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FIELD TESTS ON A PRESTRESSED CONCRETE MULTI-BEAM BRIDGE

by

A. Roesli, A. Smislova, C. E. Ekberg, Jr., and W. J. Eney

A condensed version given by
C. E. Ekberg, Jr., at the
Annual Meeting of the Highway
Research Board on January 20,
1956, at Sheraton-Park Hotel
in Washington, D.C.

INTRODUCTION

The bridge test described in this report is a part of an extensive research program on prestressed concrete bridge members being carried on at Lehigh University.

The general purpose of this research program is to check the validity of the design assumptions, determine the effect of static and repeated loads, and to furnish data that may aid in the preparation of design specifications.

Where multi-beam bridges are concerned, the main problem to be investigated is the interaction of the beams and the determination of the portion of the total live load each beam must carry. The overall problem has been divided into three phases, namely: theoretical studies, laboratory tests, and field tests on actual bridges. This report covers the first of several planned field tests.

SLIDE NO.1

The test bridge is shown in the first slide. It is located at the west end of the town of Centerport in Berks County, Pennsylvania. The bridge beams were manufactured in November 1951 by the Concrete Products Company of America at their Pottstown plant, and erection took place in December 1952. The bridge was tested in July 1954.

A two-inch layer of bituminous material covers the top surfaces of the nine prefabricated, pretensioned concrete beams. An eight-inch high precast curb is provided on each side of the roadway. The steel guard rails were bolted in the field to the outside beams.

SLIDE NO. 2

This is a view showing the nine beams in plan. The bridge has a clear roadway width of 25 ft. 4 in., and a clear span of 32 ft. A single one-inch diameter mild steel bolt, approximately 27 ft. long, passes through two-inch precast holes in the beams to tie the bridge together laterally at midspan. This bolt is not under any appreciable tension and is ungrouted.

SLIDE NO. 3

The top view is a longitudinal section showing the extent of the hollow portion of the beams. The hollows extend the total length of the beam except for a two-foot solid section at each end and a 10-in. solid section at the center of the span where the lateral tie rod passes through.

The bottom view is a cross-section showing two circular hollows in each beam. The tie rod is seen to pass through the beams at mid-depth, and the shear keys are visible between the beams just above mid-depth.

The bridge was erected by placing the beams side-by-side on the abutments, using a large truck crane. The beams had two vertical 2-1/2 in. diameter precast holes in each end and these were used to align a star drill to make corresponding holes in the abutment. Finally, 3/4 by 26-in/ anchor bolts were inserted and grouted to tie down all beams to the abutments.

SLIDE NO. 4

This slide shows the details of an individual beam which has a section approximately 36-in. wide by 21-in. deep.

It can be seen that the shear key voids, formed when the beams are placed side by side, have a width varying from 3/4-in. at the top to 1-1/2 in. near the bottom. These voids extend vertically to 9 in. below the top fiber and are completely filled with non-shrinking mortar.

Initially the 1/4-in. strands were prestressed to 135,000 psi with a twenty percent loss assumed for shrinkage, plastic flow, and elastic shortening.

The concrete specifications required a cylinder strength at release of prestress of 3300 psi and a strength at 28 days of 5000 psi.

The design live load is an H20-S16 truck with 30 percent impact. Each beam was designed to carry 40 percent of the lane loading.

SLIDE NO.5

This slide shows the location of the static and dynamic test equipment that was used.

The purpose of the static tests was to determine the percentage of live load carried by each beam of the bridge. This was accomplished by measuring the deformed shape of the bridge loaded with two different types of trucks to be described later. The loading of the bridge was performed by positioning these trucks successively at the quarter-point and midspan in both the edge and center traffic lanes. Thirty-nine dial gages, indicated by the small circles, were used to measure the vertical deflections. Of secondary importance during static loading was the measurement of the transverse rotation of three of the beams. The positions of the level bars used for this purpose are shown by the semicircular symbols. Concrete strain measurements were made with Whittemore gages, but proved too inconsistent to be of use.

The dynamic tests were intended to provide a little information regarding the behavior of the bridge due to a moving truck. These tests included deflection measurements at three critical points on the bridge while the truck was first driven on an unobstructed path, and later while the truck was driven over a plank placed flat-wise across the bridge at midspan. Dynamic deflections were measured at the points symbolized by the double circles.

SLIDE NO. 6

The left-hand photograph shows the simple timber scaffolding to provide an independent supporting structure for the gages.

The right-hand view shows the Whittemore gage, the Ames dial deflection gage, and on the extreme right, a setup for measuring dynamic deflection.

SLIDE NO. 7

The trucks shown here were used to apply various live loads on the bridge.

The total weight of the scale truck shown on the left is 37,900 lb. This truck was used only for static testing.

The tractor trailer truck on the right had a rear axle weight of 47,700 lbs. for the static tests. In all static tests, except where this truck was used in combination with the scale truck, the rear axle loading was applied to the bridge by a pair of jacks. For the dynamic testing it was necessary to remove the iron blocks shown, and thus reduce the rear axle load to 33,700 lbs.

SLIDE NO.8

This is the first of a series of slides showing the elastic surfaces that were obtained for a few typical load positions. The deflection values are given in thousandths of an inch and are plotted upward. This slide depicts the inverted elastic surface for the scale truck with rear axles centered at midspan in the middle lane. In this case, the middle beam carries from 15.4 to 16.9 percent of the truck load on the basis of independent calculations for the center gage line and each of the three lateral gage lines to the left.

SLIDE NO.9

This slide depicts the elastic surface with the rear axles of the scale truck centered at midspan in the outisde lane. Calculations show that the outside beam receives 20.8 percent of the truck load for this case.

SLIDE NO.10

This slide shows the elastic surface for the case with the trucks back to back in the center lane.

SLIDE NO.11

The two trucks, back-to-back in the edge lane produced the greatest deflections of all the static tests performed. The maximum deflection was 0.087 in. in the edge beam.

SLIDE NO.12

In this loading position, the tractor trailer truck is in the middle lane and the entire axle load is concentrated at midspan on the middle bridge beam by means of hydraulic jacks.

SLIDE NO.13

Here the tractor trailer truck is in the outside lane and the axle load is transmitted through jacks to the second and third beams from the outside.

SLIDE NO.14

These figures show the independently measured deflections and rotations of the beams at midspan for the loading cases of the last two slides.

Three level bar readings are plotted to scale in each diagram, and it can be seen that the rotations closely coincide with the slopes of the transverse deflection curves. This would tend to indicate that there is practically no relative movement between adjacent beams.

SLIDE NO.15

This figure shows the percentage of an axle load that is carried by each beam for any longitudinal truck position in the center lane. The upper and lower curves, designated by solid lines, give the maximum and minimum values observed. The broken line that is connected to the maximum value curve gives results which occurred when the rear axle of the tractor trailer truck was jacked against the middle beam. The heavy solid line represents the average values obtained from all tests, exclusive of the jack loadings on the middle beam.

Considering the middle beam which carries the largest percentage of the load, it can be seen that the load distribution factor is 16.0 percent on the average and 16.9 percent as a maximum. The percentage increases to 20.5 for the case where the axle load is concentrated on the middle beam.

SLIDE NO.16

The percentage of an axle load that is carried by each beam for any truck position in the edge lane is shown here. The upper and lower solid-line curves give the maximum and minimum values observed. The broken line that is connected to the maximum value curve at upper left gives results which occurred when the rear axle of the tractor trailer truck was jacked against the second and third beams from the left. The heavy solid line represents the average values obtained from all tests, exclusive of the jack loadings.

Considering the edge beam, it can be seen that the load distribution factor is 20.6 percent on the average and 22.6 percent as a maximum. For the cases where the jacks were used to concentrate the load from the tractor trailer truck, a maximum value of 23.9 percent was obtained for the second beam.

SLIDE NO.17

The upper figure is a time vs. deflection plot of the midpoint of bridge as the tractor trailer truck moves across at 25 mph in the centerlane. It was shown for this case, that the static deflections of the bridge at midpoint were increased by 13.9 percent.

The lower figure is a time-deflection plot for the bridge midpoint as the truck moves in the middle lane at 25 mph and strikes a 2-in. by 10-in. plank laid flatwise across the bridge at midspan. An impact effect of 106 percent was reached when the rear axle of the tractor struck the plank.

The lower figure is a similar plot for midspan deflections of the edge beam as the truck moves in the outside lane and strikes the plank at midspan. The largest impact effect was 200 percent.

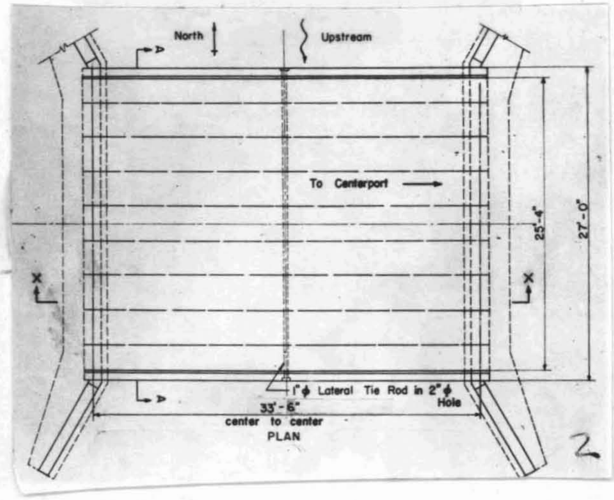
CONCLUSIONS

The results of the tests just described are summarized as follows:

1. For a truck in the centerlane the load carried by the middle beam did not exceed 20.5 percent of the lane load, even if the entire axle load was concentrated directly against the middle beam.
2. For a truck in the edge lane, the maximum load carried by any beam did not exceed 24 percent of the lane loading.
3. On the basis of the dynamic tests, it was found that the most severe condition occurrred with the truck moving at 25 mph in the outside lane. For the case where the path of the truck was unobstructed, it was found that the static deflection of the edge beam at midspan was increased by 23 percent. When the truck passed over a 2-in. by 10-in. plank, laid flatwise across the entire lane, the static deflection of edge beam was increased by 200 percent.
4. The overall behavior of the bridge seemed to approach that of a homogeneous plate.

In closing, I would like to acknowledge the sponsors of the Lehigh Prestressed Concrete Research Program; namely, the Pennsylvania Department of Highways, Bureau of Public Roads, American Steel & Wire Co., John A. Roebling's Sons Corp., Concrete Products Co. of America, and the Reinforced Concrete Research Council.

No. 1



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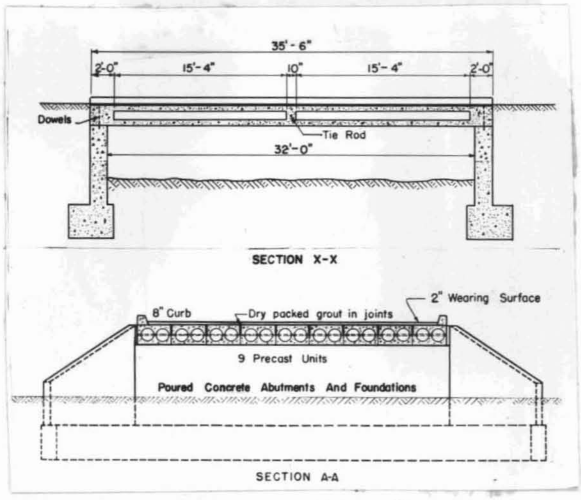

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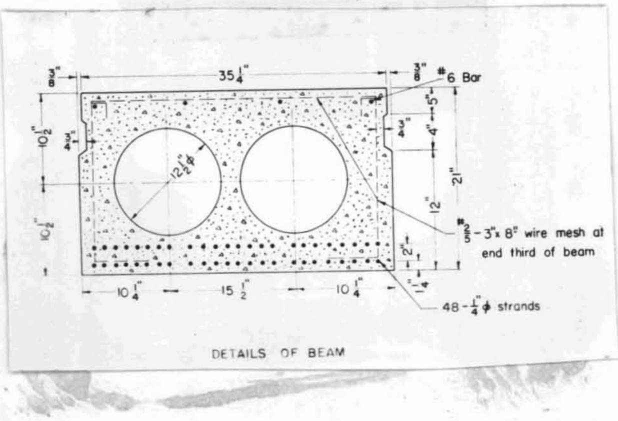

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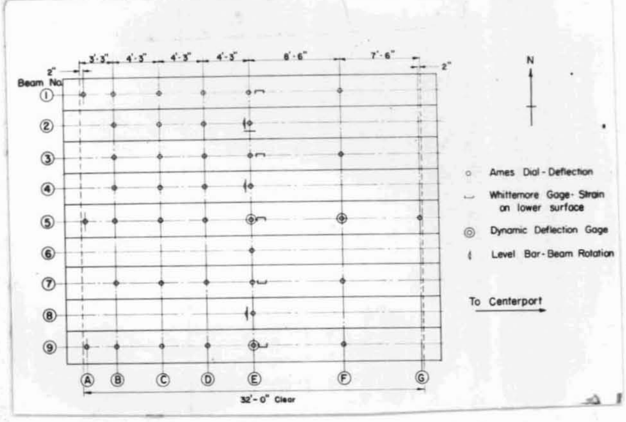

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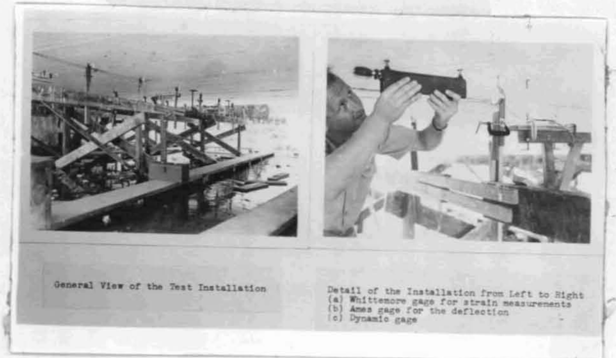

General View of the Test Installation

Detail of the Installation from Left to Right
(a) Whittemore gage for strain measurements
(b) Ames gage for the deflection
(c) Dynamic gage

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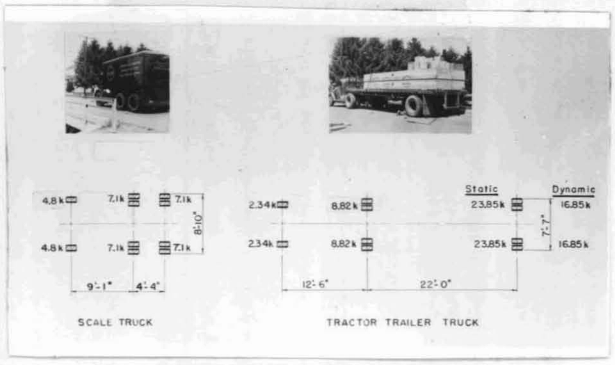

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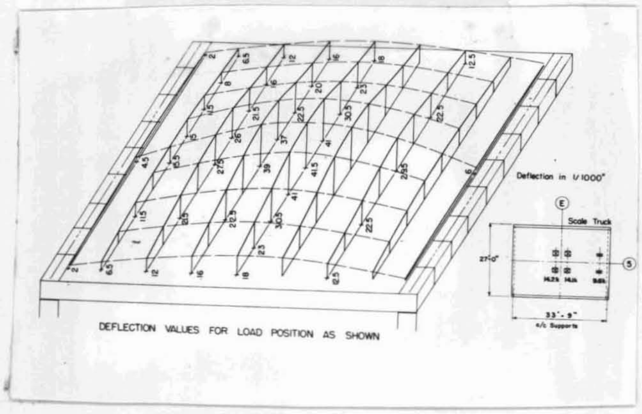
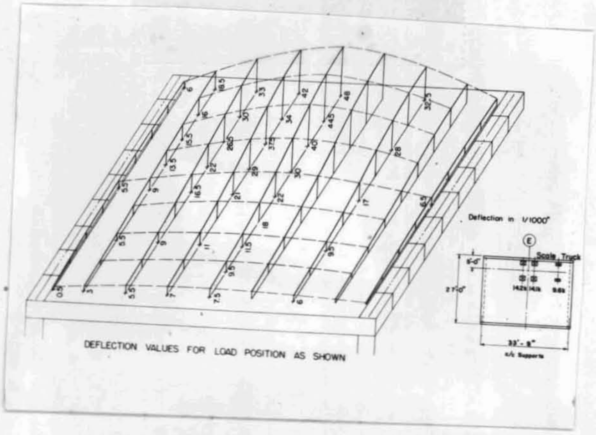


DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

No. 8



DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

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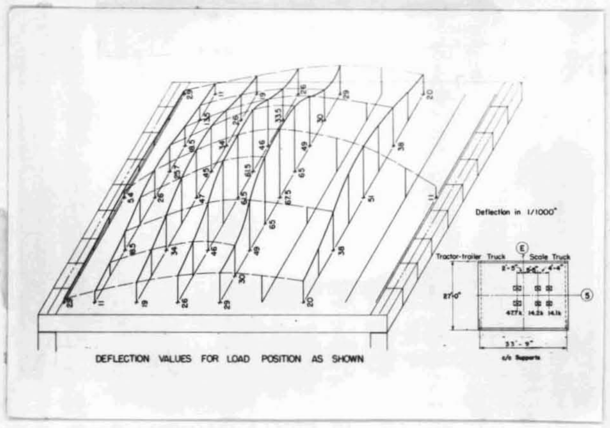

DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

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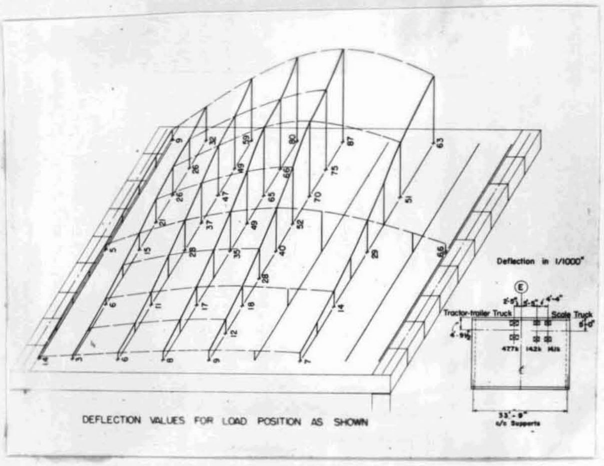
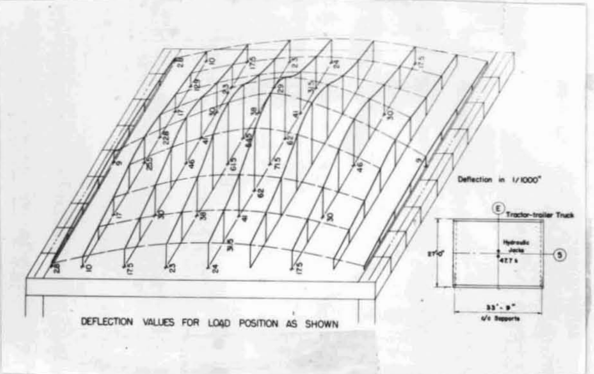


DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

No. 11



DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

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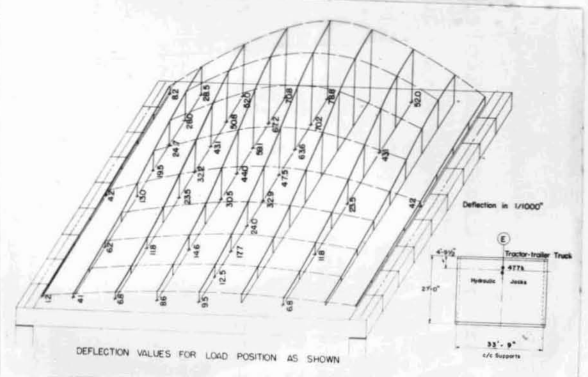

DEFLECTION VALUES FOR LOAD POSITION AS SHOWN

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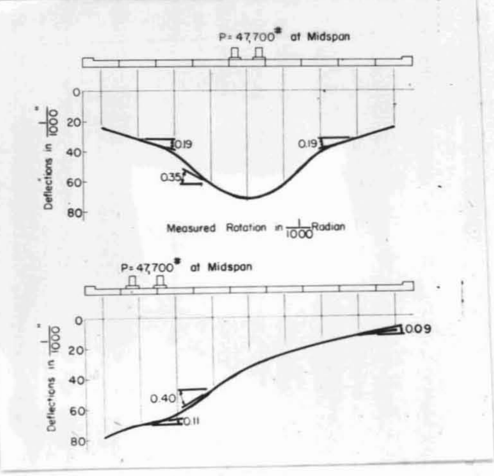

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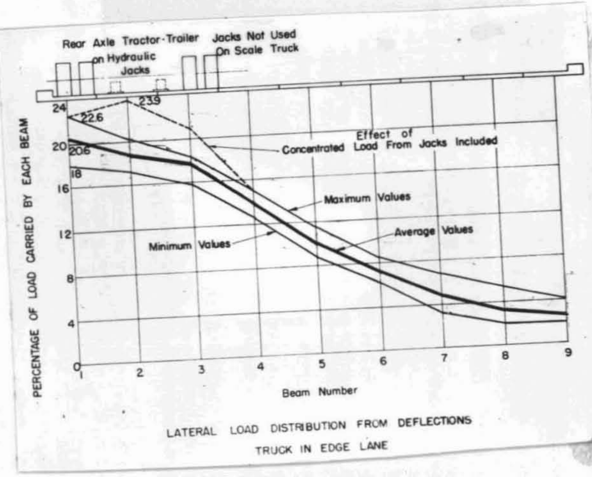
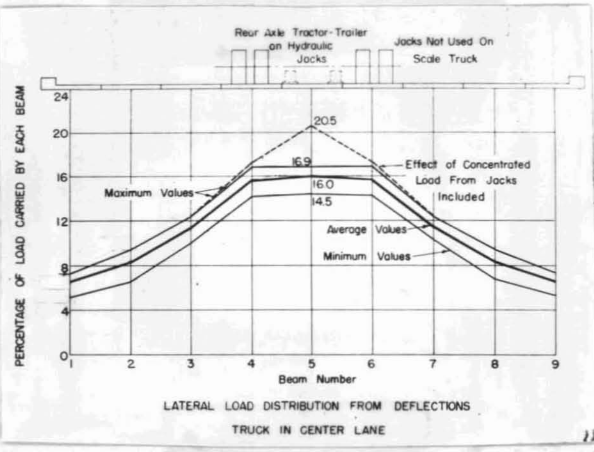


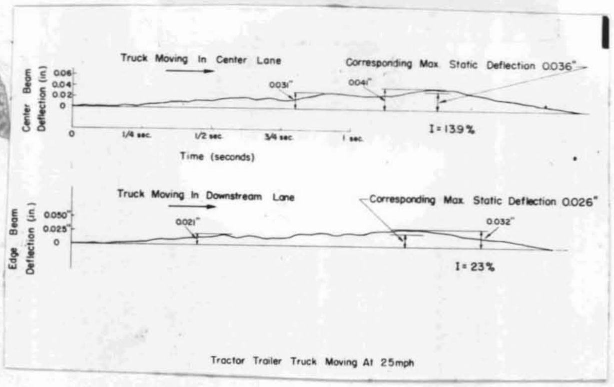
LATERAL LOAD DISTRIBUTION FROM DEFLECTIONS
TRUCK IN EDGE LANE

No. 15



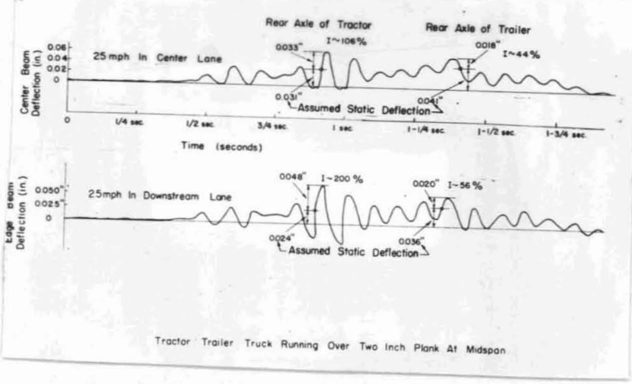
LATERAL LOAD DISTRIBUTION FROM DEFLECTIONS
TRUCK IN CENTER LANE

No. 16



Tractor Trailer Truck Moving At 25mph

No. 17



Tractor Trailer Truck Running Over Two Inch Plank At Midspan

No. 18