# Field Evaluation of Mainline Quality Track Using a Track Strength Test Vehicle

**By Allan M. Zarembski* and John Choros****

## ACKNOWLEDGEMENT

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## EXECUTIVE SUMMARY

This report presents the results of field evaluation test of the prototype Track Strength Test Vehicle, the DECAROTOR, on mainline quality track. This work is part of the ongoing Track Strength Characterization Program, directed at measurements of the load-carrying capacity of railway track structures, the development of suitable measurement techniques, the demonstrations of the usefulness of such measurements, and ultimately the matching of the track strength with the vehicle loading.

The tests reported here are the second in a series of field tests aimed at evaluating the capabilities and limitations of the Track Strength Testing concept.

The objectives of these tests were to:

(a) investigate the ability of the Decarotor to evaluate mainline quality track and to detect weaknesses in the track,

(b) determine if the track strength testing concept could detect differences in mainline track "strength," normally permitted by railroads, and

(c) evaluate the ability of stationary load-deflection tests to determine tie or fastener conditions.

In order to achieve these objectives, a series of moving and stationary lateral track strength tests were conducted in March 1980 on the Southern Railway's mainline near Charlottesville, VA. The test section included two adjacent test zones. One zone was timbered and surfaced in late 1979 and was considered to represent "strong" standard mainline track. The second zone was last timbered in 1974, and was at the end of its six years maintenance cycle. It represented the "weakest" standard mainline track permitted by the railroad.

The results of the tests showed that continuous track strength measurements were feasible. These measurements consistently and repeatedly identified weaknesses in the track, such as clusters of poor ties. In addition, these measurements were able to differentiate between the different levels of lateral track strength found in both mainline and yard quality track. These testing activities could be performed nondestructively by means of a moving inspection vehicle, so as to permit the evaluation of relatively long stretches of track. Finally, it was shown that stationary load-deflection tests can help identify the general condition of tie or fasteners. Further testing, however, is necessary in order to

* Manager, Track Research Division, Association of American Railroads Technical Center, Chicago, IL
** Research Engineer, Track Research Division, Association of American Railroads Technical Center, Chicago, IL

demonstrate the practical value of this testing technique.

## 1.0 INTRODUCTION

In order to optimize the ability of the track structure to withstand the loads imposed by both train operations and the environment, the strength or load carrying capacity of the track must be known. At present, the determination of track strength remains quite subjective, subject to the experience and judgment of the local maintenance-of-way personnel, and, therefore, significant variations in the definition of "good" or "adequate" track exist.

A necessary prerequisite to this track optimization i.e., the maintenance of safe and reliable track at minimum cost, is the development of quantitative measurements of track strength. By properly matching this measured strength of the track with the vehicle imposed loadings this optimization of the track train system can be obtained. In addition, practical measurement techniques are needed in order to accurately determine track strength in the field.

The Track Strength Characterization Program [1]* was initiated in 1977 to:

(a) Determine what parameters influence track strength,

(b) Measure those parameters that affect track strength,

(c) Develop practical methods of determining track strength in the field, and

(d) Demonstrate the benefits of track strength measurements.

As part of this program, a series of laboratory tests, aimed at providing basic information on the strength of track, were conducted at the Association of American Railroad's (AAR) Track Laboratory [1]. Subsequent to these laboratory tests, gage restraint measurement tests, aimed at investigating the feasibility of continuous track strength measurements from a moving test car, were conducted at the AAR Technical Center in October, 1978 [2]. The result of these later tests indicated that it appeared to be possible to measure the lateral strength of track, and to identify the location of specific weak spots.

As a result of these preliminary tests, a new prototype track strength test vehicle, the "DECAROTOR", was constructed [1,3]. In order to evaluate both this prototype vehicle and the track 'strength concept itself, a program of field evaluation tests was planned [1].

The initial vehicle qualification and characterization tests were conducted in the Southern Railway's Alexandria, VA yard in January, 1980 [3]. A preliminary evaluation of the car's ability to locate "weaknesses" in yard track was also conducted. These tests showed that the DECAROTOR was able to repeatedly identify "weak" sections in the track structure at test speeds ranging from one to seven miles per hour. Furthermore, it was able to conduct these tests without causing measurable damage to the track structure [3].

Based on the results of these yard tests, the second test series was designed to assess the ability of the DECAROTOR, to evaluate mainline track conditions. The purpose of this report is to describe and discuss these tests with the "DECAROTOR," conducted on the Southern Railway's mainline near Charlottesville, Virginia in March 1980.

## 2.0 TEST OBJECTIVES AND SCOPE

As a result of the preliminary field tests of the DECAROTOR, conducted in Alexandria. VA [3], it was determined that this test vehicle could identify "weak" spots in the track structure, by applying constant lateral and vertical loads to both rails as it moves along the track, and by monitoring any associated gauge widening of the track. It was also noted that this process of locating and identifying weak spots in the track could be done repetitively, at varying speeds, and without causing significant damage to the track structure. The results were, however, confined to yard track, whose level of maintenance, was significantly below that of mainline track. Thus, while the Alexandria tests did indicate that weaknesses in relatively-poor track could be identified, it was not at all certain that the test concept would also work on well-maintained, mainline track.

The tests on the Southern Railway's mainline near Charlottesville, VA were designed to further examine this concept by addressing three specific objectives.

* The numbers in the brackets [ ] refer to the References listed in Section 6.0 of this Report.

The first objective was to investigate the ability of the DECAROTOR to evaluate mainline track. In particular, it was intended to determine whether the track strength testing concept could consistently identify specific weakness in the track, at practical test speeds, and with a minimum of damage to the track itself.

The second objective was to evaluate the extremes of mainline track "strength" by testing two adjacent track sections: one that was recently timbered and surfaced, and the other that was near the end of its timbering and surfacing cycle. The objective here was to determine if the DECAROTOR could detect the differences in track strength between these two sections, which represented the maximum differences in mainline track quality permitted by the railroad.

The third objective was to conduct stationary track strength measurements at individual tie locations along the test track to more carefully study the tie-fastener behavior at these sites. These locations were to be selected from the results of the moving DECAROTOR inspections. The stationary tests, along with the visual observations, would then be used to determine if the test vehicle could accurately locate ties or fasteners in "poor" condition.

All three of these tests were designed to evaluate the ability of the track strength vehicle to provide maintenance of way personnel with useful information about the condition of their track and to help them in their maintenance planning activities.

## 3.0 FIELD TESTS

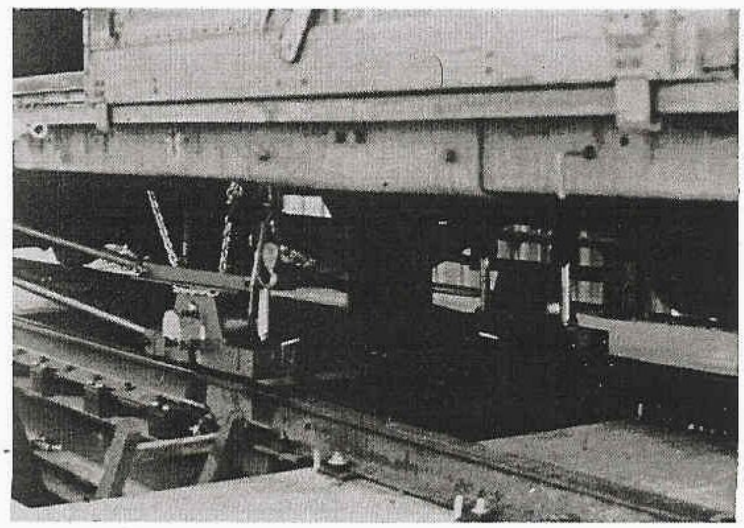
The mainline track field tests of the Track Strength Test Vehicle, shown in Figure 1, were conducted on the Southern Railway's Washington. D. C.—Atlanta, GA mainline, approximately six miles south of Charlottesville, Virginia in March 1980. The test site included one of two mainline tracks located between mile posts 118 and 120. This trackage handles approximately 25 million gross tons of mixed freight traffic annually.

The test section consisted of 132RE continuously welded rail (CWR), spiked to 7" x 9" x 8'6" hard wood ties (2 spikes per plate) at 19-1/2" spacing, with granite ballast and resting on a well-drained embankment. The test section was divided into two zones, as shown in Figure 2. Zone A was 1500 feet long, containing 300 feet of tangent track and 1200 feet of 3 degree curve. This zone had been timbered in late 1979 and represented "strong" standard mainline track. Zone B was a 1500 foot stretch of track, approximately 150 feet north of Zone A on the sane track. Zone B was subdivided into two test zones, BA and BB, separated by a grade crossing, as shown in Figure 2. Zone B was last timbered and surfaced in 1974, and was near the end of its six year maintenance cycle. It was scheduled for timbering and surfacing in 1980, and represented the "weakest" standard mainline track permitted by the railroad.

The tests were conducted in two parts, as shown in Table 1. The first, shown in Table 1A, involved the DECAROTOR tests, run at speeds ranging from 1 to 15* miles per hour. All of these tests were run with applied load levels of 15,000 pounds vertical and 10,500 pounds lateral, resulting in a constant L/V ratio of 0.7.

* The higher speed runs were inconclusive because the hydraulic system could not maintain the applied rail loads.


A. General View



B. Loading Apparatus

FIGURE 1. Track Strength Test Vehicle - DECAROTOR.

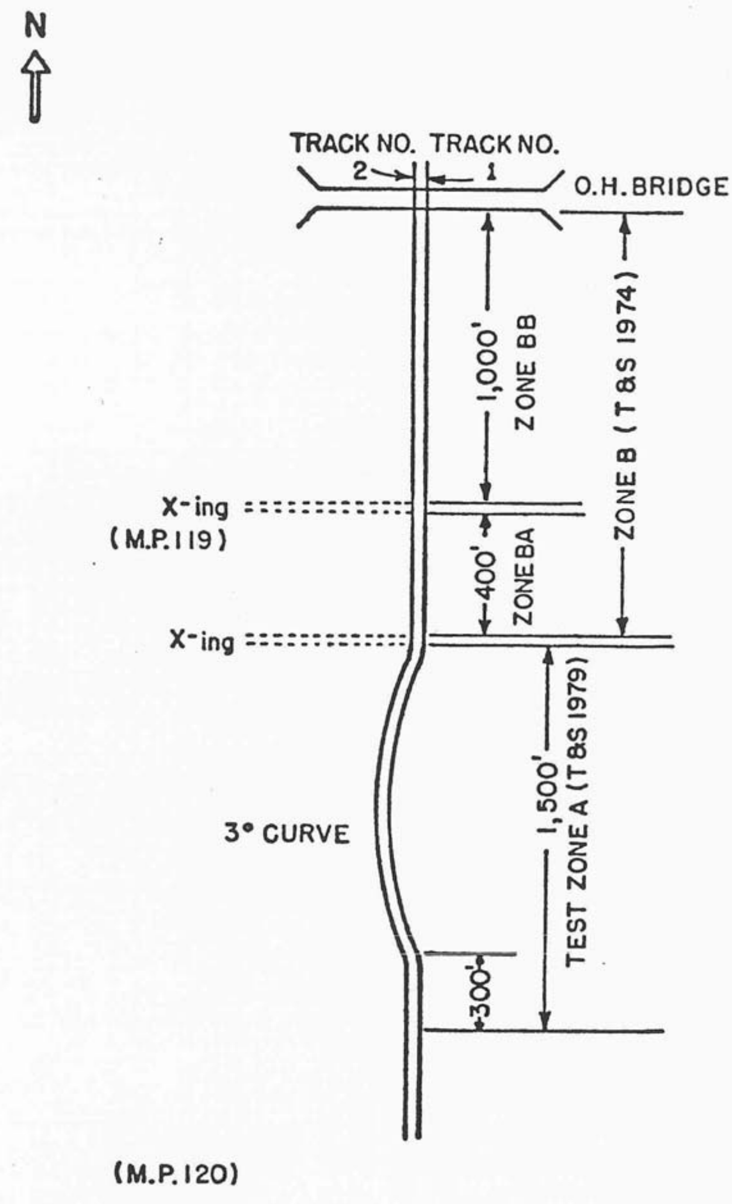



FIGURE 2. TEST ZONES FOR TRACK STRENGTH TEST, CHARLOTTESVILLE VA.

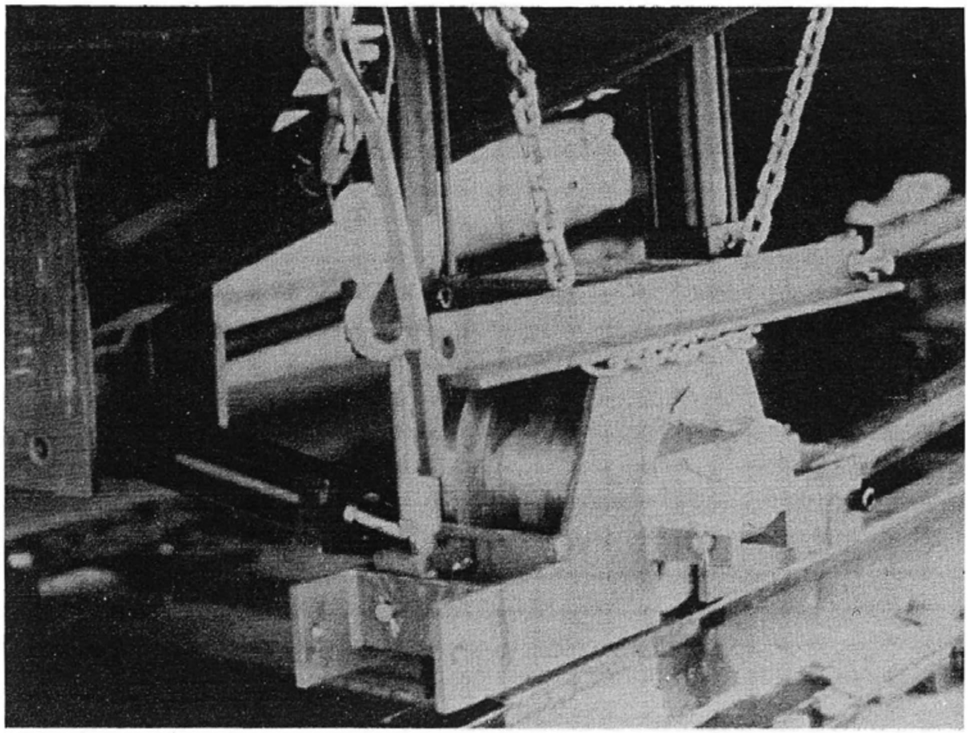


FIGURE 3. Stationary Load Deflection Test Using Decarotor Loading Apparatus

TABLE 1. CHARLOTTESVILLE, VA MAIN LINE TRACK TESTING SCHEDULE

A. DECAROTOR DYNAMIC GAGE—WIDENING TESTS

| RUN NO. | DIRECTION | SPEED (MPH) | APPLIED LOAD LEVELS | ZONE(Tie Numbers) |
|---|---|---|---|---|
| 1 | N | 3 | | A (1-830) |
| 2 | S | 3 | VERTICAL = 15,000 POUNDS | A (830-1) |
| 3 | N | 1 | LATERAL = 10,500 POUNDS | A (1-250) |
| 4 | N | 3 | for all tests | B (260-780) |
| 5 | S | 3 | | B (800-262) |
| 6 | N | 3 | | B (350-700) |
| 7 | S | 3 | | B (699-400) |
| 8 | S | 1 | | BA (230-1) |
| 9 | N | 1 | | BA (1-230) |
| 10 | S | 3 | | BA (230-1) |
| 11* | N | 10 | | B (270-780) |
| 12* | S | 15 | | B (780-270) |

*These test results were inconclusive, because the DECAROTOR'S hydraulic system could not maintain constant applied loads at these higher test speeds.

B. STATIC LOAD—DEFLECTION TIE TESTS

| TEST NUMBER | TIE NUMBER | | CONDITION | VERTICAL LOAD (POUNDS) | MAX DEFL. (INCHES) |
|---|---|---|---|---|---|
| 1 | B | 160 | FAIR** | 1,15K | 0.5 |
| 2 | B | 93 | POOR | 1,15K | 0.5 |
| 3 | B | 79 | GOOD | 1,15K | 0.5 |
| 4 | A | 198 | GOOD*** | 15K | 0.5 |
| 5 | A | 89 | GOOD*** | I5K | 0.5 |
| 6 | A | 108 | GOOD*** | 15K | 0.5 |

** Difference of opinion between inspection groups (see Table 2)

*** Test Zone A, all ties considered to be good.

The second part of the tests involved the stationary tie load—deflection tests as shown in Table 1B. In these tests, the test vehicle was slopped with the loading heads centered over the particular tie to be examined, (Figure 3). The vertical load indicated in Table 1 was first applied and then the lateral load was applied and increased until a maximum lateral rail head deflection of 0.5 inch was obtained.

Prior to the start of the tests, visual inspections were made in the two test zones. in Zone A, no group of defective ties, i.e., two or more adjacent ties classified as poor, or three or more classified as mixed poor and fair, were observed. In Zone B, however, clusters of defective ties were observed and recorded. Table 2 lists those defective ties in Zone BA. as identified by three different inspection teams. Note the different evaluations of tie conditions, made by the visual observations of the three independent teams.

The test consist consisted of a Southern locomotive, the Southern's R-2 Instrumentation Car, and the Track Strength Test Vehicle, the DECAROTOR. (For a complete description of the DECAROTOR, the reader is referred to Reference [3].) During each test run shown in Table 1A, the locomotive was located at the North end of the test consist adjacent to the R-2 car. The DECAROTOR was at the South end of the consist. Thus for the southbound test runs, both the loaded track gauge (G2) and the unloaded, i.e., nominal, gauge (G1, G3) were recorded, as well as the applied vertical and lateral loads on each rail [3]. Figure 4 shows the overall transducer layout. The data was recorded on both magnetic tape and strip charts. Visual observations of the condition of the track were made upon completion of all of the tests.

## 4.0 RESULTS

4.1 Decarotor Test

The first part of the Charlottesville tests consisted of twelve DECAROTOR test runs over the test sections. as shown in Table 1A.

Each run consisted of one pass (either northbound or southbound) along a test section of several hundred ties in one of the test zones. Both the loaded track gauge and the unloaded (nominal) track gauge were measured under a used applied load. Figure 5 shows the loaded and unloaded gauge measurements along a 100 tie section of Zone BA during Run 8. The calculated net gage widening $\Delta G = G2 - G1$, is shown in Figure 6.

One of the test objectives was to determine if the track strength testing concept, could consistently identify weaknesses in the track.

For the purpose of these tests, track strength is defined as track gauge widening under constant applied load. Gauge widening is, in turn, defined as the difference between the loaded gage, i.e. gage of the track as loaded by the test vehicle, and the unloaded, i.e. nominal, track gauge. Figures 6 and 7 compare the gauge widening, $\Delta G$, for two stretches of track in the "weaker" test section, Zone BA. Note that the data, shown in these Figures, is in agreement with the visual observations made by three different inspection teams! one consisting of Southern Railway maintenance-of-•ay personnel, and the other two consisting of outside personnel. it should be noted that the tie evaluation refer to clusters or groups of poor ties, as defined in Table 2. It is interesting to note the differences among the visual observations of the three teams. This is due both to differing definitions of poor ties and to the subjectivity of the observers. Those tie clusters, which were noted by all three teams, corresponded quite well to the DECAROTOR measurements. since a large $\Delta G$ value corresponded to a significant movement under load and thus, by definition, represented a weakness. Those clusters which were noted by only the Southern Railway personnel did appear to correlate with the measured data. but in some instances, exhibited certain inconsistencies with regard to the gauge widening measurements shown in Figures 6 and 7. Several of the individual tie tests performed in the second part of the test, as shown in Table IB, were intended to clarify these inconsistencies.

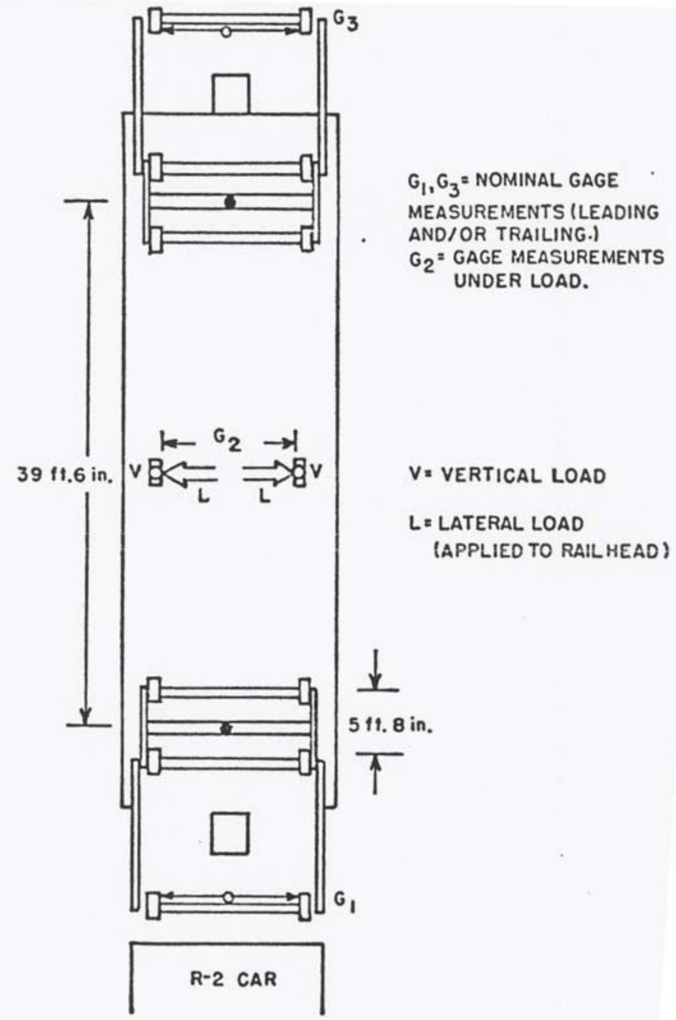



FIGURE 4. OVERALL TRANSDUCER LAYOUT OF THE TRACK STRENGTH TEST VEHICLE

**TABLE 2**

**VISUAL OBSERVATIONS OF TIE CONDITIONS* IN TEST SECTION BA (TIE 1-230)**

| TIES NO | SOUTHERN RY | TEAM A | TEAM B |
|---|---|---|---|
| 12-16 | P**• | P(14-16) | F(14-16) |
| 23-26 | P & F | NC | F(23) |
| 32-34 | P (33 GOOD) | NC | G |
| 43-44 | P | NC | G |
| 49-55 | P | P (50-52,54- | P(49-50) |
| 58-62 | P(one F) | P(60-62) | P(60-61), F(62) |
| 64-67 | P | NC | P(64) |
| 85-88 | P | NC | F(86) |
| 91-94 | P | P(91-94) | P(93,94), F(91) |
| 100- | P | NC | G |
| 103- | P | P(103-105) | F(103-105) |
| 115- | P & F | NC | G |
| 121- | P & F | NC | P(123) |
| 127- | P | NC | G |
| 136- | P & F | NC | F(140) |
| 144- | P | NC | G |
| 150- | P | P(150-152) | P(151,152), |
| 160- | P (161 | NC | F (160,162) |
| 171- | F & P | NC | G |
| 177- | F & P | NC | G |
| 189- | P | P | F |
| 194- | P | NC | F(194) |
| 198- | P | P(198-200) | P(199-200), |
| 204- | F & P | NC | No observation |
| 211- | P | NC | No observation |
| 218- | P | NC | No observation |
| 222- | P | NC | No observation |
| 228- | P | NC | No observation |

*INDIVIDUAL "POOR" TIES ARE NOT INDICATED HERE, ONLY CLUSTERS OF DEFECTIVE TIES ARE SHOWN

**P = POOR, F = FAIR G = GOOD NC = NO CLUSTER OF POOR TIES*

It should be noted that the general levels of gage widening for the two Zone BA test sections were quite similar, indicating a general uniformity of tie conditions in the older section. When the gage widening, ΔG, for the newly-timbered section was compared with the older section, as shown in Figure 8, the differences became quite significant. Since identical test loads were applied to the two sections, the differences represent relative movements and, therefore, the relative weaknesses of the two test zones. This difference in strength between newly-timbered and six year old track is only to be expected, since track is known to weaken with traffic.

However the fact that this difference is so apparent in the DECAROTOR measurements shows that this technique is capable of differentiating between the very narrow extremes of good mainline track. Furthermore, this measurement is done repeatedly and consistently, as shown in Figure 9, which compares Runs 8 and 9 over test Zone BA. Since these two runs were made in opposite directions, any directional effects appear to be relatively insignificant.

The results of these tests were compared with the results from the Alexandria tests [3], where the DECAROTOR was used to test yard track. Since the load levels used in the yard tests were 7,000 lbs. lateral and 10,000 lbs. vertical in contrast to the 10,500 lbs. lateral and 15,000 lbs. vertical loads used in the mainline tests, the net gauge widening values measured at Alexandria were linearly extrapolated to equivalent mainline test load levels using the results from earlier laboratory gauge widening tests [4]. The results are shown in Figure 10, where the "weaker" mainline track, zone BA, is compared with the extrapolated yard track data. With the exception of Ties 33-46, the overall levels of gauge widening are higher for the weaker yard track. Furthermore, weak spots in the yard track, such as at Ties 26, 60, 94, 106, and 119 show significantly greater gauge widening. In the case of Ties 33-46 at Alexandria, it was observed that these ties were in very good condition. Since the rail section in Alexandria was 100 lb. as opposed to the 132 RE section in the Charlottesville mainline, it was concluded that the combination of good ties and relatively flexible rail section permitted the larger changes in AG shown in Figure 10, which the heavier (and more rigid) rail section would not permit.

With regards to the second test objective, determining the sensitivity of the DECAROTOR to variations in overall track strength, it appears that this sensitivity is quite good. The DECAROTOR was able to measure the differences in overall track strength between newly maintained mainline track, mainline track at the end of its maintenance cycle and yard track.

Once the capability for measuring and defining levels of track strength exists, one must consider matching the track strength with the vehicle loading. Since the lateral loads imposed by traffic on curved track is significantly higher than for tangent track [5,6], it should be expected that the lateral strength of curved track be greater. Yet many railroads do not use significantly-different track configurations for curves, although most do increase the number of rail spikes used on sharper curves. In many cases these differences are not measurable. This can be seen in Figure 11, where the strength of tangent track and the track in a three degree curve, both in test Zone A, are compared. These data show no significant differences in track strength.

Finally, the question of whether track strength testing, in turn, weakens or causes damage to the track must be addressed. Visual observations in the test zones, made after all of the test runs were completed, disclosed no evidence of damage. In addition, repeated runs over the test sections, such as shown in Figure 9, showed no changes in track strength. However, in order to conclusively determine whether track strength testing can cause damage, two sets of track geometry car measurements were made over the test site, using the Southern Railway's R-1 Geometry Car. The first run was made on January 30, 1980, prior to the start of the tests. The second run was made on May 8, 1980, 7 weeks after the conclusion of the tests. The results of the track gauge measurements for those two dates arc shown in Figure 12. It can be readily seen that no increase in gauge was measured. This confirmed the results of previous track strength tests [2,3] which also showed that if tests are conducted at properly-selected load levels, no significant damage occurs, even though measurable gauge widening does take place.

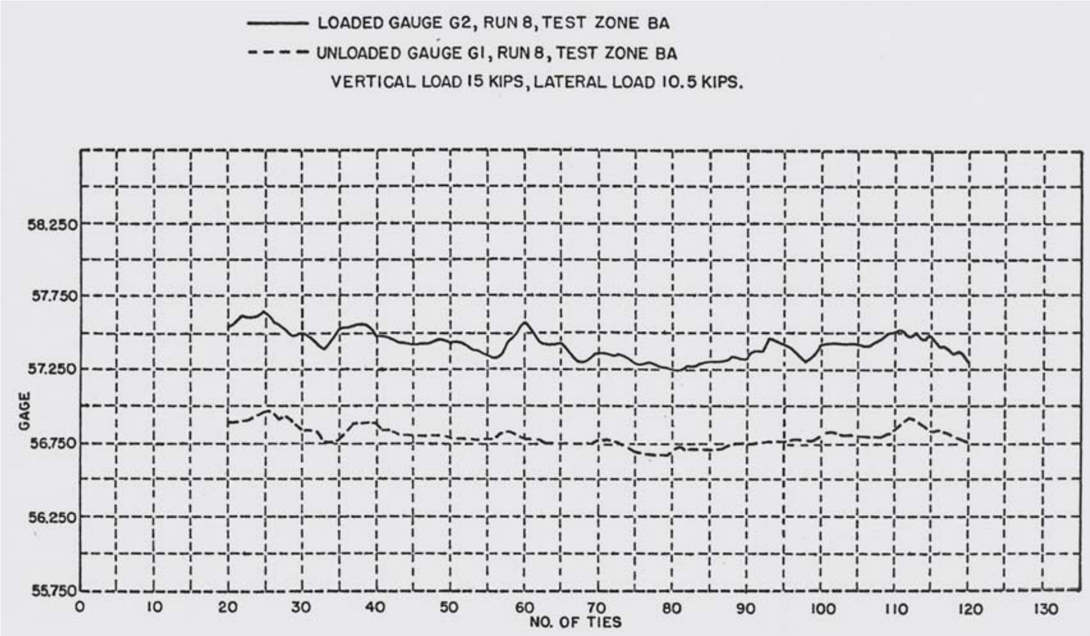



FIGURE 5. COMPARISON OF LOADED AND UNLOADED GAUGE FOR TEST ZONE BA.

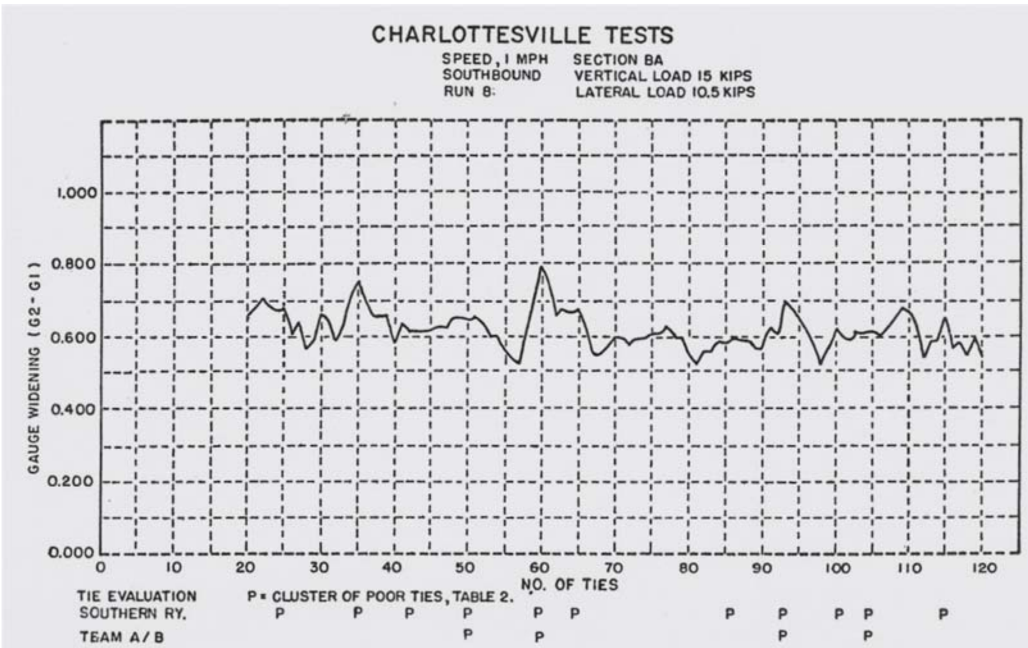



FIGURE 6. NET GAUGE WIDENING, TEST ZONE BA (TIES 20-120)

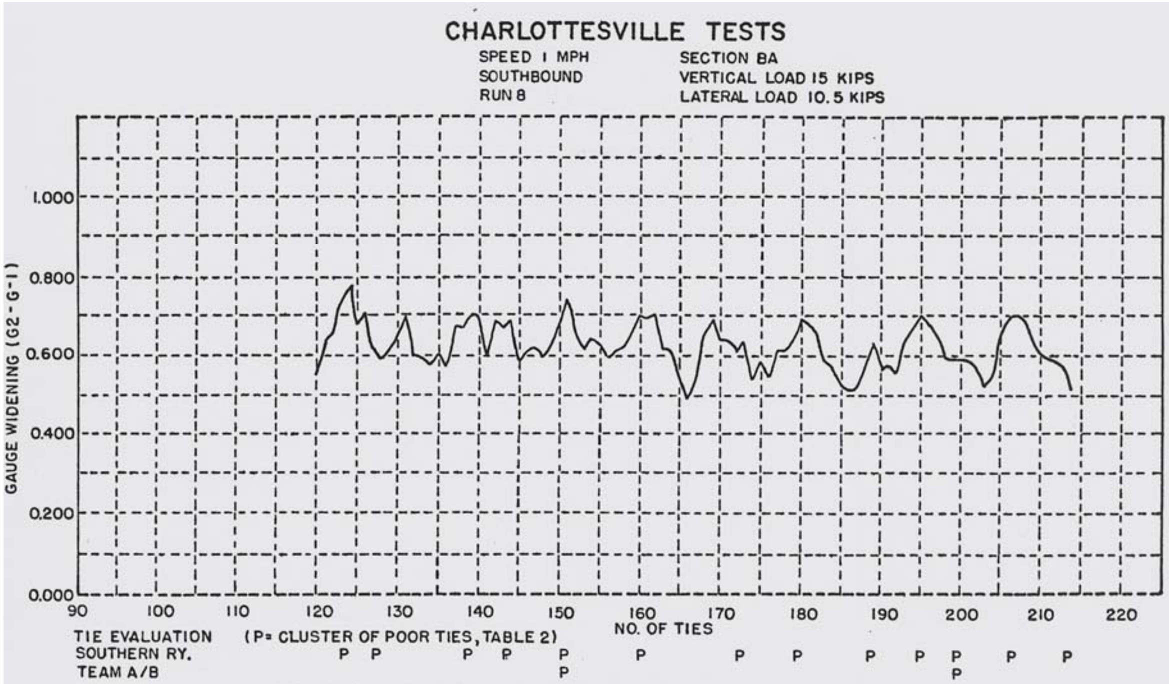



FIGURE 7. NET GAUGE WIDENING, TEST ZONE BA (TIES 120-210)

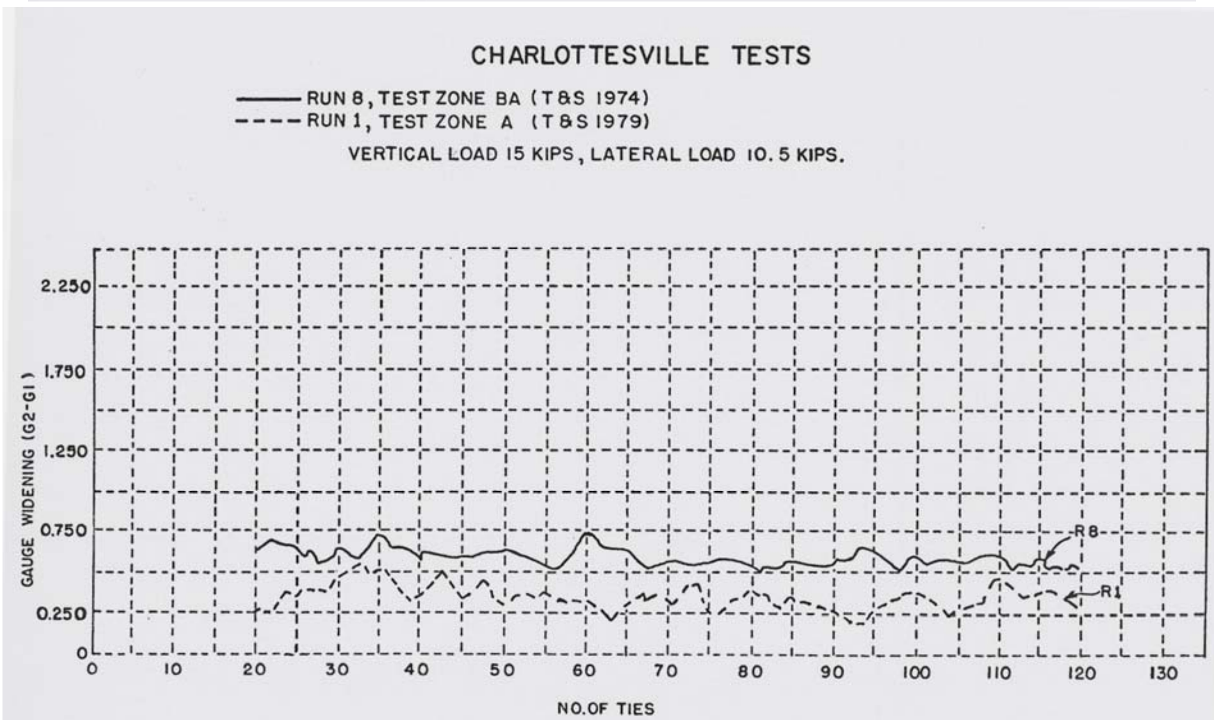



FIGURE 8. COMPARISON OF NET GAUGE WIDENING FOR “NEW” AND “OLD” TIE TEST SECTIONS.

**CHARLOTTESVILLE TESTS**

- - - - - - - RUN 9, TEST ZONE BA.
_______ RUN 8, TEST ZONE, BA.
VERTICAL LOAD 15 KIPS, LATERAL LOAD 10.5 KIPS.

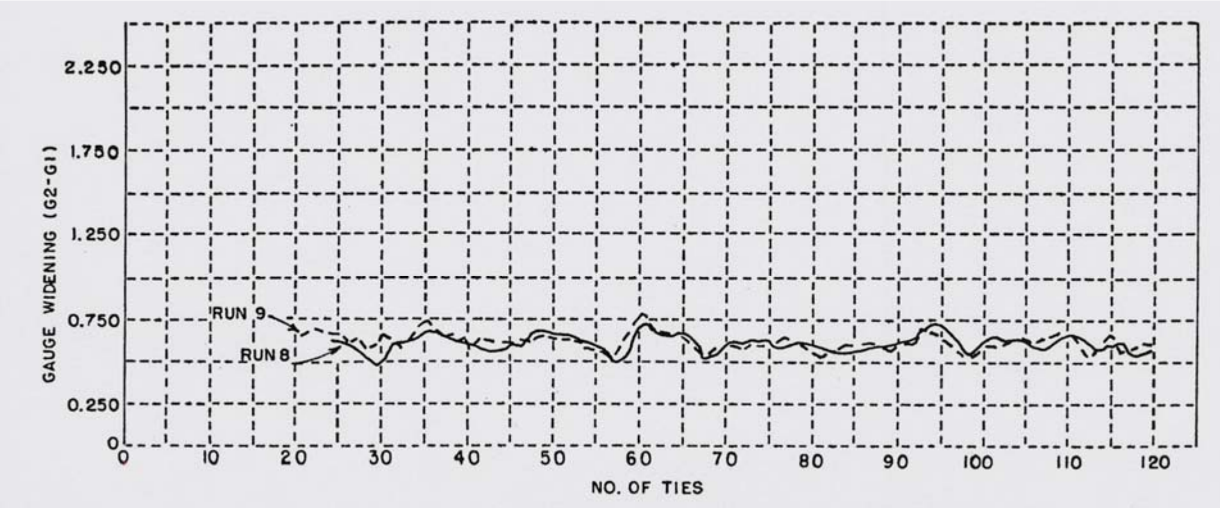



FIGURE 9. COMPARISON OF NET GAUGE WIDENING FOR DIFFERENT TEST RUNS ON SAME TEST SECTION.

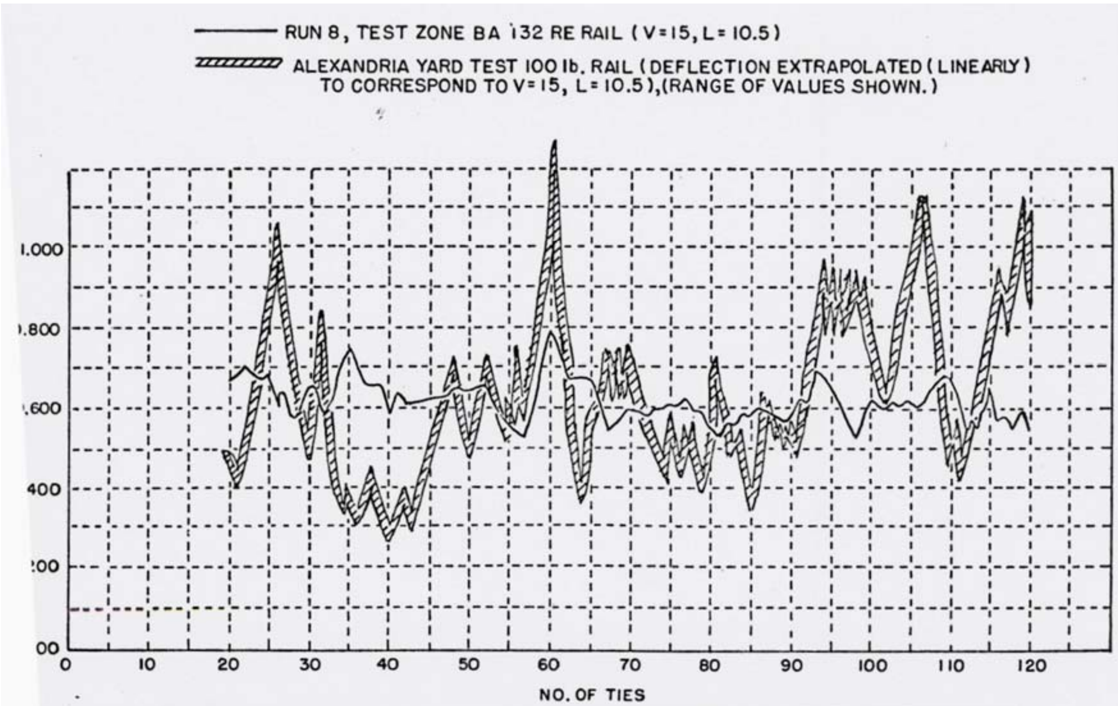



FIGURE 10. COMPARISON OF NET GAUGE WIDENING, CHARLOTTESVILLE "WEAK" MAIN VS. ALEXANDRIA YARD TRACK.

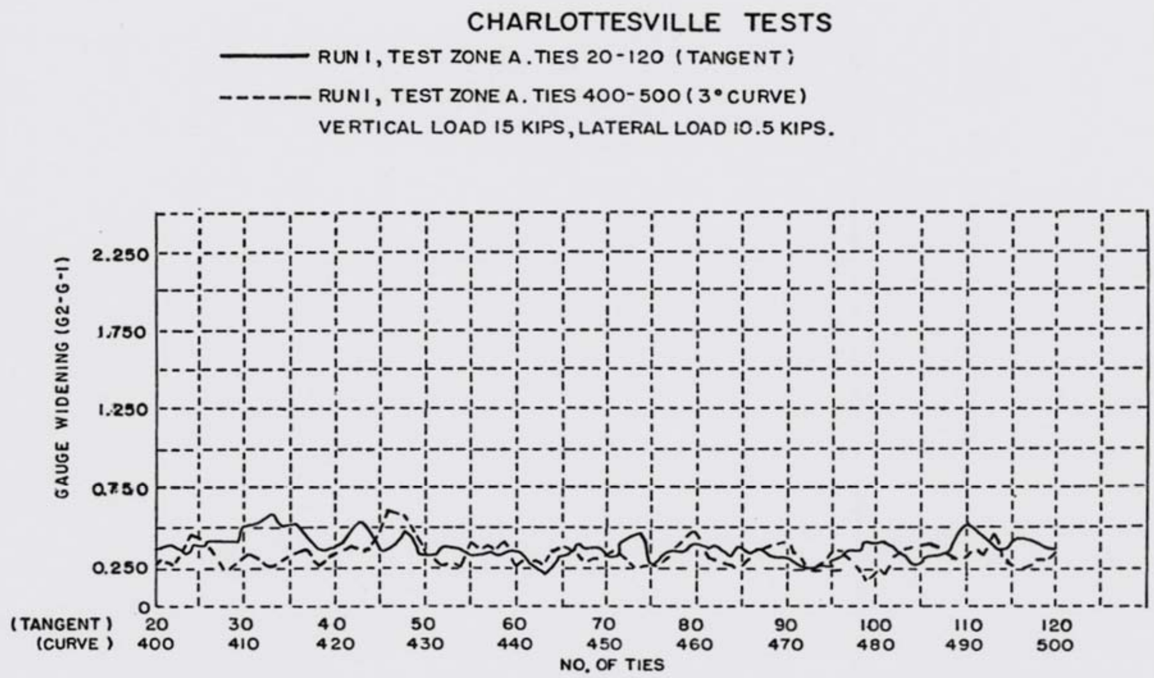



FIGURE 11. NET GAUGE WIDENING TEST, ZONE A. TANGENT VS. 3° CURVE.

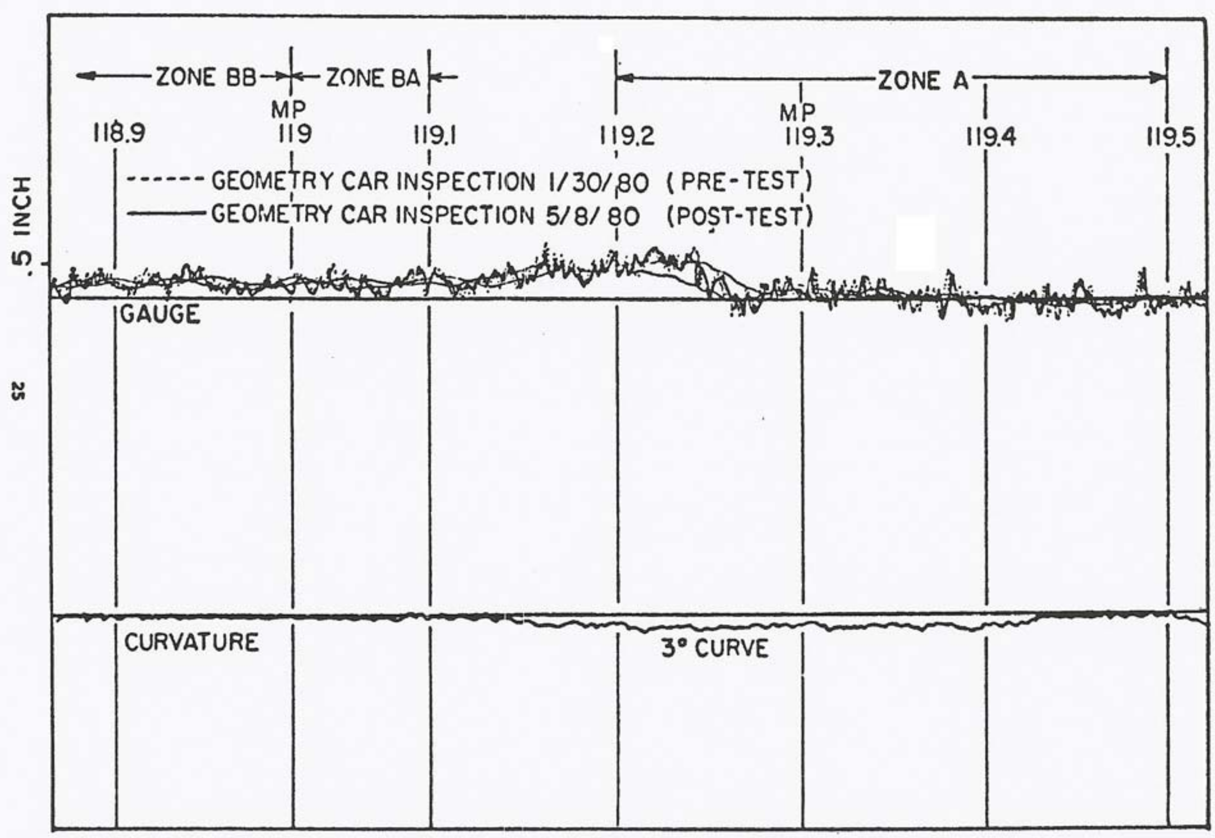



FIGURE 12. PRE AND POST TEST TRACK GEOMETRY CAR MEASUREMENTS OF CHARLOTTESVILLE TEST SITE.

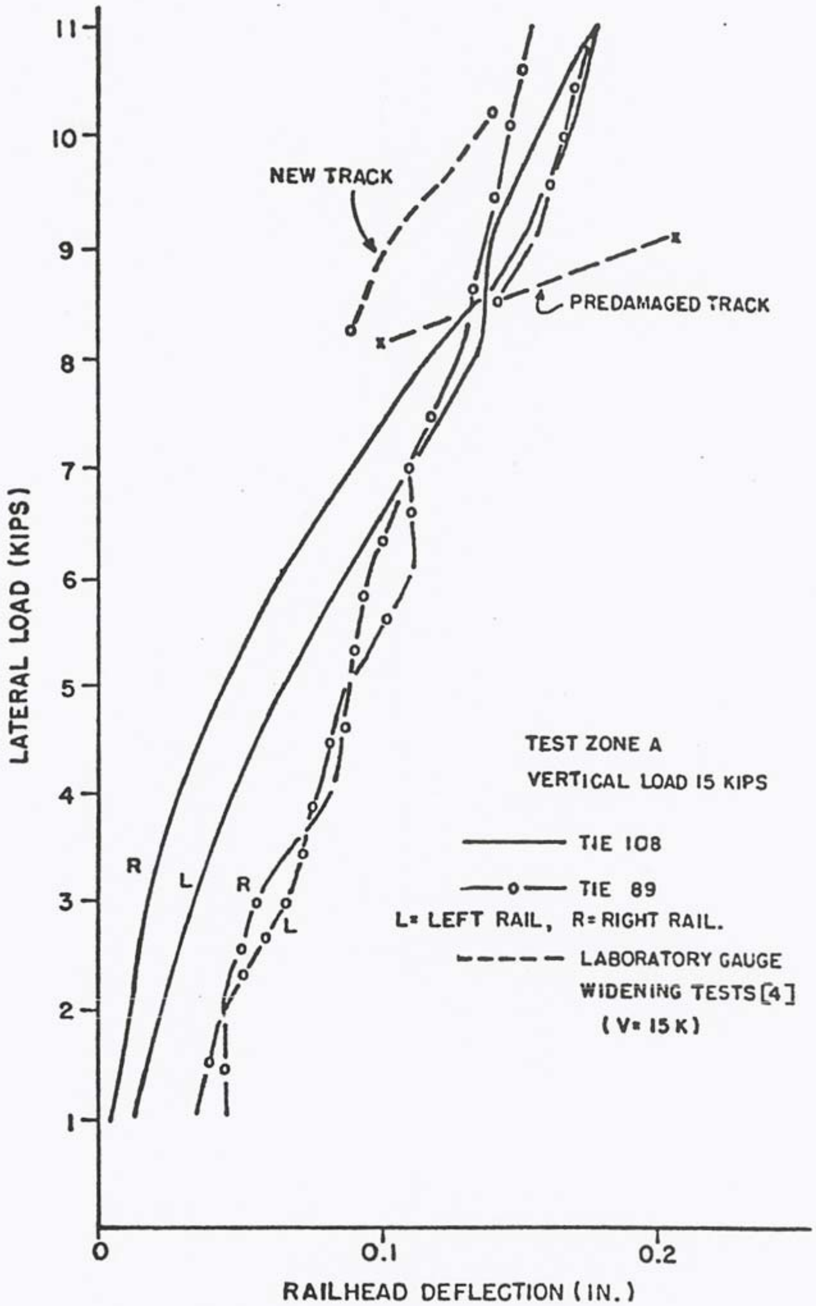



FIGURE 13. STATIONARY LOAD DEFLECTION TESTS, ZONE A.

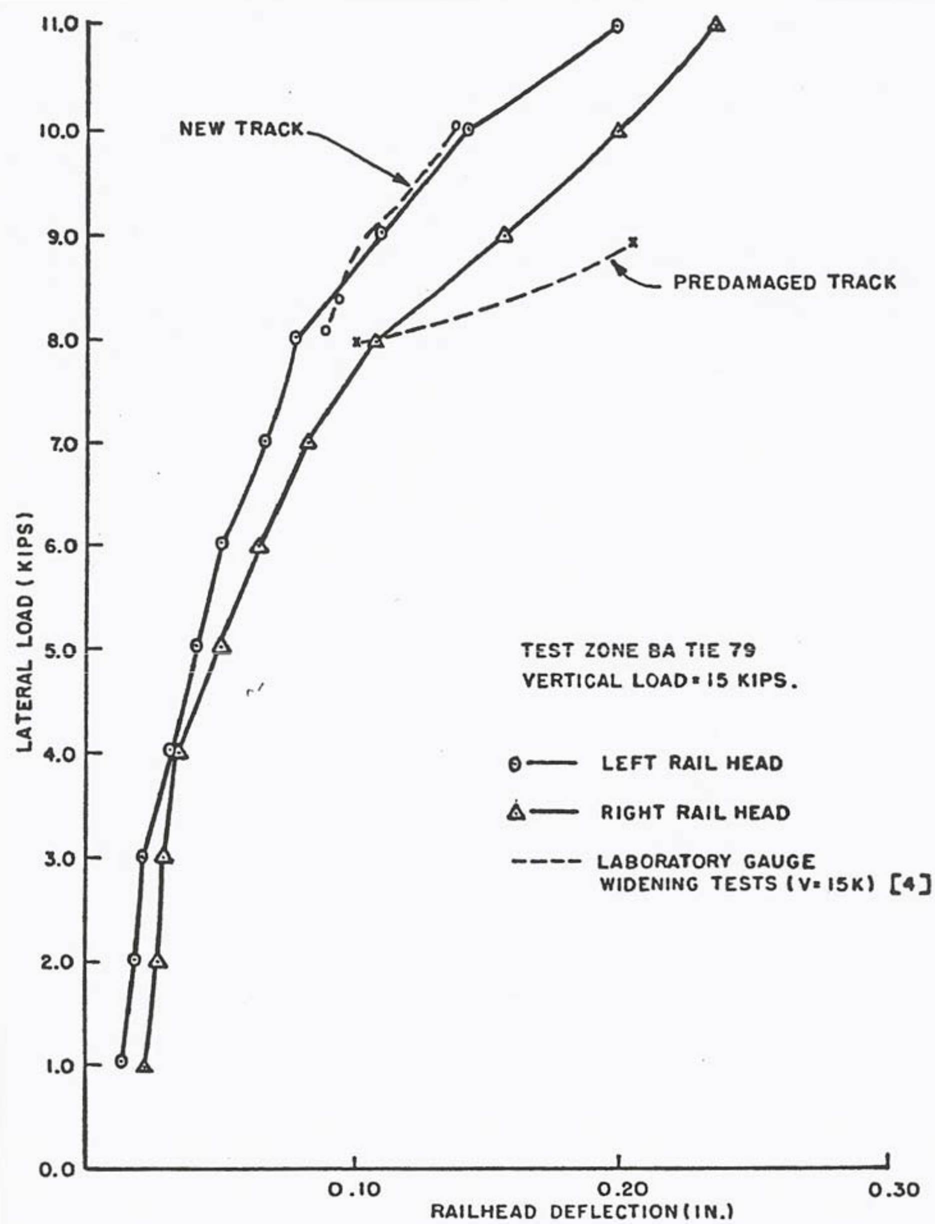



FIGURE 14. STATIONARY LOAD DEFLECTION TESTS, TEST ZONE BA, TIE NO. 79.

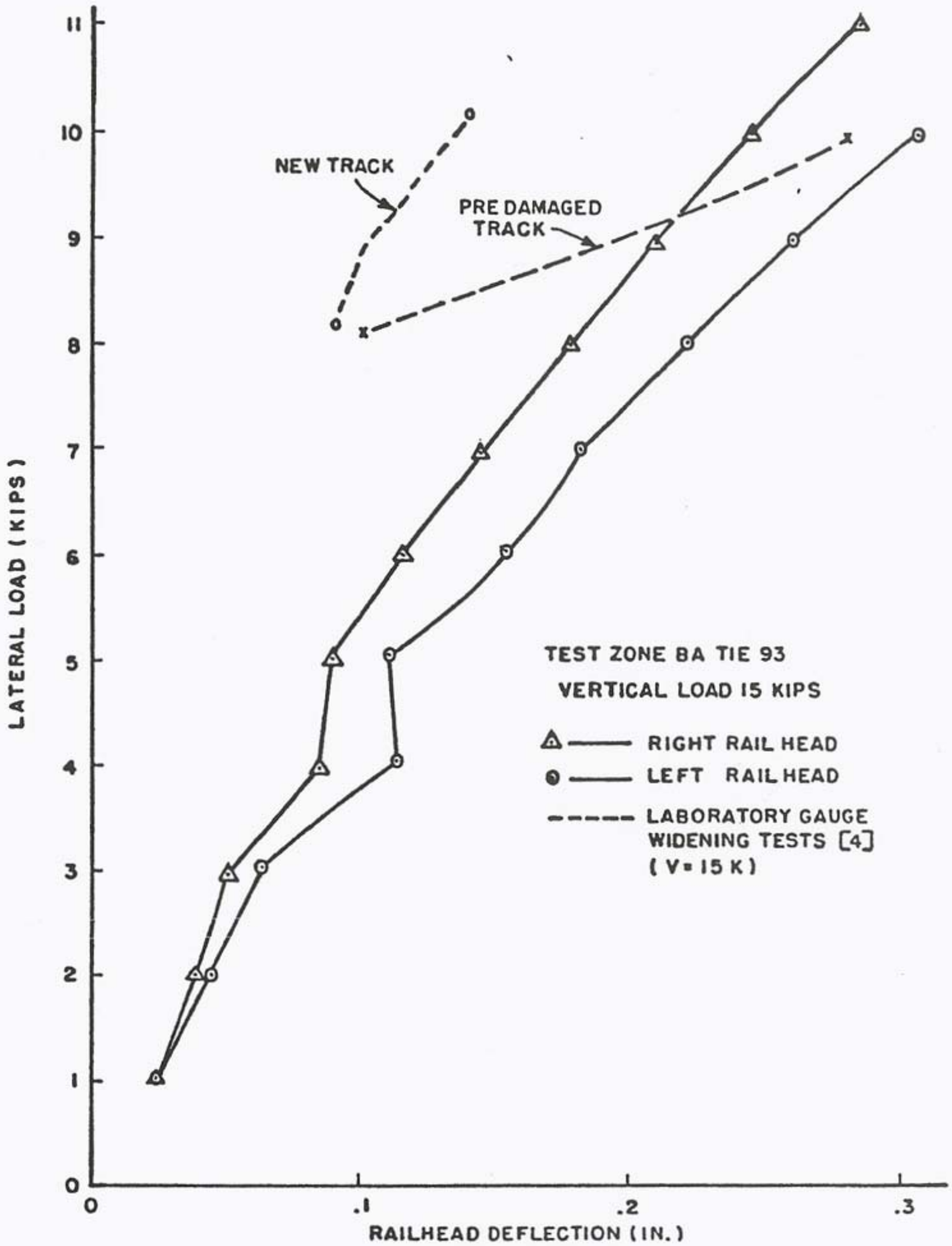



FIGURE 15. STATIONARY LOAD DEFLECTION TESTS, TEST ZONE BA, TIE NO. 93.

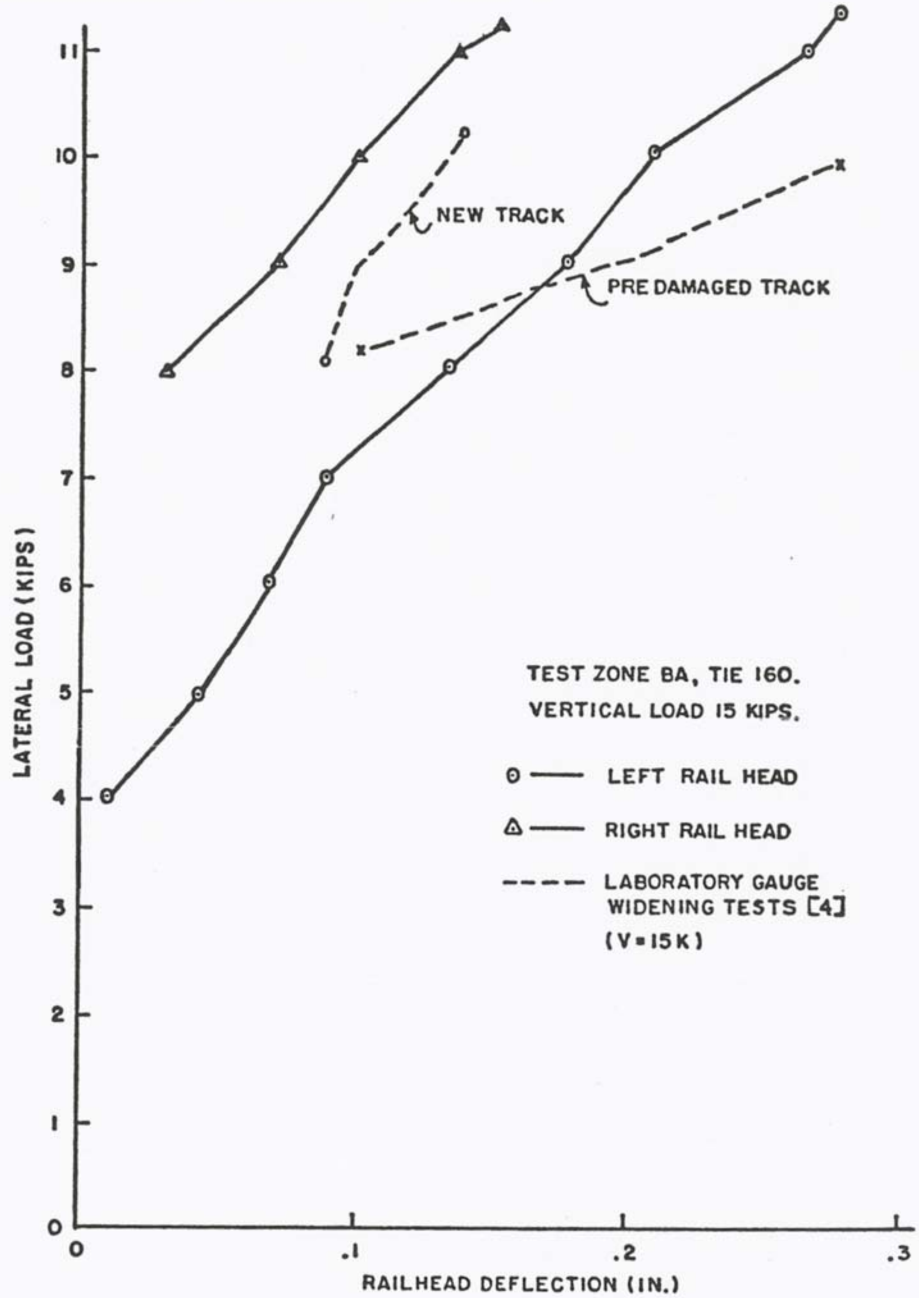



FIGURE 16. STATIONARY LOAD DEFLECTION TESTS, TEST ZONE BA, TIE NO. 160.

## TABLE 3

### SUMMARY OF STATIC LOAD-DEFLECTION TEST RESULTS, FOR SELECTED CROSS TIES IN THE CHARLOTTESVILLE MAINLINE TESTS

| TIE NUMBER | VISUAL EVALUATION SOUTHERN | TEAM A | TEAM B | DECAROTOR EVALUATION | STATIONARY TEST* |
|---|---|---|---|---|---|
| Test Zone A | | | | | |
| A 89 | ** | ** | ** | GOOD (Figure 8) | Good (Figure 13) |
| A 108 | ** | ** | ** | GOOD (Figure 8) | (Figure 13) |
| A 198 | ** | ** | ** | DATA NOT AVAILABLE | |
| Test Zone BA | | | | | |
| B 79 | G*** | G | G | GOOD (Figure 6) | GOOD (Figure 14) |
| B 93 | PP | PP | P | POOR (Figure 6) | POOR (Figure 15) |
| B 160 | PP | NC | F | POOR (Figure 7) | QUESTIONABLE (Figure 16) |

*As compared with laboratory gauge-widening tests [4]
**All ties in Test Zone A were considered to be in good condition
***G = good, F=fair, P = poor, PP = cluster of poor ties, NC = no cluster of poor ties

### 4.2 Static load-Deflection Tie Tests

The second part of the Charlottesville tests included stationary load-deflection tie tests, as shown in Table 1B.

Each test included a loading cycle, followed by an unloading cycle, in which the deflections of each rail head were measured at discrete increments of applied lateral load.

The objective of this test series was to more carefully study the tie-fastener behaviour at those sites identified as having individual ties or fasteners in poor condition. This was accomplished by comparing the load-deflection curves with those obtained during earlier laboratory tests [4]. These earlier tests were conducted on both a track section with new ties and fasteners and on a "predamaged" track section. Furthermore, these tests were conducted under identical load levels, i.e., a vertical load of 15 kip and an increasing lateral load, applied to similar rail sections (136 vs. 132RE). Thus, meaningful limits for "good" and "fair" tie conditions were available.

It was also intended to compare these stationary tests with both the visual evaluations of the three inspection teams and the dynamic gauge widening measurements taken by the DECAROTOR.

The results of these comparisons are shown in Table 3. In test Zone A, the newly-timbered section, both the visual observations and the DECAROTOR evaluations indicated that Ties 89 and 108 were in good condition. Figure 13 shows the stationary load-deflection curves for these two ties, together with the laboratory-established values for new and pre-damaged track. Note that these curves also indicate a good tie condition.

In test Zone BA, Tie 79 was also identified as being in good condition by both the DECAROTOR and the inspection teams. The stationary load-deflection test, shown in Figure 14, confirmed this.

Tie 93, in test Zone BA, was identified by all three observations as being in poor condition, and was located in a cluster of poor ties. The gauge widening diagram in Figure 6 shows that an increase in gauge widening was also measured by the DECAROTOR, indicating a weakness in the track at that location. Examination of the stationary load-deflection test results in Figure 15 shows that the curve for this location exhibits deflections equal to, or larger than, the predamaged track laboratory tests. This indicates that the condition of Tie 93 was in fact weak, in agreement with both the visual observations and the DECAROTOR measurements.

In all of the above cases, good agreement was obtained between the visual observations of the three inspection teams, the DECAROTOR tests and the stationary tie tests. However, an examination of the condition of Tie 160 in test Zone BA was not as simple. The Southern Railway team identified Tie 160 as being a poor tie, part of a three tie cluster, in which the center tie was good and the other two ties (one of which was Tie 160) were poor. Team A indicated that there was no cluster of poor ties at or near Tie 160. Team B considered Tie 160 to be in fair condition, with no adjacent poor ties. In this particular case, the visual observations of qualified personnel all differed significantly. The DECAROTOR run, shown in Figure 7, found an increase in gage widening at that location, and, therefore, a weakness in the track structure. The stationary load—deflection curve, shown in Figure 16, however, clarifies the situation. Comparing the individual rail head deflection curves at Tie 160 with both the new and pre-damaged track values, it can be seen that one end of the tie was in good condition, exhibiting good gauge-holding strength. However, the other end of the tie exhibited a significant rail head movement, similar to that for pre-damaged track. Thus, while this tie was not as weak as Tie 93, it was, at least on one end, questionable in regard to its gauge- holding capability. This kind of distinction is extremely difficult to make with visual observations, and, therefore, explains the differences of opinion among the three inspection teams.

While a sample of only five individual tie tests is not sufficient to permit generalized conclusions, it should be noted that the stationary load-deflection tests did correlate well with both the visual observations and the DECAROTOR measurements in the clear-cut situations. Furthermore, in the one questionable case, it showed an ability to identify the tie condition in a situation where visual observation resulted in a range of opinions.

## 5.0 CONCLUSIONS

The results of the Charlottesville, Virginia tests of the prototype Track Strength Test Vehicle, the DECAROTOR, show that continuous track strength measurements can be made on mainline track. These track strength measurements can also be used to differentiate between the different levels of strength found in both mainline and yard track. These tests confirmed and extended the results of earlier track strength tests, which showed that the track strength concept could be used to locate and identify "weak" spots in track.

The results of these tests showed that:

a. The DECAROTOR can consistently and reproduceably identify clusters of poor ties, or other individual weaknesses in track. These weaknesses involve specific locations where the track cannot maintain gauge under loaded conditions.

b. The DECAROTOR can differentiate between different levels of track strength. It can detect differences in strength between mainline and yard track, and also appears to be able to detect the strength differences between newly-timbered track, where all bad ties or fasteners have been replaced, and track that is in need of timbering. i.e., at the end of its maintenance cycle. Thus, the track strength concept offers the potential for determining when track maintenance should he performed in order to maintain adequate track strength. Furthermore, this testing concept can permit track exposed to different service conditions to be maintained at different levels of strength. Thus, curved track, tangent mainline and secondary track could all be maintained at optimum levels of strength, at minimum cost.

c. The DECAROTOR can test with minimal damage to the track. After repeated test runs, no damage to the test locations could be found, either through visual observations, repeated track strength measurements or geometry car measurement, taken before and seven weeks after the tests.

d. Stationary load-deflection tests can help identify tie or fastener conditions. These stationary tests can be used to help determine whether local track condition, including tie and fastener conditions, are adequate to withstand traffic loadings. These tests exhibited agreement with visual observation, in the more obvious situations. In addition, in the one case where visual observations led to differing opinions, this test appeared to be able to identify the tie condition.

Based on the results of these, and previous, tests of the track strength testing concept, it appears that this type of testing can provide quantitative information regarding the strength or load-carrying abilities of track. In particular, these tests can show the relative differences in gauge-holding ability of track at different levels of maintenance. Furthermore, this testing can be performed repeatedly and non-destructively, by means of a moving inspection vehicle, so that relatively long stretches of track can be evaluated. It appears that it can provide maintenance-of-way personnel with an objective evaluation of their tracks' strength, so as to locate weaknesses, which are potential derailment sites, as welt as to provide guidance for track maintenance requirements.

Thus, in this and previous tests, the basic concept of track strength testing has been shown, to be a viable and potentially-valuable track inspection technique, however, further testing is necessary in order to demonstrate the practical value of this technique as well as to obtain additional knowledge about the meaning of the test information.

## 6.0 REFERENCES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