement deflections at those installations where LVDT gage installations were not available, the Benkelman beam data did provide an opportunity to compare the shapes of the transverse deflection profiles from the outside tire edge for each wheel configuration. These plots are shown by Figures 12 through 14. They indicate, in every case, a smaller area of influence and, hence, sharper bending of the pavement by the flotation tire.

As previously mentioned, a final portion of the program at the State Fair Grounds was devoted to a determination of the effect of lowered flotation tire pressures on transverse tensile strain and deflection. In addition to the strain and deflection measurements obtained at flotation tire single axle loadings of 10,000, 12,000, 15,000, and 18,000 pounds, additional data was obtained at the 12,000 and 18,000 pound flotation tire single axle loadings, for a flotation tire pressure of 55 psi. This tire pressure was selected as the minimum at which the flotation tires could be operated without incurring tire damage. Deflection and strain data resulting from the lowered flotation tire pressures is presented by Figures 15 through 17. On Figure 15 we note that pavement deflection at the flotation tire single axle loading of 12,000 pounds was not significantly reduced by lowering the tire pressure. At the 18,000 pound flotation tire single axle loading, however, the lowered flotation tire pressure induces a 10% reduction in pavement deflection. On Figures 16 and 17, we find that lateral surface tensile strain was actually increased by 13% at both the 12,000 and 18,000 pound flotation tire single axle loadings, with a reduction in flotation tire pressure. This phenomenon is apparently the result of an increased pressure concentration at the side walls due to the reduction of pressure. This conclusion tends to be borne out by the work of Freitag and Green in a paper presented to the Highway Research Board in January, 1962 (8). On Figure 4 of this report, vertical stress contours under an 11.00-20, 12-ply smooth tire loaded to 3,000 pounds are presented for three inflation pressures. Here, side wall vertical stress remains relatively high for all three inflation pressures, with interior vertical stresses increasing in approximate proportion to increased inflation pressure. It is interesting to note that maximum edge or side wall stress was attained at the median inflation pressure rather than at the highest or design inflation pressure. The data presented in the paper also indicate that vertical stress is very much a function of the construction or ply of the tire; i.e., the lower the ply, the more closely the contact pressure approximates air pressure. We may conclude, therefore, that a tangible reduction in surface tensile strain through lowered air pressure could be accomplished only by a tire specifically designed for the lower pressure and as low a ply rating as possible, consistent with the operational demands of the truck.

SUMMARY

From April until November, 1963, an investigation for the purpose of comparing the destructive effect of wide base flotation tires and the standard dual wheel configuration on pavement was completed by the Pavement Section of the Materials and Research Laboratory. Transient pavement deflection and surface tensile strain were selected as the two criteria for evaluating destructive effect. Pavement deflection and strain measurements were obtained over eight roadways, representing a relatively wide range of flexible and composite structural section. Sufficient data was accumulated to evaluate the effect of pavement temperature, single axle load, and tire inflation pressure on pavement deflection and surface tensile strain. With the cooperation of the University of California, it was

possible to obtain bottom longitudinal and transverse strain measurements at the Shell Avenue test road.

Analysis of the data resulting from this investigation indicates that:

1. Using maximum pavement deflection as a criteria, the destructive effect of a flotation tire with a single axle loading of 12,000 pounds equals or exceeds that of a dual wheel configuration at an axle loading of 18,000 pounds.
2. The relationship between the maximum transverse tensile surface strains induced by flotation tires at various axle loadings and the dual wheel at an 18,000 pound single axle loading relates directly to pavement temperature.
3. At a pavement temperature of 80°F, a 12,000 pound flotation tire axle loading is equivalent to the dual wheel axle configuration at 18,000 pounds. At lesser temperatures, balloon tire strains are lower and at higher temperatures are greater than those induced by the dual wheel configuration.
4. At 105°F, the flotation tire axle loading at 11,000 pounds is approximately equivalent to the dual wheel axle configuration at 18,000 pounds.
5. Absolute surface strain values are significantly greater for weaker structural sections for both wheel configurations than those resulting from relatively strong structural sections.

6. The data available indicates surface tensile strain is relatively low at extremes of temperature and approaches a definite peak at an intermediate temperature range. The temperature for peak tensile strain is probably a function of the type of structural section. This being the case, it is probable that even though the ratio of flotation-dual wheel strain increases with temperature, absolute values of strain for both types of wheel configuration decrease at higher temperatures.
7. At a flotation tire single axle loading of 18,000 pounds, pavement deflection decreased by 10% with a reduction in inflation pressure from 75 to 55 psi. At a flotation tire single axle loading of 12,000 pounds, the reduction in deflection due to fluctuations of inflation pressures was not found to be significant.
8. Lateral surface tensile strain increased by 13% at both the 12,000 and 18,000 pound flotation tire single axle loadings with a reduction in tire pressure of from 75 to 55 psi. This is believed to be the result of a greater concentration of contact stress at the side walls resulting from a decrease in tire pressure.

CONCLUSION

Based upon the above, it may be concluded that a standard flotation tire with a 12,000 pound single axle loading is, insofar as relative destructive effect on a flexible or composite pavement is concerned, the equal to a standard dual wheel configuration with an 18,000 pound single axle loading. This equivalency, however, is subject to a certain degree of variation with pavement temperature. Also, it appears that variations in flotation tire pressure will have a beneficial effect on this equivalency only with an accompanying change in the tire structure. In terms of absolute destructive effect, both tire and wheel configurations induce greater destructive effect on a relatively thin or weak structural section than a thick or composite pavement section.

ACKNOWLEDGEMENTS

We wish to acknowledge the advice and assistance of Messrs. James Barton, William Chow, and Albert Sequeira of the Structural Materials Section in the instrumentation of the LVDT deflection and pavement strain gages. We also wish to express our appreciation to Professor Carl Monismith and the University of California for their assistance in obtaining and evaluating the strain and deflection data from the Shell Avenue test road. The work of Harold Munday, Carl Johnson, and Orvis Box in taking and tabulating the test data is acknowledged and appreciated. Mr. J. L. Beaton is Materials and Research Engineer.

Table 1

Tabulation of Peak Values of Transverse Surface Tensile Strain

Location	Structural Section	Pav't Temp. (°F)	Flotation Tire Axle Loading (lbs)	Max. Surface Tensile Strain (Flotation) Micro in./in.	Max. Surface Tensile Strain (Dual Wheel) Micro in./in
III-Sac-232-A	3-3/4" AC	110°-118°	11,000	28*	36*
Sta. 304+04	8" CTB(Cl"A")	94°- 98°	12,000	48*	42*
	Exist. Pav't				
III-Sac-232-A	3-3/4" AC	93°- 94°	11,000	112	108
Sta. 405+90	3" AC (Base)	92°- 99°	11,000	170	185
	6" AB	85°- 90°	12,000	170	170
	Exist. Pav't	87°- 92°	12,000	175	163
III-Sac-232-A	3-3/4" AC	75°- 77°	10,000	90	125
Sta. 354+00	12" AB	130°-132°	12,000	62	49
	Exist. Pav't	68°- 71°	12,000	105	116
Service&Supply	3" AC	105°-115°	10,000	314	352
Yard (60th St.	9" AB	85°- 95°	11,000	257	277
& Folsom Blvd)		118°-128°	12,000	352	310
City of Woodland	3" AC	100°-110°	10,000	385	468
(Pendergast St.)	6" AB	70°- 75°	11,000	473	588
		61°- 64°	12,000	427	463
Shell Ave.	3" AC (New)	70°- 71°	12,000	795**	800**
Test Road	2" AC (Old)				
Martinez	Var. AB				
StateFairGrounds	2" AC				
(Women's Bldg.)	4" AB				
Gage #1		40°- 42°	10,000	145	190
		42°	12,000	167	205
		46°	15,000	253	228
		43°- 46°	18,000	283	188
Gage #2		40°- 42°	10,000	80	122
		42°	12,000	100	125
		46°	15,000	148	140
		43°- 46°	18,000	160	119
Gage #3		40°- 42°	10,000	110	150
		42°	12,000	124	162
		46°	15,000	190	177
		43°- 46°	18,000	215	155
Gage #4		40°- 42°	10,000	110	158
		42°	12,000	135	167
		46°	15,000	205	198
			18,000	232	155

*Point of stress reversal not determined.
**Transverse tensile strain at bottom of AC layer.

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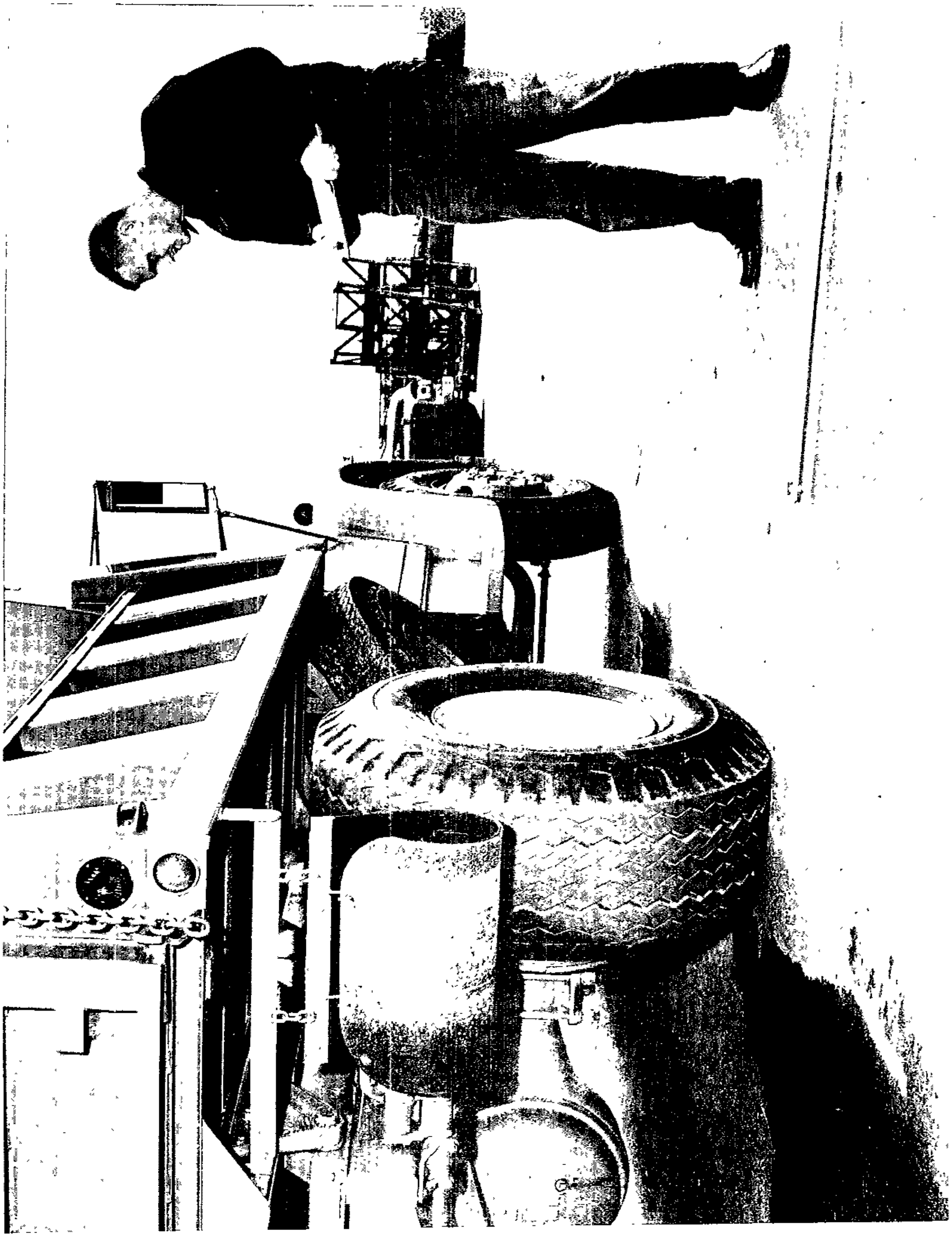


Figure 1
Truck with Single Axle "Flotation" Tire Configuration

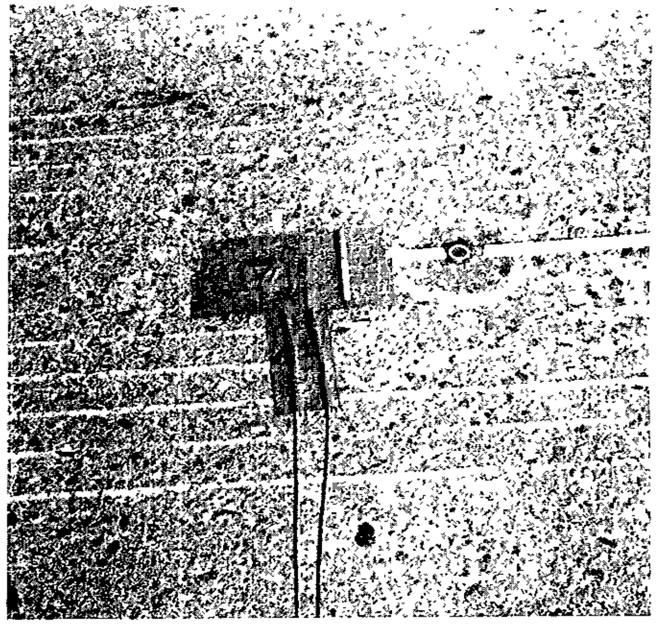
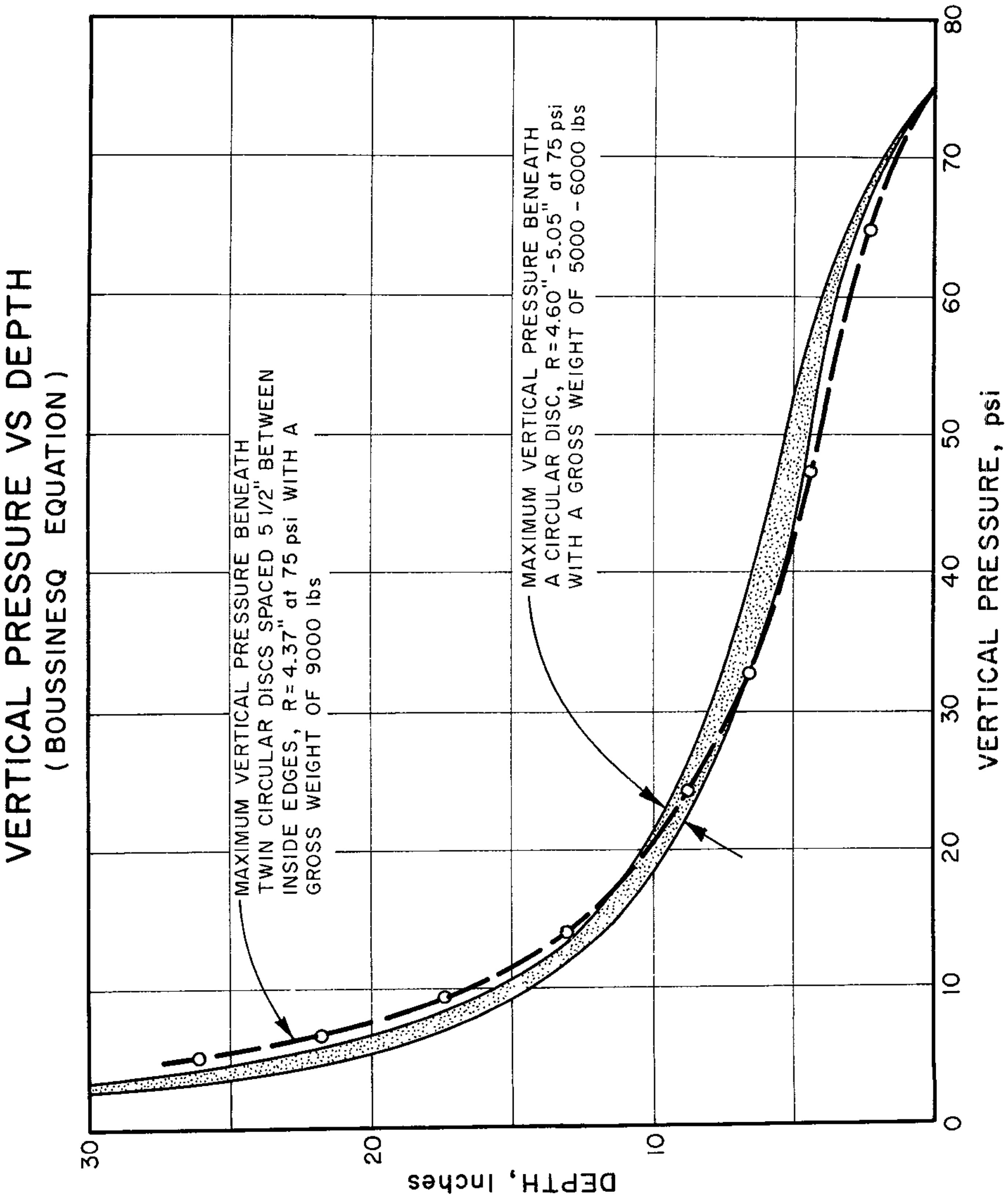


Figure 2

SR-4 Pavement Strain and LVDT Deflection Gage Installations at Shell Ave. Test Road at Martinez.

Figure 3

Strain Recording Equipment Operated by Personnel of the University of California at the Shell Ave. Test Road.


VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)
MAXIMUM VERTICAL PRESSURE BENEATH TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN INSIDE EDGES, R = 4.37" at 75 psi WITH A GROSS WEIGHT OF 9000 lbs
MAXIMUM VERTICAL PRESSURE BENEATH A CIRCULAR DISC, R = 4.60" - 5.05" at 75 psi WITH A GROSS WEIGHT OF 5000 - 6000 lbs
VERTICAL PRESSURE, psi
0
10
20
30
40
50
60
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DEPTH, Inches
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20
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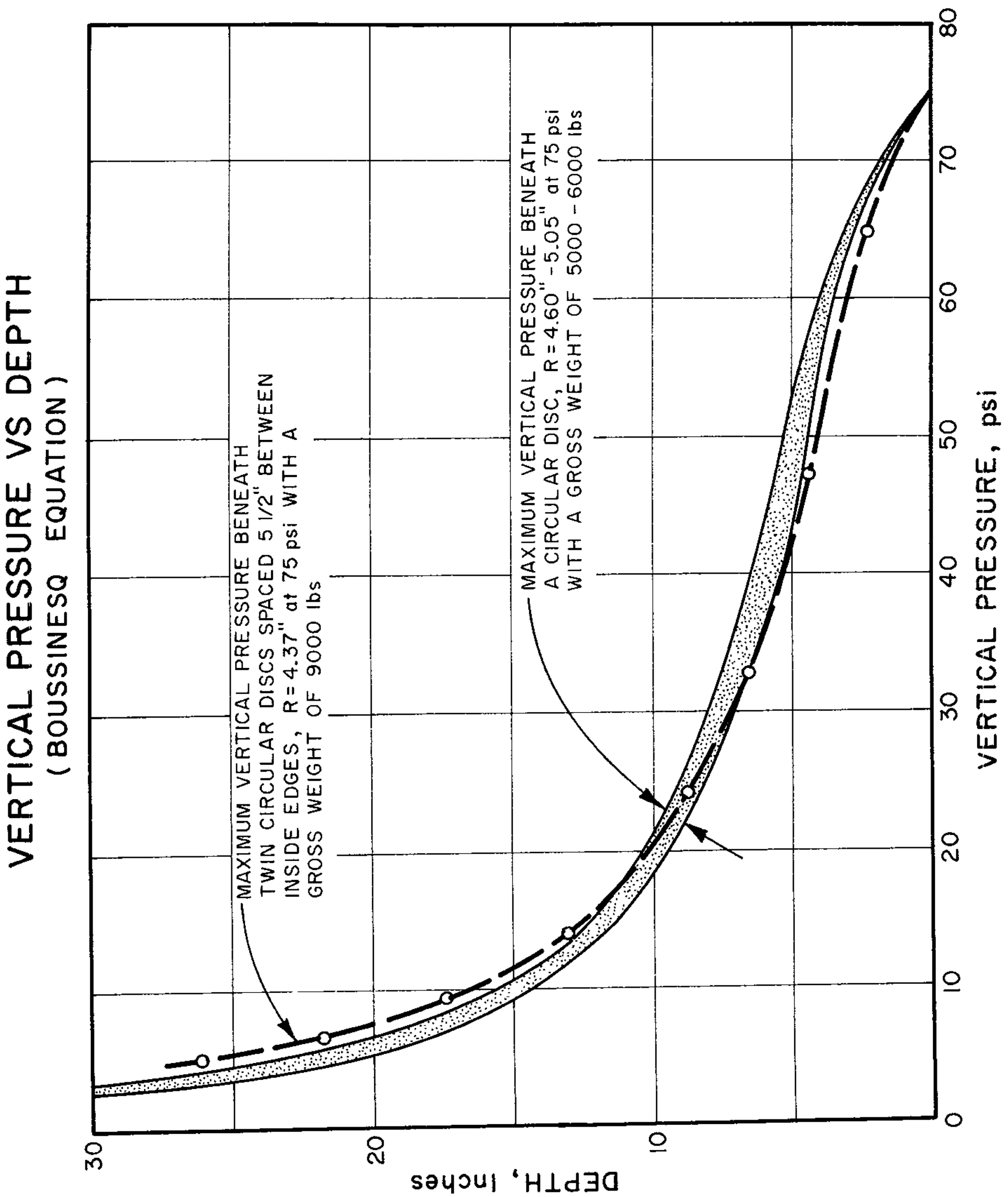

VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)
MAXIMUM VERTICAL PRESSURE BENEATH TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN INSIDE EDGES, R = 4.37" at 75 psi WITH A GROSS WEIGHT OF 9000 lbs
MAXIMUM VERTICAL PRESSURE BENEATH A CIRCULAR DISC, R = 4.60" - 5.05" at 75 psi WITH A GROSS WEIGHT OF 5000 - 6000 lbs
VERTICAL PRESSURE, psi
0
10
20
30
40
50
60
70
80
DEPTH, inches
30
20
10

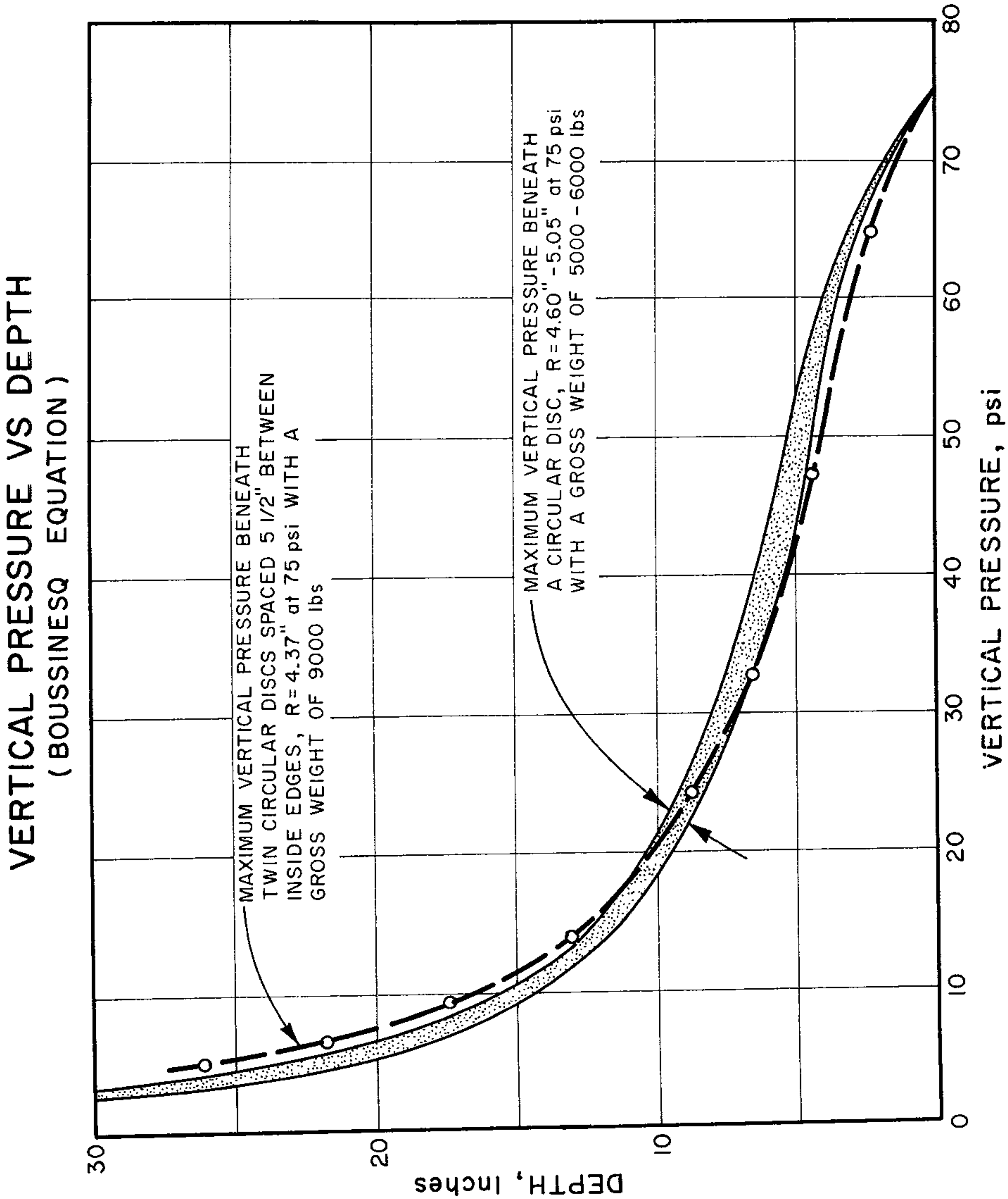
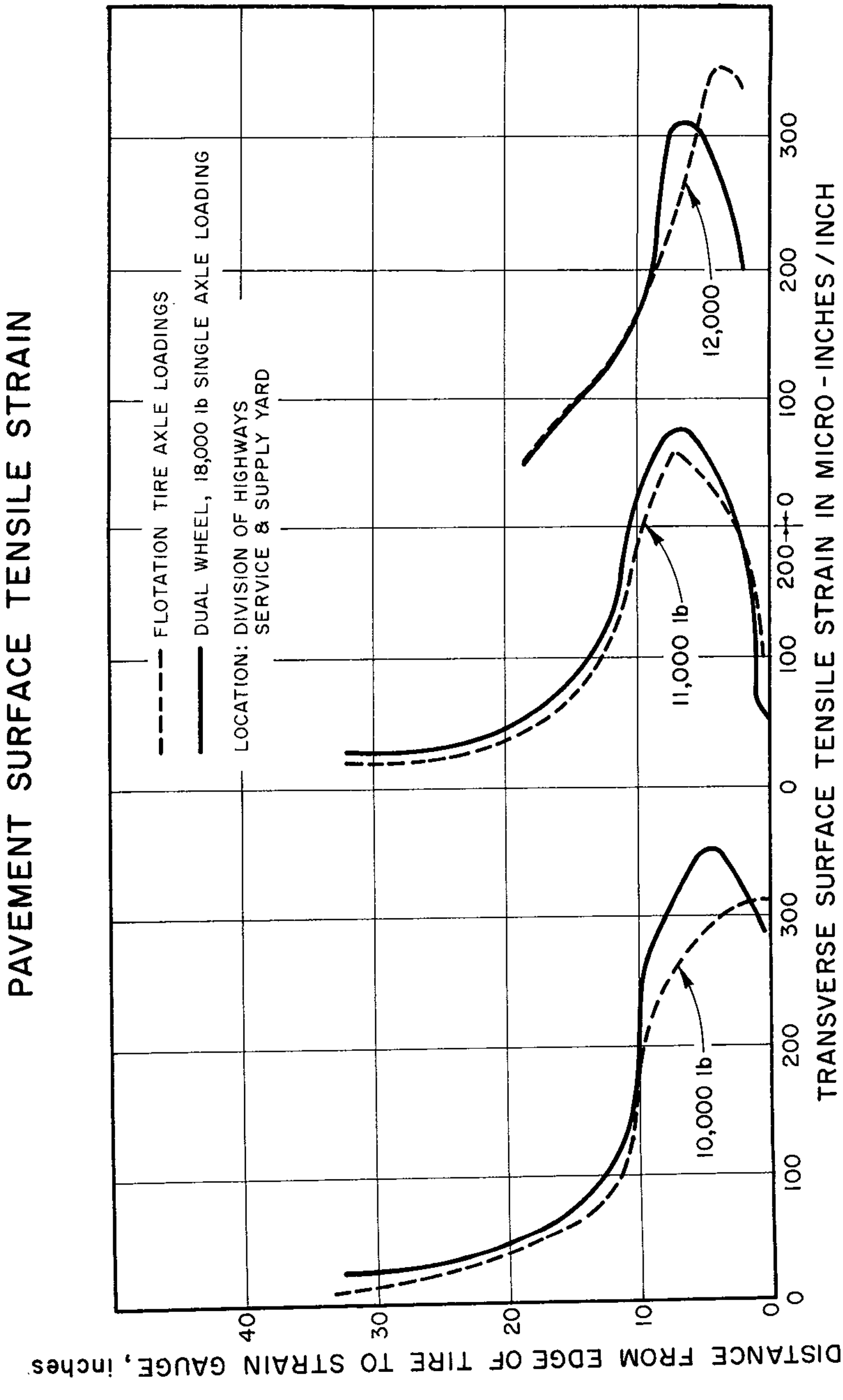

VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)
MAXIMUM VERTICAL PRESSURE BENEATH TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN INSIDE EDGES, R = 4.37" at 75 psi WITH A GROSS WEIGHT OF 9000 lbs
MAXIMUM VERTICAL PRESSURE BENEATH A CIRCULAR DISC, R = 4.60" - 5.05" at 75 psi WITH A GROSS WEIGHT OF 5000 - 6000 lbs
VERTICAL PRESSURE, psi
0
10
20
30
40
50
60
70
80
DEPTH, inches
30
20
10

Figure 5



PAVEMENT SURFACE TENSILE STRAIN
FLOTATION TIRE AXLE LOADINGS
DUAL WHEEL, 18,000 lb SINGLE AXLE LOADING
LOCATION: DIVISION OF HIGHWAYS SERVICE & SUPPLY YARD
12,000
11,000 lb
10,000 lb
TRANSVERSE SURFACE TENSILE STRAIN IN MICRO-INCHES / INCH
DISTANCE FROM EDGE OF TIRE TO STRAIN GAUGE, inches
0
100
200
300
40
30
20
10

VARIATION IN TRANSVERSE SURFACE STRAIN
INDUCED BY CHANGE OF PAVEMENT TEMPERATURE

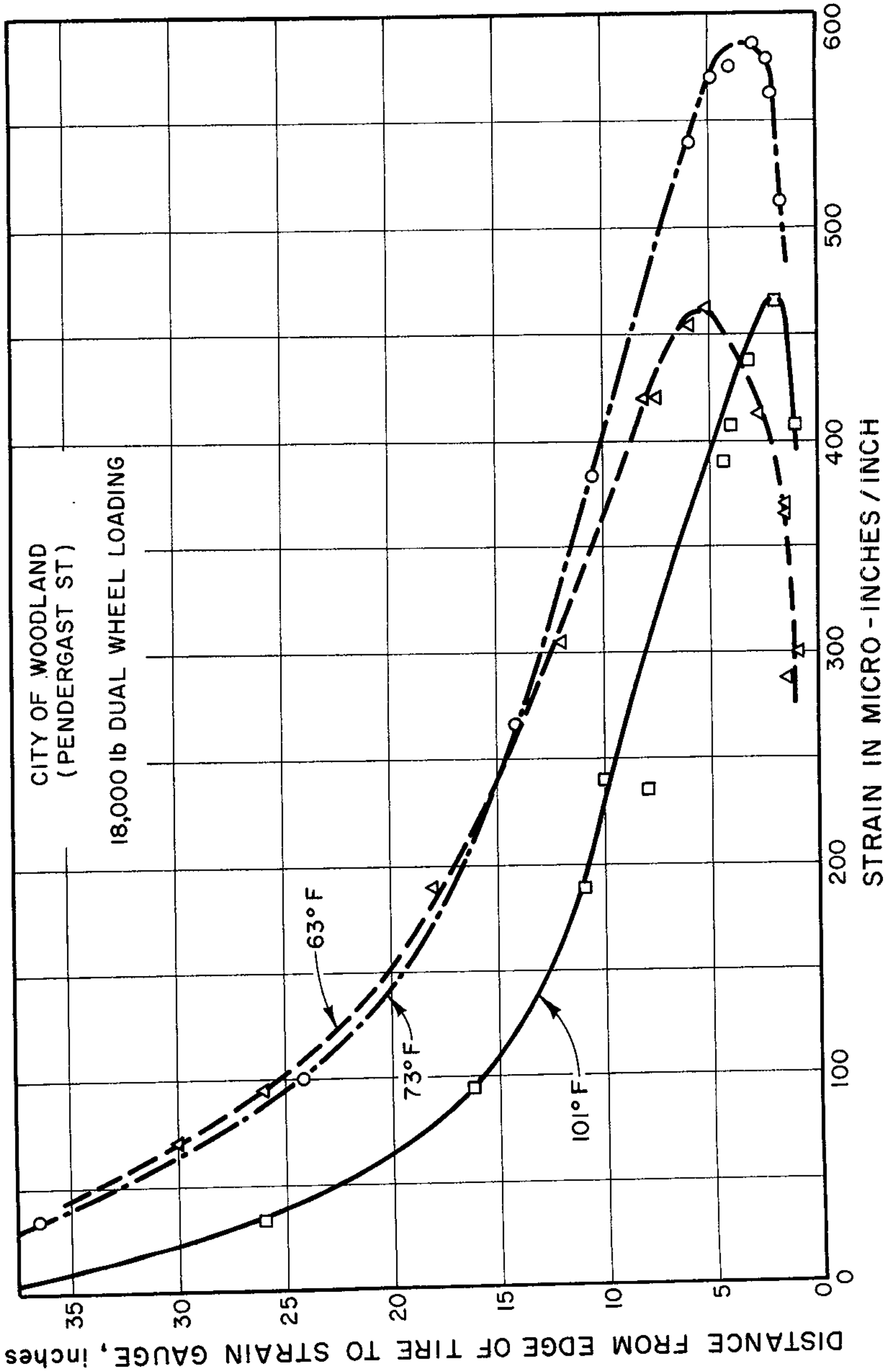


Figure 7

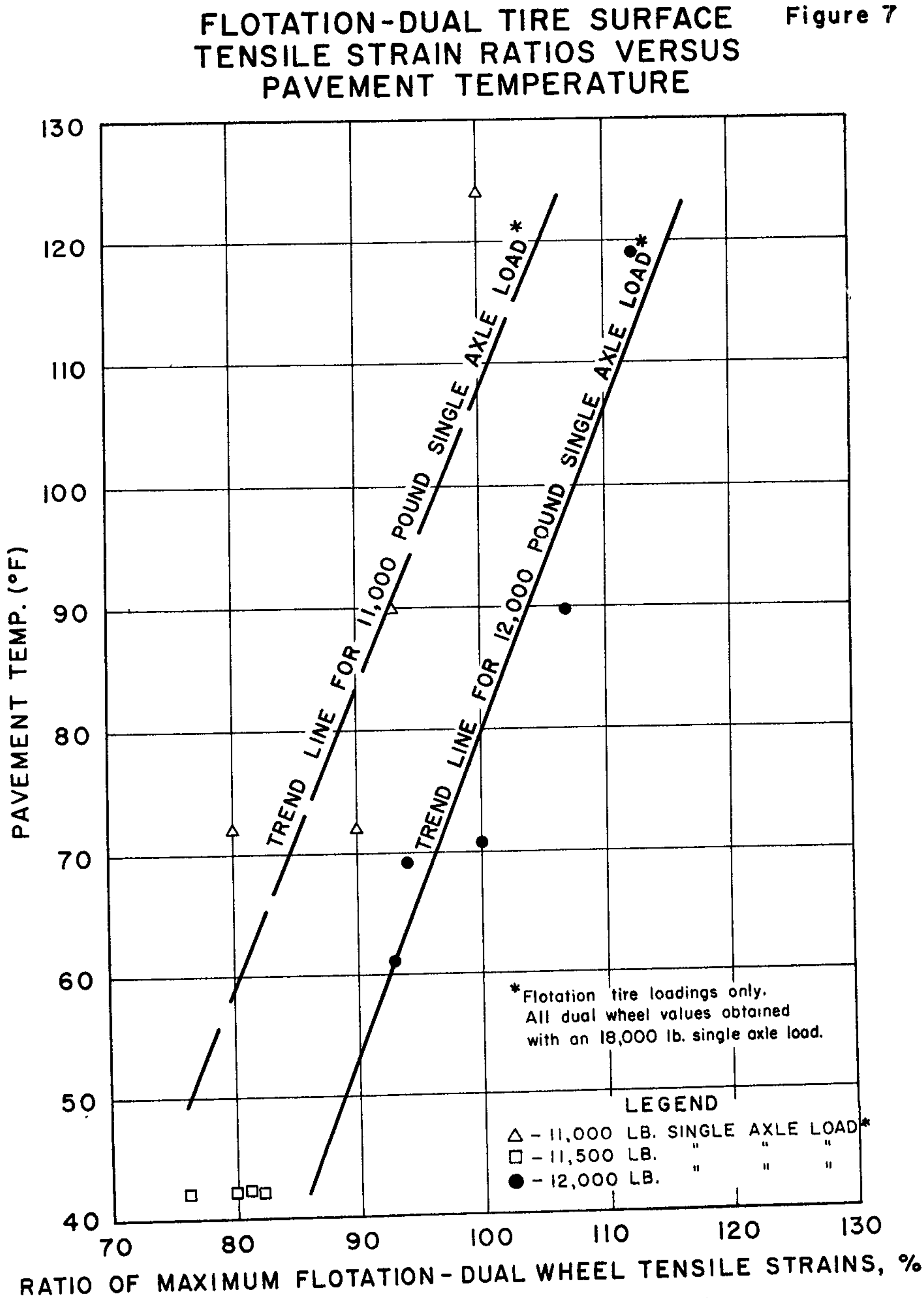
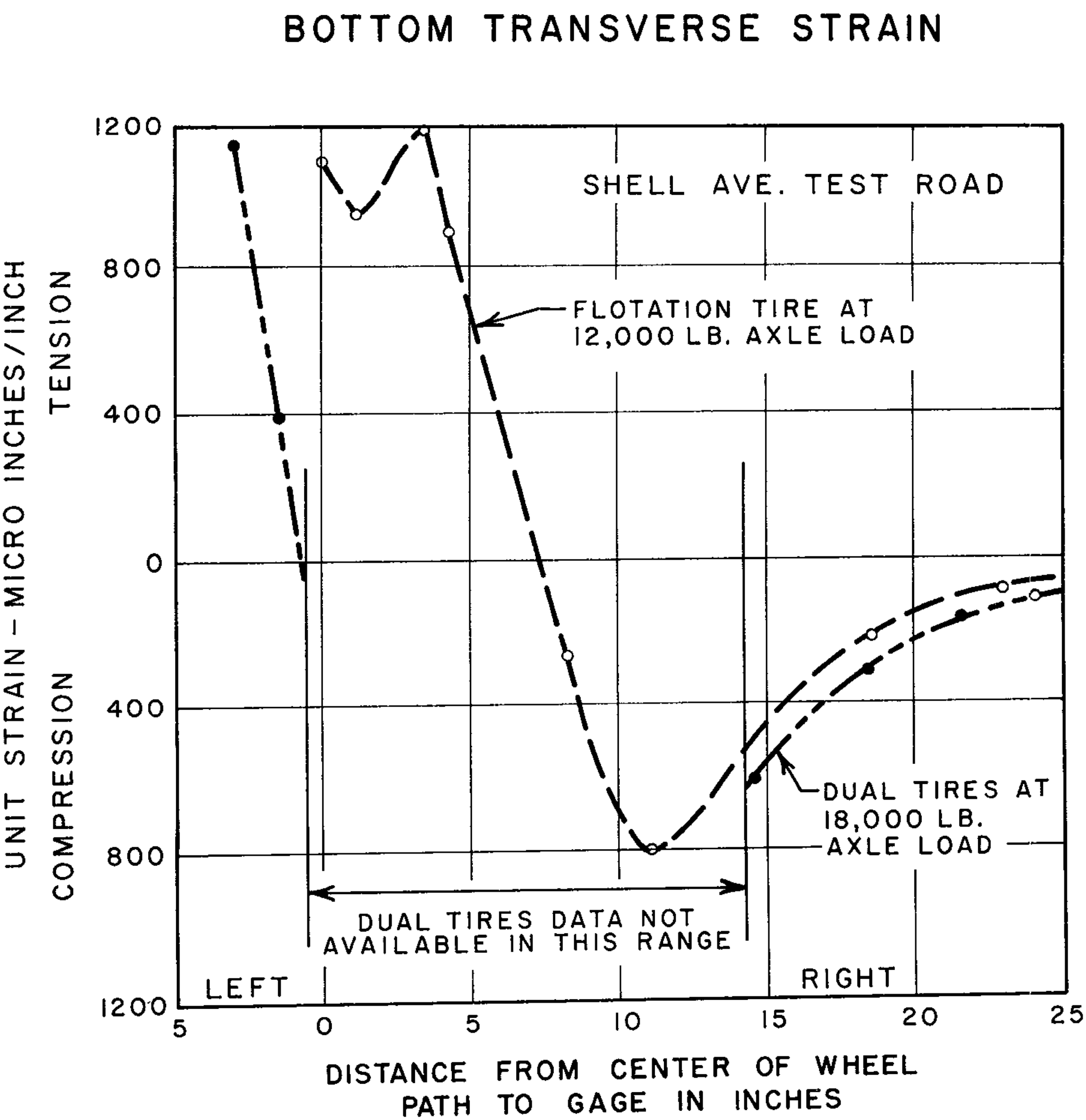
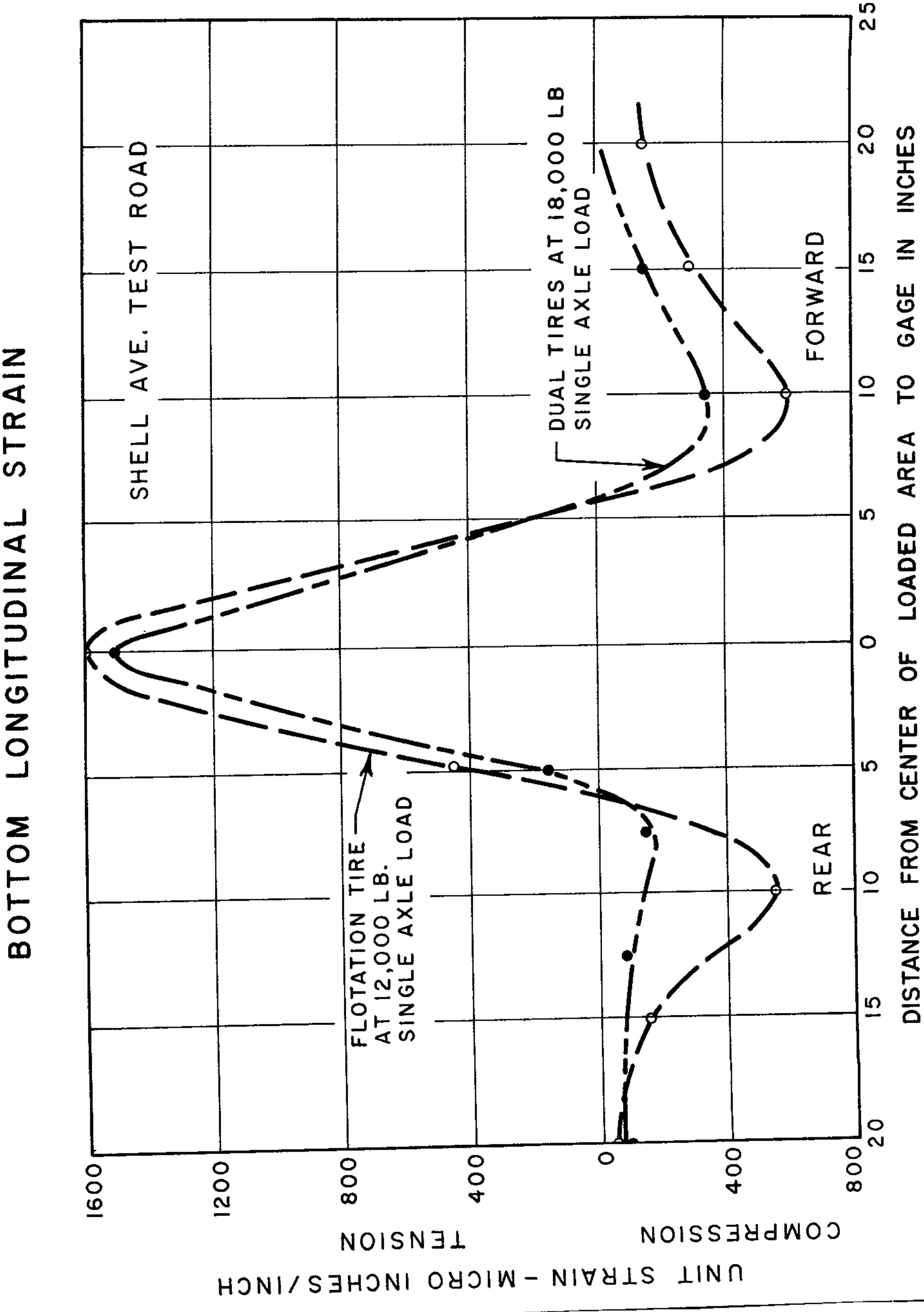
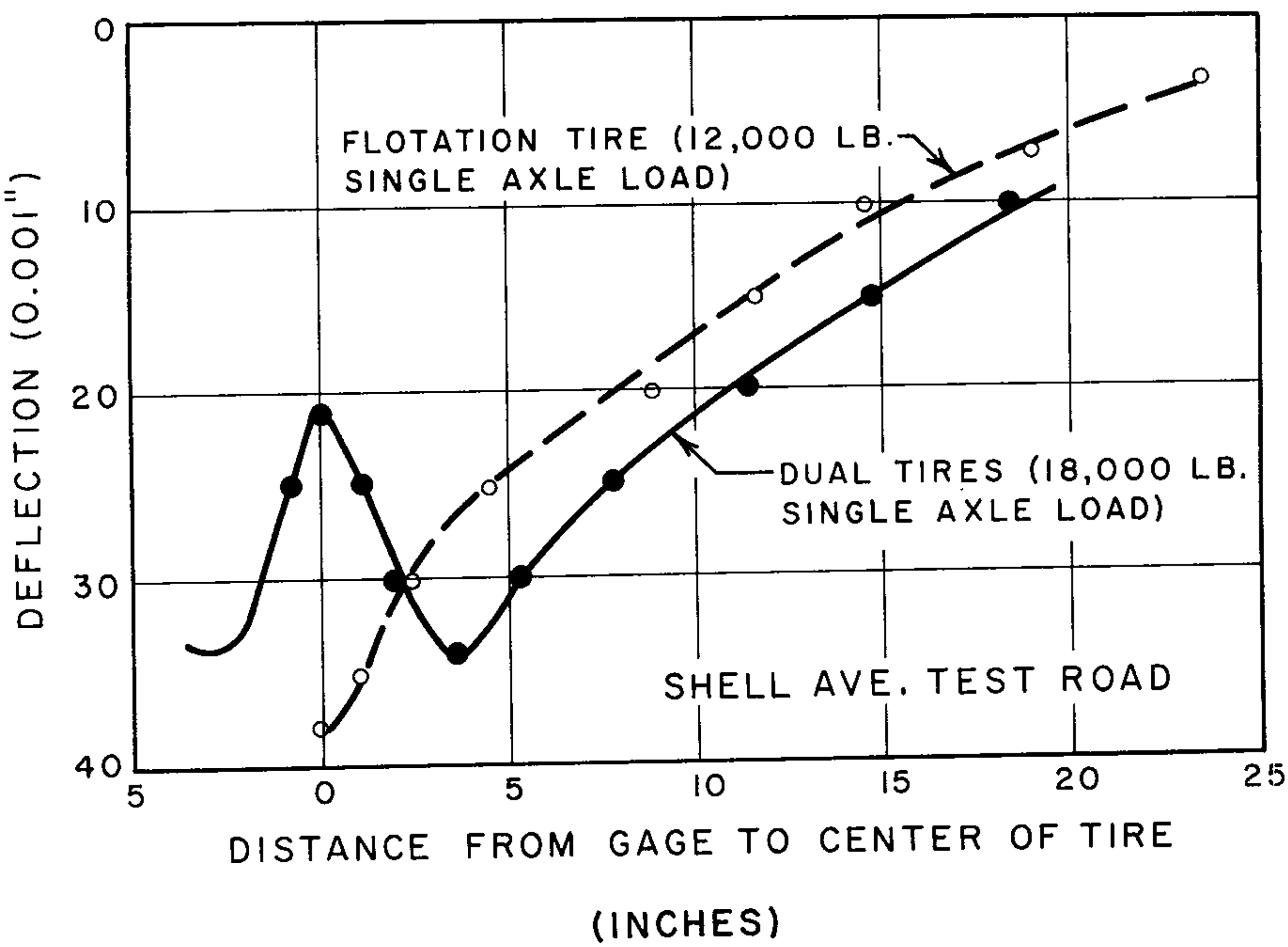

FLOTATION-DUAL TIRE SURFACE
TENSILE STRAIN RATIOS VERSUS
PAVEMENT TEMPERATURE
PAVEMENT TEMP. (°F)
130
120
110
100
90
80
70
60
50
40
70
80
90
100
110
120
130
RATIO OF MAXIMUM FLOTATION-DUAL WHEEL TENSILE STRAINS, %
TREND LINE FOR 11,000 POUND SINGLE AXLE LOAD*
TREND LINE FOR 12,000 POUND SINGLE AXLE LOAD*
*Flotation tire loadings only.
All dual wheel values obtained
with an 18,000 lb. single axle load.
LEGEND
△ - 11,000 LB. SINGLE AXLE LOAD*
□ - 11,500 LB. " " "
● - 12,000 LB. " " "

Figure 8


BOTTOM TRANSVERSE STRAIN
SHELL AVE. TEST ROAD
FLOTATION TIRE AT
12,000 LB. AXLE LOAD
DUAL TIRES AT
18,000 LB.
AXLE LOAD
DUAL TIRES DATA NOT
AVAILABLE IN THIS RANGE
LEFT
RIGHT
UNIT STRAIN - MICRO INCHES/INCH
TENSION
COMPRESSION
1200
800
400
0
400
800
1200
5
0
5
10
15
20
25
DISTANCE FROM CENTER OF WHEEL
PATH TO GAGE IN INCHES


BOTTOM LONGITUDINAL STRAIN
SHELL AVE. TEST ROAD
DUAL TIRES AT 18,000 LB
SINGLE AXLE LOAD
FLOTATION TIRE
AT 12,000 LB.
SINGLE AXLE LOAD
FORWARD
REAR
25
20
15
10
5
0
5
10
15
20
DISTANCE FROM CENTER OF LOADED AREA TO GAGE IN INCHES
1600
1200
800
400
0
400
800
TENSION
COMPRESSION
UNIT STRAIN - MICRO INCHES/INCH

TRANSVERSE DEFLECTION PROFILE
LVDT GAGE UNIT



FLOTATION-DUAL TIRE DEFLECTION RATIOS VERSUS FLOTATION SINGLE AXLE LOADING

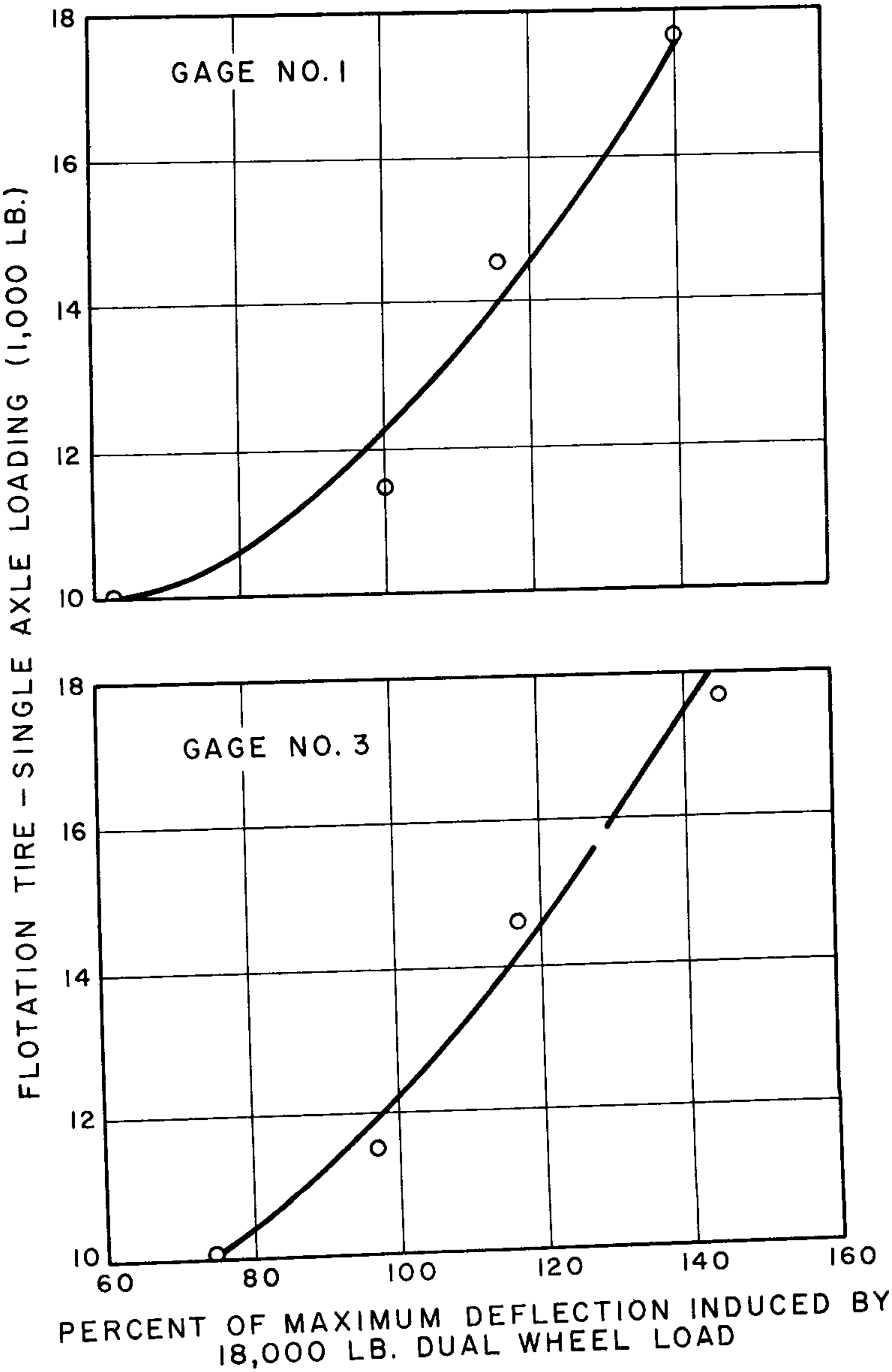
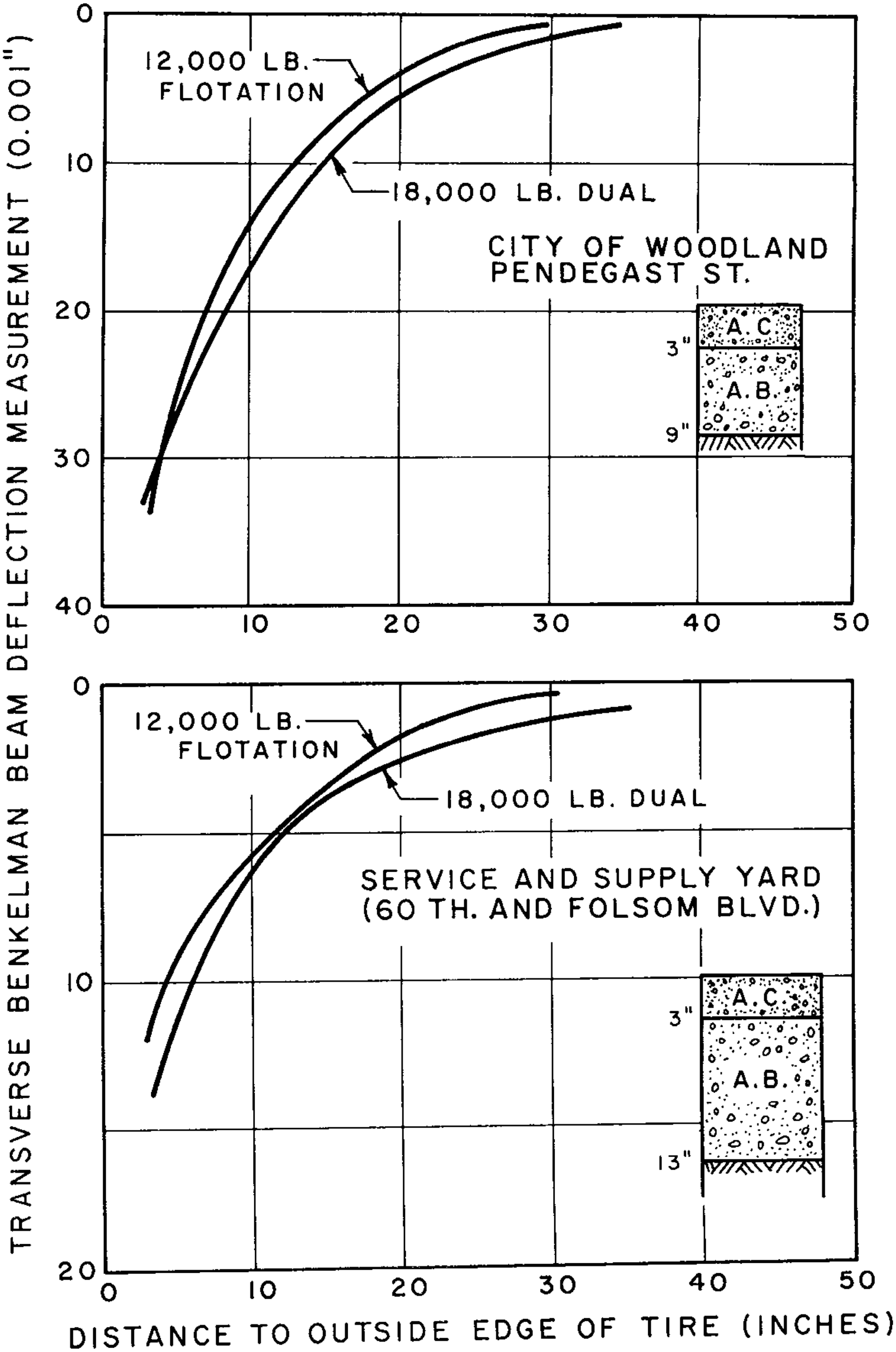
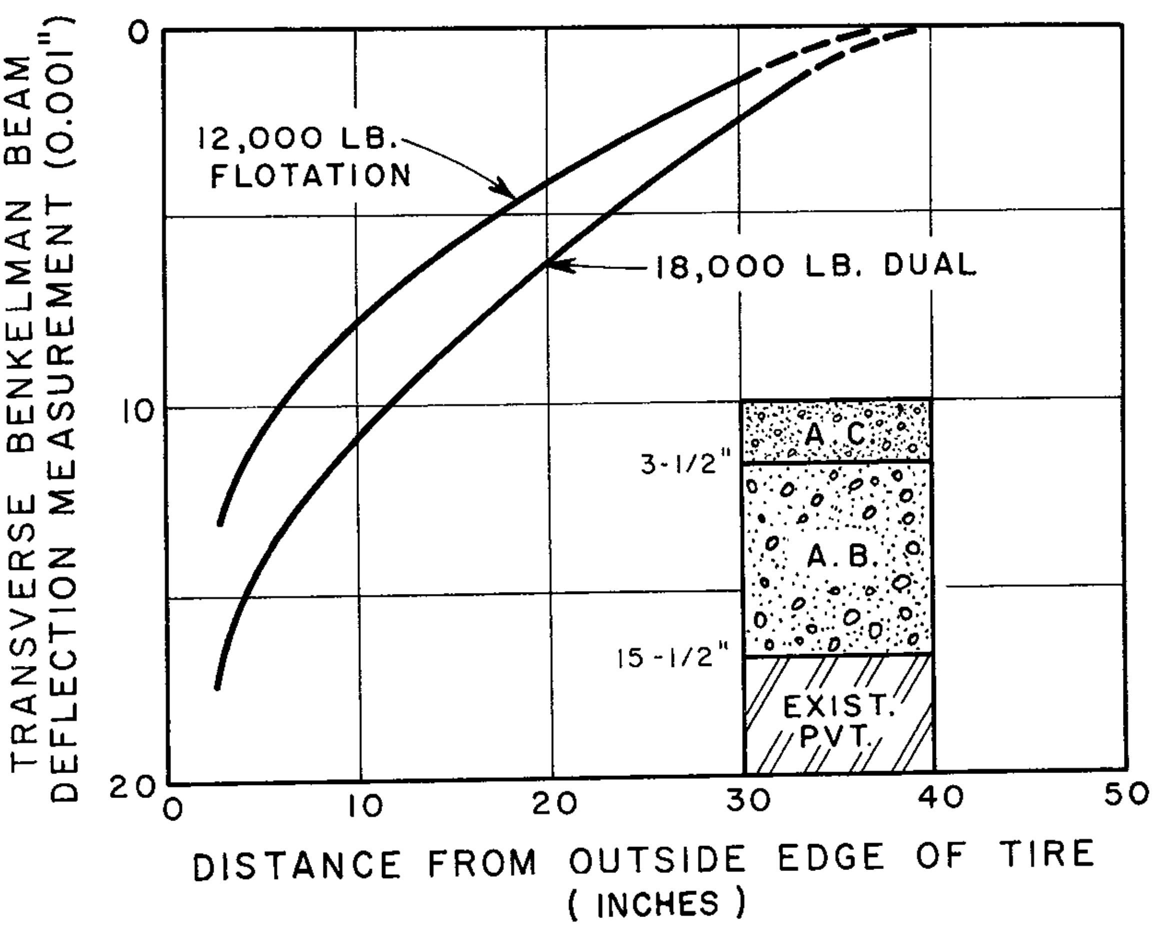


Figure 12

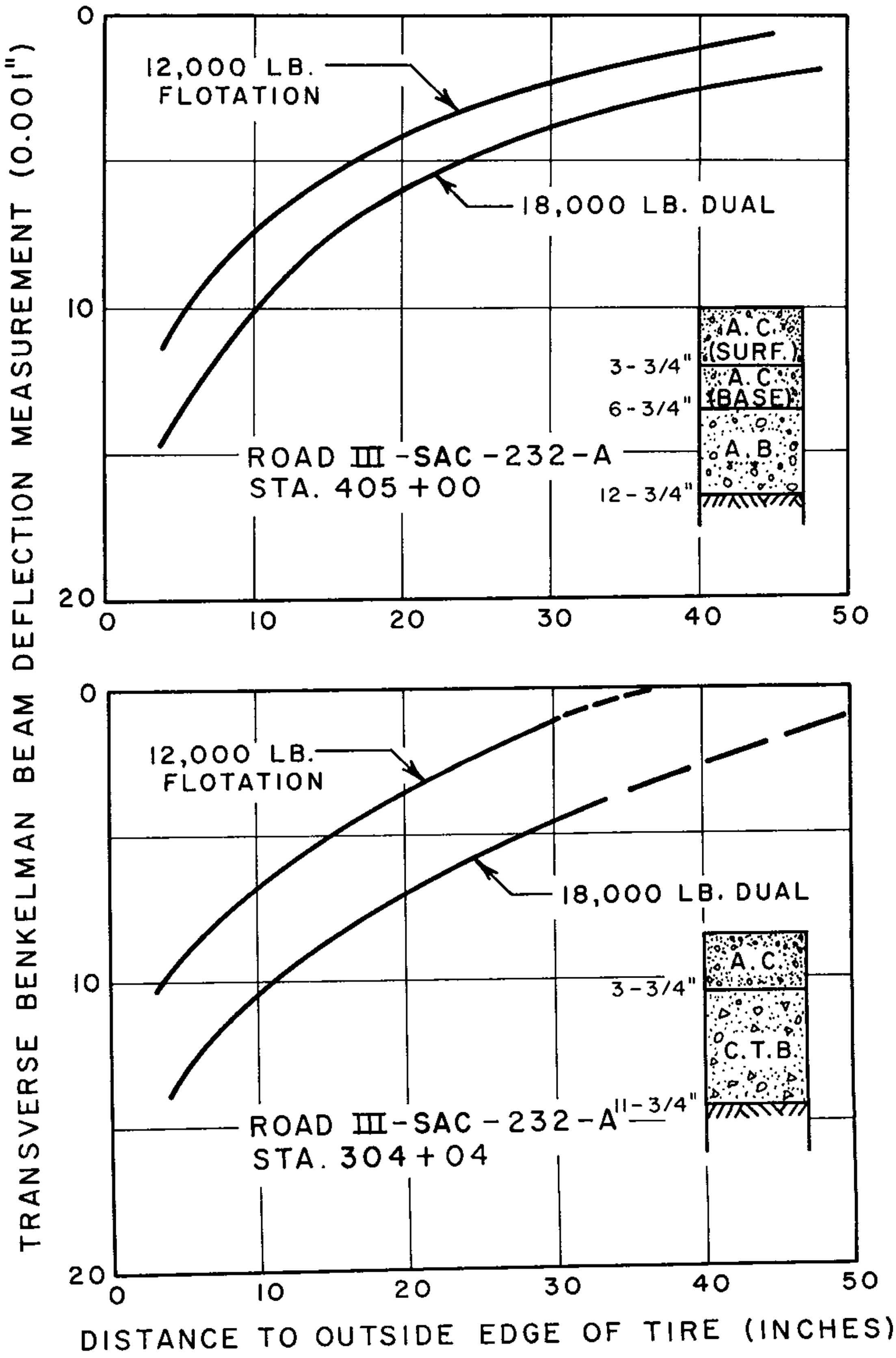
TRANSVERSE DEFLECTION PROFILE (BENKELMAN BEAM)



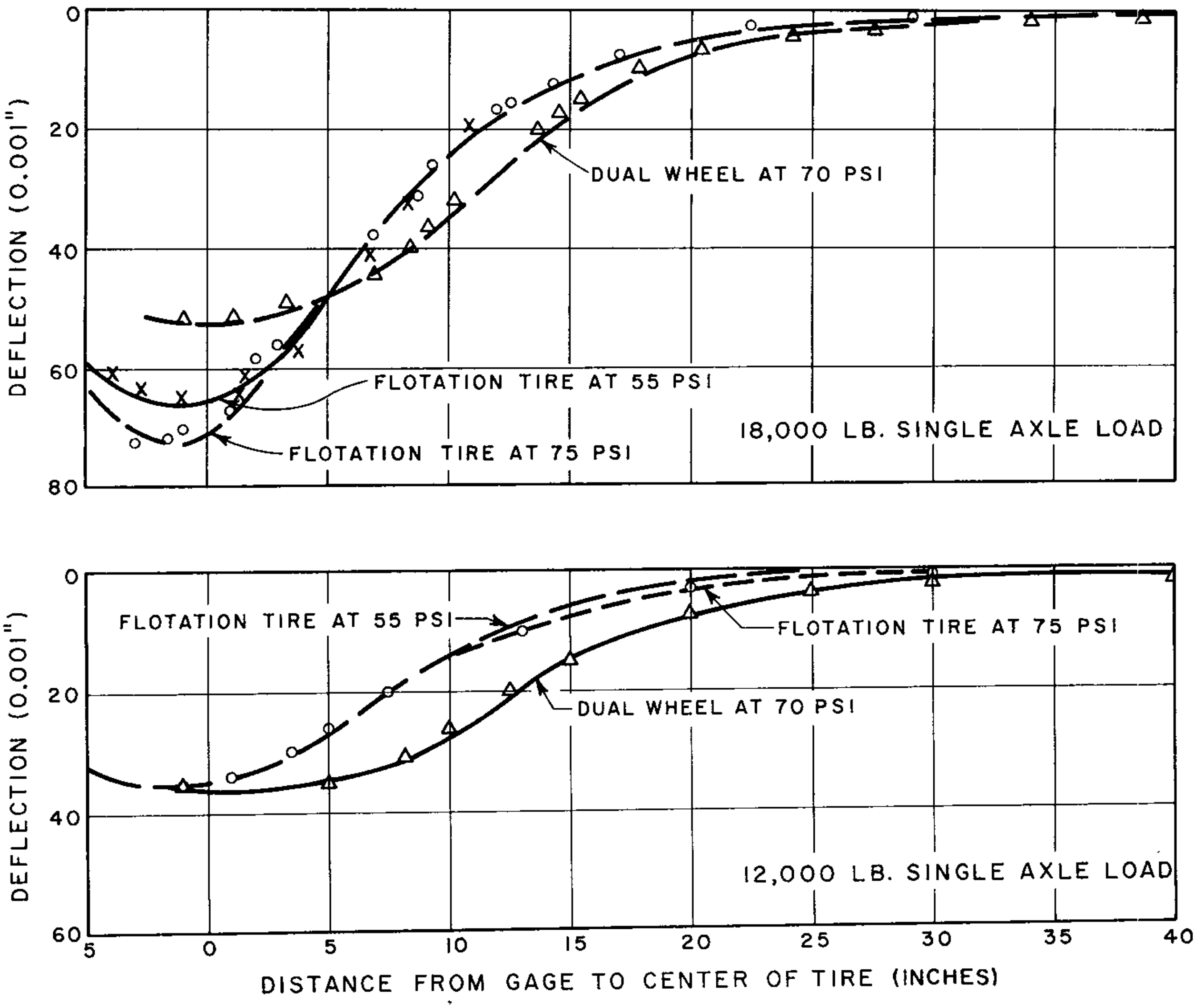
TRANSVERSE DEFLECTION PROFILE
(BENKELMAN BEAM)
ROAD III-SAC-232-A
STA 354+00

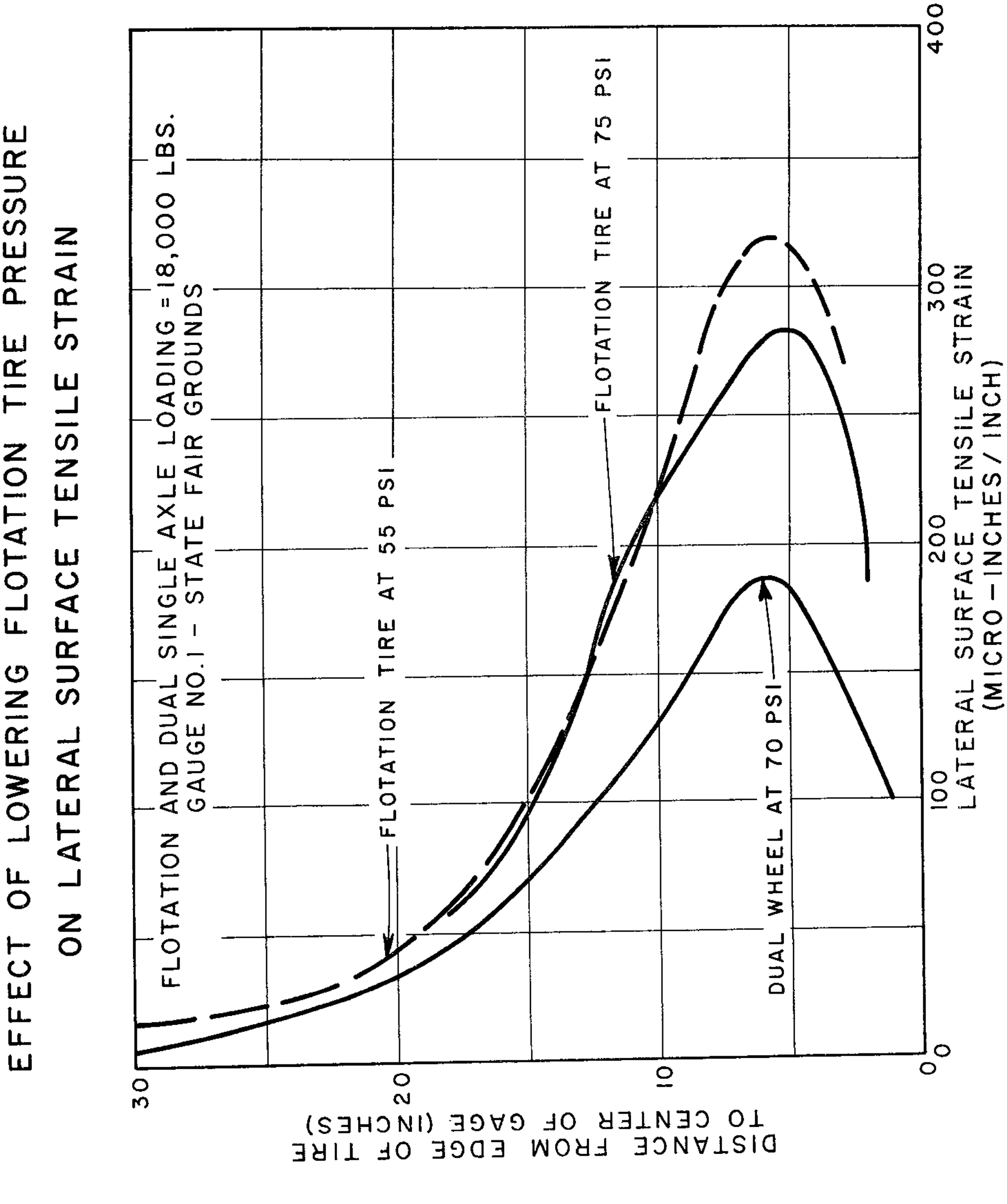


TRANSVERSE DEFLECTION PROFILE (BENKELMAN BEAM)



EFFECT OF LOWERING FLOTATION TIRE PRESSURE ON TRANSVERSE DEFLECTION PROFILE LVDT GAGE UNIT




EFFECT OF LOWERING FLOTATION TIRE PRESSURE
ON LATERAL SURFACE TENSILE STRAIN
FLOTATION AND DUAL SINGLE AXLE LOADING = 18,000 LBS.
GAUGE NO. 1 - STATE FAIR GROUNDS
FLOTATION TIRE AT 55 PSI
FLOTATION TIRE AT 75 PSI
DUAL WHEEL AT 70 PSI
0
100
200
300
400
LATERAL SURFACE TENSILE STRAIN
(MICRO-INCHES/INCH)
30
20
10
0
DISTANCE FROM EDGE OF TIRE
TO CENTER OF GAGE (INCHES)

EFFECT OF LOWERING FLOTATION TIRE PRESSURE ON LATERAL SURFACE TENSILE STRAIN