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SPONSORED PROJECT INITIATION

no action

Date: 9/26/77

Project Title: "Study of Rail Fastening Clips."

Project No: E-20-623

Project Director: J. S. Lai

Sponsor: TRANSIT Products Company, Inc.

Agreement Period: From 9/21/77 Until 11/20/77

Type Agreement: Standard Industrial Research Agreement dated 9/21/77

Amount: $5,572

Reports Required: Preliminary Findings, Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

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Defense Priority Rating: N/A

Assigned to: Civil Engineering (School/Laboratory)

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OH

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SPONSORED PROJECT TERMINATION

Date: 12/15/78

Project Title: Study of Rail Fastening Clips

Project No: E-20-623

Project Director: Dr. J. S. Lai

Sponsor: Transit Products Company, Inc.

Effective Termination Date: 10/31/78

Clearance of Accounting Charges: 10/31/78

Grant/Contract Closeout Actions Remaining:

x Final Invoice ~~and Closing Documents~~
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other ____________

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CA–4 (3/76)

A SUMMARY REPORT

for

EVALUATION OF HIXSON CONCRETE CROSSTIE FASTENING SYSTEM

submitted to

Transit Products Company, Inc.
846 South Central Avenue
Atlanta, Georgia 30354

by

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October 11, 1978

1. INTRODUCTION

This summary report contains the procedures and results from two series of tests performed on the Hixson Concrete Crosstie Fasteners. In each test series a separate concrete crosstie and fastening system were used. Sequence of testing for each test series is listed in the following:

(1) Series One: Spring Clip Load-Deflection-Strain Test
Longitudinal Restraint Test
Fastening Unlift Test
Insert Pull-Out Test

(2) Series Two: Spring Clip Load-Deflection-Strain Test
Longitudinal Restraint Test
Lateral Restraint Test
Repeated Load Test
Longitudinal Restraint Test

Summary of the test results along with the corresponding Amtrak specifications for the two test series are shown in Table 1 and 2. The Amtrak specifications (NI 8306-66-68) were followed as closely as possible for all the tests performed as reported herein.

2. MANUFACTURE OF CONCRETE CROSS-TIE

Two short concrete crossties (approximately 8" x 8" x 36") reinforced with 4 - #8 reinforcing steel bars was casted with two steel inserts imbedded at proper positions in each concrete crosstie. The inserts imbedded in concrete crossties are part of the fastening system. Type III portland cement was used for making the concrete and a 7-day strength of the concrete based on cylinder test was 6200 psi. The crossties were cured in a moisture room for at least 14 days.

3. SERIES ONE TESTING

The series one testing consists of the following tests:

Spring Clip Load-Deflection-Strain Test
Longitudinal Restraint Test
Fastening Uplift Test
Insert Pull-Out Test

3.1 Load-Deflection Strain Test of Spring Clip

In order to determine the maximum hold-down force the spring clip can exert on rail without causing the spring clip to induce any permanent deformation, a spring clip, selected randomly from those supplied by the Transit Products Co., was tested beyond its yield point. The clip was strain-gaged and subsequently tested under a loading condition similar to that of under normal installation. During this test, strains from the strain gage as well as the deflections at the tip of the clip were measured. The results of the test are shown in Fig. 1. A maximum load of 6,000 lbs. was applied to the clip. From the load vs. strain curve, the initial yield of the spring clip occurred at about 4,500 lbs.

Two additional spring clips were strain-gaged and were subsequently loaded up to 3,000 lbs. The load vs. strain relation for each spring clip was used later to monitor the actual hold-down force exerted by the spring clips on a rail during assembly.

In the previous preliminary study it was estimated that in order to meet the longitudinal restraint test requirement, a minimum of about 2,800 lbs. hold-down force exerted by each spring clip on a rail will be required. Thus, 3,000 lb. was selected as the upper limit for the calibration of the clips.

3.2 Longitudinal Restraint Test

Longitudinal Restraint Test was conducted on the fastening system first, because it was viewed that this test was one of the most critical tests in determining if the spring clips and the geometry of the inserts as imbedded in the concrete tie would generate sufficient hold-down forces to the system. A 3/16" grooved rubber pad and a piece of rail with 6 in. wide base (about 20" long) were placed on the rail seat between the inserts and the nylon insulating pads were placed at the proper positions and finally spring clips were driven in using a hammer. No problem was encountered in this installation operation. The hold-down forces generated by the spring clips as monitored from the strain gage outputs were about 2,800 lbs. each.

Longitudinal restraint test was conducted according to the Amtrak specifications. The set-up of this test is shown in Figure 3. The longitudinal load was applied at a 400 lb. increment until a 2,400 lb. load was reached. The longitudinal movement of the rail with respect to the crosstie was monitored continuously. The results of the longitudinal load vs. movement are shown in Table 3. The average movement in the first three minutes after the load had reached 2,400 lbs. was 0.024 in. and from 3 minutes to 15 minutes the additional movement was about 0.003 in. This 0.024 in. movement was far below the maximum allowable value of 0.25 in. The longitudinal load was then released slowly. It is apparent that the fastening system can adequately provide the longitudinal restraint force as required by the Amtrak specification.

For the purpose of determining the maximum longitudinal load the fastening system could hold, longitudinal load was applied again to the rail until a maximum load of 3,100 lbs. was reached. At this load, it was evident that slippage occurred.

3.3 Fastening Uplift Test

Fastening uplift test as shown in Figure 3 was conducted according to the specifications. The deflections were monitored continuously during the uplift test until a maximum uplift load of 12,000 lbs. was reached. The results of uplift load vs. deflection are shown in Figure 4. The initial separation between the rubber pad and the rail base was at about 4,000 lbs. of uplift load and final separation occurred at about 5,400 lbs. According to the Amtrak specifications, a maximum uplift load corresponding to an additional 0.1 in. rail deflection beyond the final separation point should be applied. From Figure 4, this maximum load equals 8,000 lbs. Since from the results of the load-deflection test as shown in Fig. 1 indicates that each spring clip can resist up to 4,500 lbs. load without causing any permanent deformation, it can be concluded that at 8,000 lbs. of uplift load (4,000 lb. load on each clip) there should be no permanent deformation induced to the spring clips.

The "spring rate" computed from the uplift load vs. deflection curve was 230,000 lbs./in. The Amtrak specifications requires a spring rate of 200,000 lbs./in. to 350,000 lbs./in.

3.4 Insert Pull-Out Test

One of the inserts was used to determine the pull-out resistance. An adapter for facilitating the pull-up was welded to the top of the insert and a vertical pull-up load was applied to the insert until a 12,000 lb. pull-out load was applied to the insert. This load was held for 3 minutes, and no measurable movement within this three minute period was observed. Upon unloading, the insert was examined and no apparent damage was in evidence.

4. SERIES TWO TESTING

This testing series consists of the following tests:

Spring Clip Load-Deflection-Strain Test
Longitudinal Restraint Test
Lateral Restraint Test
Repeated Load Test
Longitudinal Restraint Test

The spring clips used in this series of testing have been slightly modified from those used in the series one tests. The modification was mainly to simplify the extraction of spring clip from the insert. The strength of the clip should not be affected. Also, different insulating pads were used.

4.1 Spring Clip Load-Deflection-Strain Test

The testing is identical to that described in Section 3.1. Two spring clips were strain-gaged and each was tested up to 3,000 lbs. of load. Results from the tests were used to develop calibration curves for the clips.

4.2 Longitudinal Restraint Test

The test procedure was identical to that described in Section 3.2. The hold-down forces generated by the spring clips as monitored from the strain gage outputs were about 2,800 lbs. each.

At 2,400 lbs. of longitudinal load, the average slippage in the first 3 minutes was about 0.020 in. and between 3 minutes to 15 minutes an additional 0.001 in. was observed.

4.3 Lateral Restraint Test

The lateral restraint test was conducted following the Amtrak Specifications.

During the test, a preload of 10 kips lateral and 44 kips vertical load were applied to the rail to seat the rail. After that, the lateral

load and vertical load were reduced to 200 lbs. and 500 lbs. respectively. At this small initial load, the three dial gage readings were set to zero. A 44 kips vertical load was applied to the rail first and a lateral load of 21 kips was then applied slowly (at a rate of slightly less than 5 kips per minute). When the lateral load reached 21 kips, and the vertical load remained at 44 kips, the deflection reading from deflection gages located at the top and base of the rail opposite directly to the lateral loading plane were 0.035 in. and 0.023 in. respectively.
The loads were maintained for approximately 5 minutes. All the deflection readings during this period remain the same.

Based on the results, the rail translation was 0.023 in. (average value of gage 2 and 3 readings) and the rail rotation was 0.012 in. (0.035 in. - 0.023 in.).

4.4 Repeated Load Test

Figure 5 shows schematically the loading conditions for the repeated load test. The amplitude-frequency relationships among these three loads specified by the Amtrak specifications are shown in the same figure. The two vertical forces are basically a sine wave having mean value equals 6.5 kip (push) superimposed on a load amplitude of about 9 kip (push and pull). Thus each vertical load can generate a 15.5 kip push and 2.5 kip pull. These two vertical loads have a phase difference of about 20 degrees. The lateral force equals to 1/3 of the sum of the two vertical forces in the push cycle. These three forces were generated by three closed-loop hydraulic loading systems (MTS system). The two vertical loading heads each was connected at the ends by heavy duty ball bearings and a spherical head was used on lateral load head to provide for free rail rotation. Fig. 6 shows the testing set-up. The rail was repositioned after the lateral load test. This involved extracting the clips out from the inserts, repositioning the rubber pad, rail, and driving the clips back again. In this last operation, the overhang part of the insulating pads were broken.

During the test, the outputs of each load cell attached to each load head were continuously monitored, together with many other responses from the test including strain gage outputs from the gages attached to the spring clips, the temperature in the rubber pad, vertical deflection of the spring clips, vertical and lateral deflection of the rail.

After the initial shake-down, the frequency of a complete load cycle was set at 1.25 cycles per second. At this frequency, the temperature in the rubber pad was quite close to the ambient room temperature.

During the initial 0.1 million cycles, the responses of the system remained fairly constant. After that, the rail and the rubber pad started to drift laterally (under the action of the repeated lateral load) until the rail base was butted against the steel pad which in turn was butted against the insert. If the nylon insulating pad were not broken, the rail base and the steel pad should butt against the insulating pad and the insulating in turn would butt against the insert instead of having the steel pad butted directly against the insert. At this stage, the rail showed a greater lateral deflection (about 0.08 in.) and the rail clip, on the side where the lateral load was applied, showed a greater deflection and the strain gage readings of this clip were also increased (peak to peak readings). Under rest condition, however, the strain gage response from this clip was small. This could be attributed to the lateral shifting of the rail.

After the repeated load reached over one million cycles, the rubber pad started to show some degree of deterioration and the strain gage output from the clip on the lateral load side was also increased gradually. Also, small separation between the insert and the concrete crosstie was observed.

After about 1.6 million cycles, it was evident from the strain gage outputs that the spring clips did not have sufficient hold-down forces exerted on the rail to meet the longitudinal restraint test. Thus, the repeated load test was terminated. At the end of this test, the spring clips did not show any slippage (back off) from the inserts.

4.5 Longitudinal Restraint Test

A longitudinal restraint test was performed after the repeated load test was terminated. At about 1,800 lbs. of longitudinal restraint force, rail slippage occurred.

The spring clips were extracted from the inserts. Examining the spring clips and the rubber pad indicated that both the spring clips showed a slight permanent deformation and the rubber pad showed signs of deterioration.

Table 1. Summary of Static Test Results (Test Series One)

Test	Amtrak Specification	Test Results
(1) Longitudinal Restraint Test	Applied 2400 lbs. longitudinal load. Rail shall not move more than 0.25 in. during initial 3 minutes at 2400 lbs. and shall not move at all afterwards.	At 2400 lb., rail movement was 0.024 in. during initial 3 min. and 0.003 in. from 3 min. to 15 min.
(2) Uplift Test	Applied uplift load to deflect rail upward to a maximum of 0.1 in. Residual deflection shall be less than 0.001 in. Spring rate shall be between 200,000 lb/in. to 350,000 lbs/in.	At 0.1 in. deflection uplift load equals 8,000 lbs. Residual deflection is negligible Spring rate = 235,000 lb/in. Maximum uplift load applied equals 12,000 lbs.
(3) Insert Pull-Out Test	Apply 12 kips pull-out load for 3 minutes and 250 ft-lb forque for 3 minutes.	No cracking of the concrete, slippage or rotation of the insert.

Table 2. Summary of Test Series Two

Test	Amtrak Specification	Test Results
(1) Longitudinal Restraint Test	Applied 2,400 lbs. longitudinal load. Rail shall not move more than 0.25 in. during initial 3 minutes at 2,400 lbs. and shall not move at all afterwards.	At 2,400 lbs., rail movement was 0.020 in. during initial 3 min. and 0.001 in. from 3 min. to 15 min.
(2) Lateral Restraint Test	Apply 44 kips vertical load and 21 kip lateral load. At 21 kips the rail translation and rotation shall be less than 1/8 in. and 1/4 in. respectively.	At 21 kips of lateral load rail translation and rotation were 0.023 in. and 0.012 in. respectively.
(3) Repeated Load Test	Applied repeated load for 3 million cycles at the specified vertical and lateral loading conditions. At end of 3 million cycles, no sign of failure of any fastening components is allowed.	After 1.6 million cycles several failures were observed. Rubber pad showed deterioration. Rail and rubber pad drafted. Insulating pad failed. Spring clip showed permanent deformation. No slippage of the rail clip was observed. The longitudinal restraint test after the repeated load test was failed.

Table 3. Longitudinal Restraint Test

Load (lbs.)	Deformation left gage (in.)	right gage (in.)
0	0	0
Loading:		
400	0.006	0.002
800	0.011	0.004
1200	0.015	0.008
1600	0.044	0.018
2000	0.065	0.039
2400* t = 0	0.095	0.067
2400 t = 1 min.	0.104	0.078
2400 t = 2 min.	0.113	0.088
2400 t = 3 min.	0.115	0.095
2400 t = 15 min.	0.120	0.095
Unloading:		
2000	0.120	0.095
1600	0.119	0.095
1200	0.117	0.094
800	0.116	0.092
400	0.112	0.088
0	0.100	0.073

* Average movement in the first 3 minutes = 0.024 in.
  Average movement from 3 min. to 15 min. = 0.003 in.

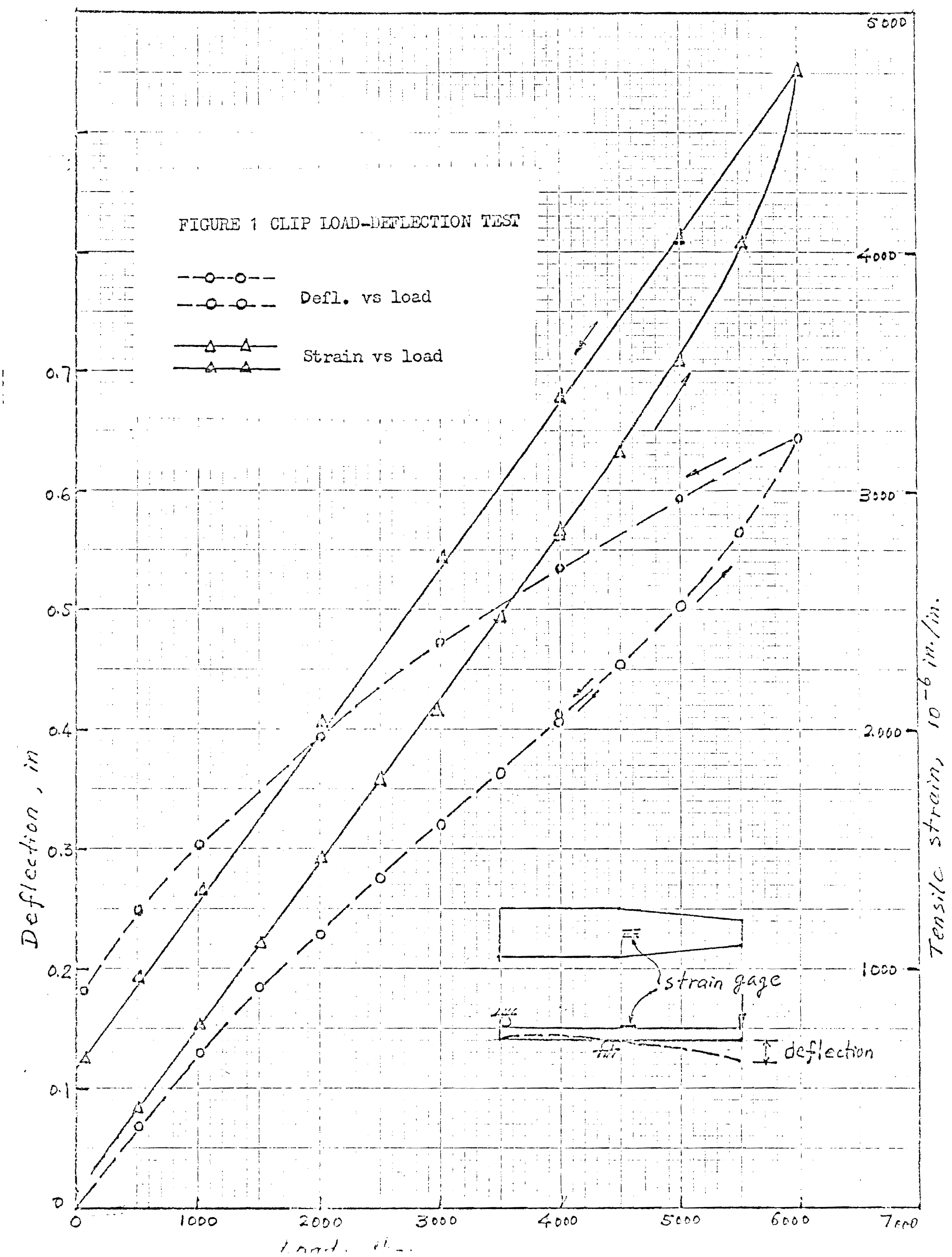
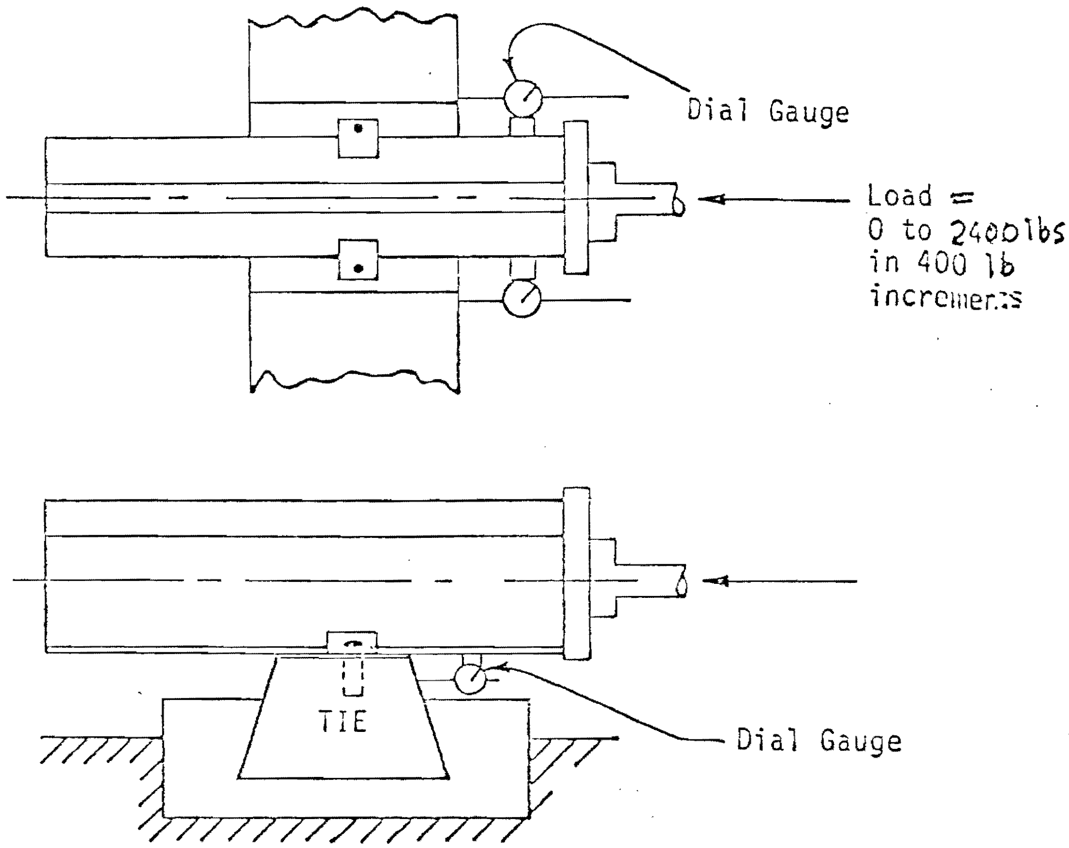


FIGURE 1 CLIP LOAD-DEFLECTION TEST
Defl. vs load
Strain vs load
Deflection, in
Tensile strain, 10^{-6} in./in.
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1000
2000
3000
4000
5000
0
1000
2000
3000
4000
5000
6000
7000
strain gage
deflection



Record dial gauge readings at each load increment to 2400 lbs.
Hold maximum load for 15 minutes.

FIGURE 2 FASTENING LONGITUDINAL RESTRAINT TEST

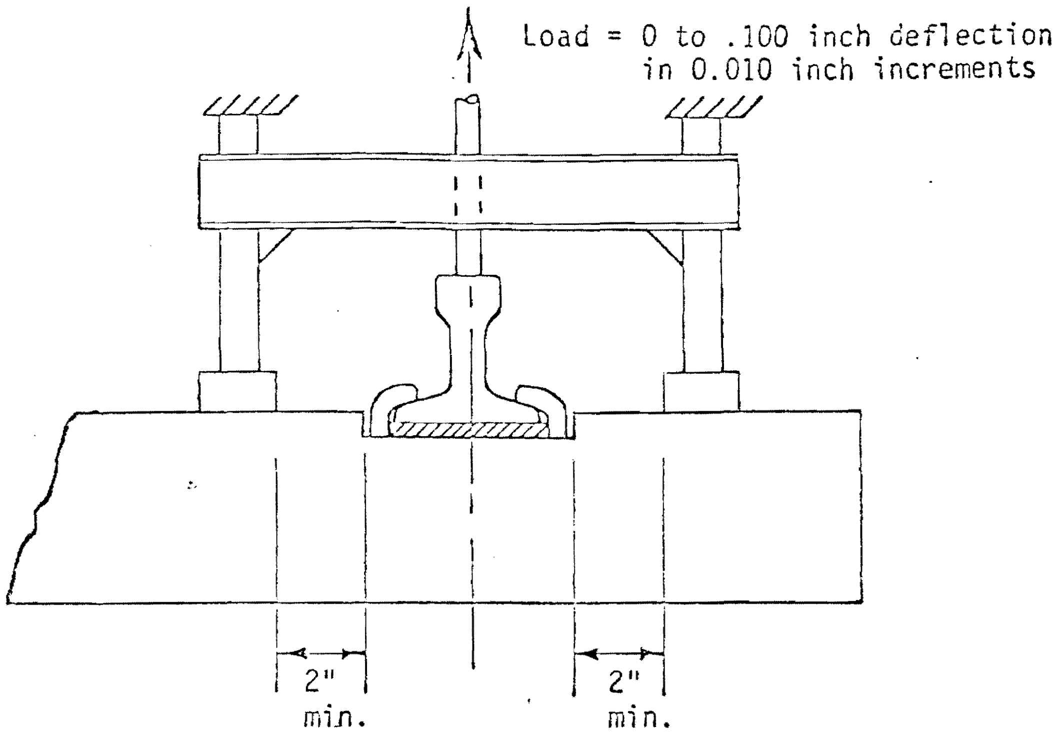


FIGURE 3 FASTENING UPLIFT TEST

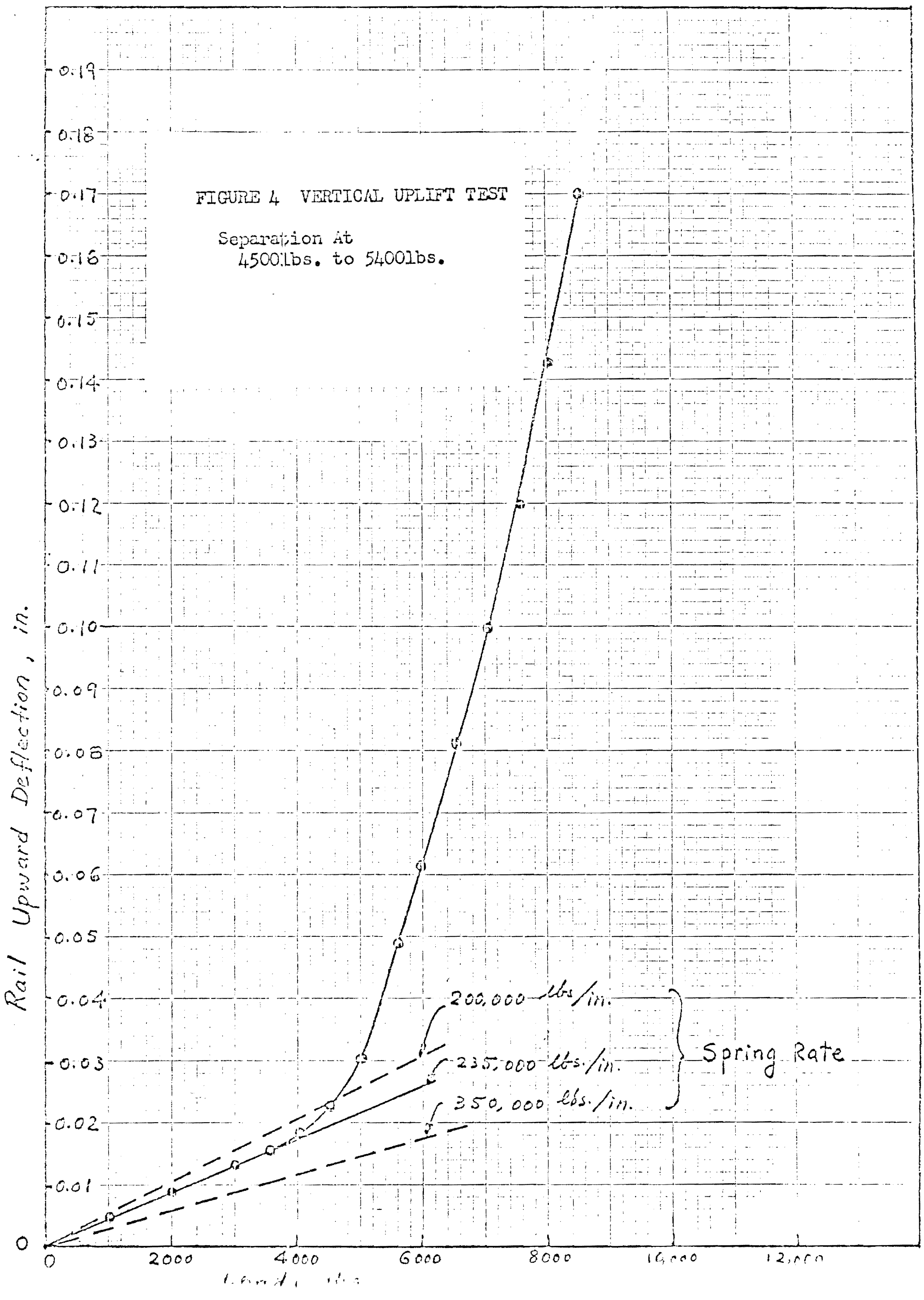


FIGURE 4 VERTICAL UPLIFT TEST

Separation At
4500lbs. to 5400lbs.

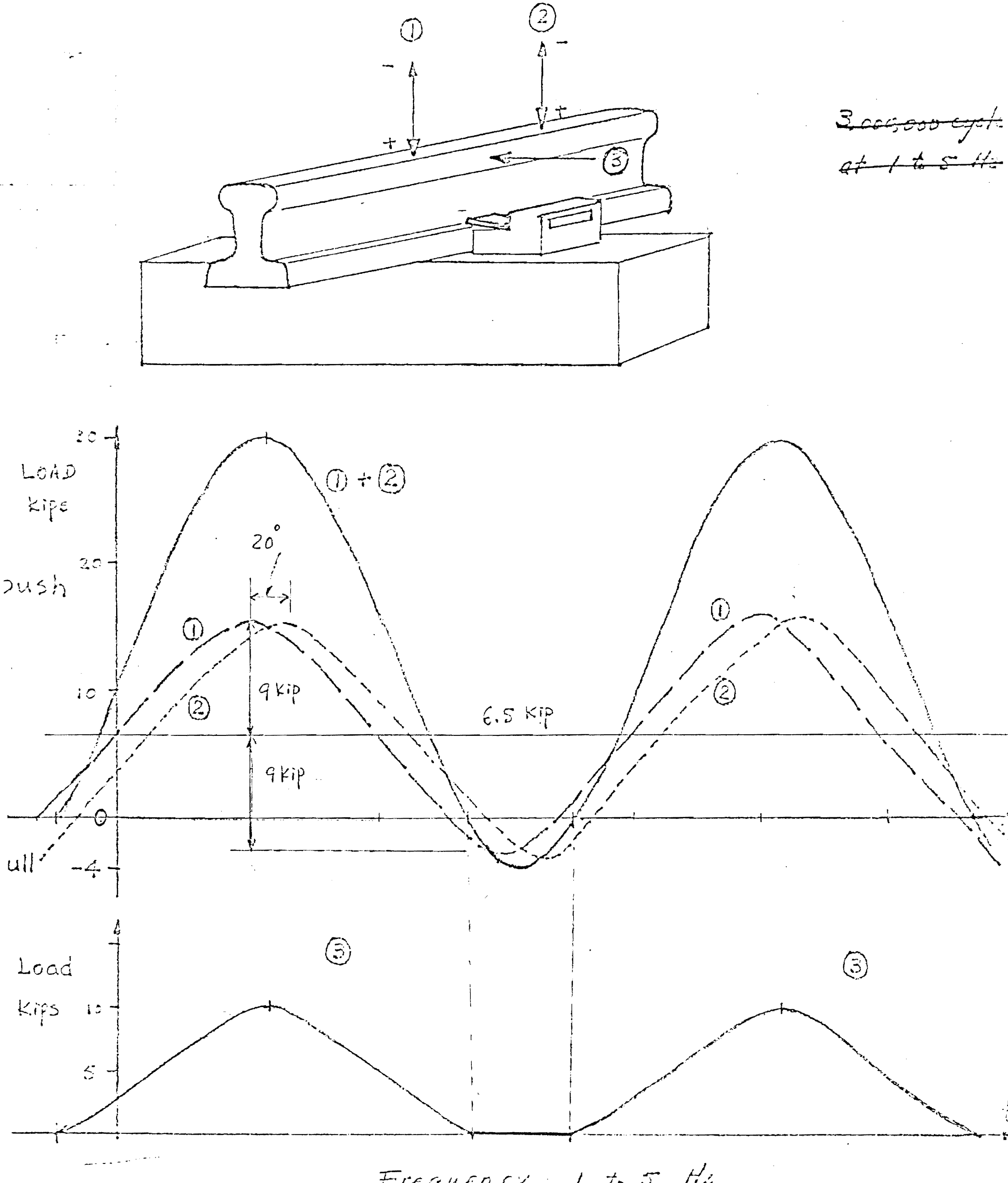


Fig 5 Repeated Load Test