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Posttraffic Testing at the National Airport Pavement Test Facility: Test Item MFC

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16. Abstract

The National Airport Pavement Test Facility (NAPTF) is located at the Federal Aviation Administration (FAA) William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. It is used to generate full-scale pavement response and performance data for development and verification of airport pavement design criteria. Additional information is available on the FAA Airport Pavement Technology web site “www.airporttech.tc.faa.gov.” During the traffic tests, the conventional flexible pavement test item on medium-strength subgrade (MFC) exhibited severe rutting with upheaval outside the traffic lane and asphalt surface (AC) cracking in the wander path. A trench was dug perpendicular to the centerline of the test item at the 367-foot (111.8-m) mark on the test pavement to conduct posttraffic investigation into the failure mechanism of the pavement structure. The trenching involved removal of the P-401 AC layer, the P-209 base, and the P-154 subbase layers to reveal the subgrade interface and subsequent subgrade layers below. Tests conducted on the pavement component layers included CBR, in situ densities and moisture contents, and dynamic cone penetrometer tests. Elevation profiles of the interfaces show clear evidence of shear flow in the subgrade, with vertical movement of the subgrade material in the upheaval areas.

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- Dr. Navneet Garg (Galaxy Scientific Corporation) for data analyses and final document preparation

Dr. Satish Agrawal is the manager of the FAA Airport Technology Branch (AAR 410).

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EXECUTIVE SUMMARY

The conventional flexible pavement test item on medium-strength subgrade (MFC) exhibited ruts 4 to 6 inches (100 to 150 mm) deep with upheaval outside the traffic lane and asphalt surface (AC) cracking in the wander path. A trench was dug perpendicular to the centerline of the test item at the 367-foot (111.8-m) mark on the test pavement to conduct posttraffic investigation into the failure mechanism of the pavement structure. The trenching involved removal of the P-401 AC layer, the P-209 base, and the P-154 subbase layers to reveal the subgrade interface and subsequent subgrade layers below. The P-401 AC cores showed delamination in the south wheel track (four-wheel traffic path). All of the cracks (except in one core from the south wheel path) initiated from the top. The maximum crack depth was 2.5 inches (63.5 mm). Only one core was cracked in the bottom lift. In the P-209 base, the dry densities ranged from 152.7 pcf (2446 kg/cu.m) to 158 pcf (2531 kg/cu.m), and moisture content ranged from 2.19 percent to 2.85 percent. For the P-154 subbase, the dry density ranged from 117.8 pcf (1887 kg/cu.m) to 135.1 pcf (2164 kg/cu.m) and the moisture contents ranged from 3.79 percent to 4.65 percent. The California Bearing Ratio (CBR) values for the P-154 subbase ranged from 20 to 26 in the nontrafficked areas and 61 to 98 in the trafficked areas. At the top of the subgrade, CBR tests were performed at 2-foot (0.61-m) intervals in the transverse direction (along the length of the trench). The CBR values at the subgrade surface (58 tests) ranged from 3.7 to 8 with a mean value of 5.7. The moisture contents ranged from 30.28 percent to 33.29 percent. Lower CBR values were observed in the trafficked areas. CBR tests were run inside test pits at depths of 6 inches (152 mm), 12 inches (305 mm), 18 inches (457 mm), and 24 inches (610 mm) below the surface of the subgrade. CBR measurements in the test pits ranged from 4.2 to 10.4. Drive cylinder dry densities at the subgrade surface ranged from 88.2 pcf (1413 kg/cu.m) to 91.6 pcf (1467 kg/cu.m) with a mean of 90.4 pcf (1448 kg/cu.m). All the layer interfaces were very well defined except in three places where subgrade material had penetrated upwards into the subbase. Elevation profiles of the interfaces show clear evidence of shear flow in the subgrade, with vertical movement of the subgrade material in the upheaval areas. A decrease in thickness of the subbase in the wheel tracks and increase in thickness in the upheaval areas is also indicated by the interface profiles.

POSTTRAFFIC ACTIVITIES IN THE EAST END MFC TRENCH AT THE NATIONAL AIRPORT PAVEMENT TEST FACILITY (NAPTF)

INTRODUCTION.

A CL-CH soil classification material known as DuPont Clay was used for the medium-strength subgrade. The target California Bearing Ratio (CBR) was 8. Figure 1 shows the cross-section of test item medium-strength subgrade (MFC) (conventional flexible pavement on medium-strength subgrade). The test item was trafficked by a six-wheel tridem landing gear configuration on the north side and a four-wheel, dual-tandem landing gear configuration on the south side. The wheel load was 45,000 lbs (200 kN) and the tire pressure was 188 psi (1295 kN/m^2) cold. After trafficking was completed, MFC exhibited ruts 4 to 6 inches (100 to 150 mm) deep with upheaval outside the traffic lane and asphalt surface (AC) cracking inside the traffic lane. A trench (figure 2) was dug perpendicular to the centerline of test item MFC at the 367-foot (111.8-m) mark on the test pavement. The purpose of the trench was to conduct posttraffic investigation into the failure mechanism of the pavement structure. The trenching involved removal of the P-401 AC layer, the P-209 crushed stone base, and the P-154 subbase layer to reveal the subgrade interface and subsequent subgrade layers below. The final trench dimensions were 60 feet (18.3 m) long (across the width of the test pavement), 4 feet (1.22 m) wide, and 4 feet (1.22 m) deep. Tests and measurements were performed on the various layers of the pavement structure. Table 1 summarizes the trenching and testing activities.

After the completion of testing, the trench walls were cleaned to clearly expose the layer interfaces. Measurements of the pavement layer interface profiles were made relative to a horizontal string line to quantify the contribution of each component layer to the total pavement rutting and upheaval, see figures 3 and 4. Subgrade intrusion into the P-154 base at two locations in the six-wheel traffic path and one location in the four-wheel traffic path was observed. Reduction in thickness of the P-154 in the wheel tracks was observed. Thickness of the P-154 layer increased in the upheaval area. Rutting was primarily contributed by the subgrade and the P-154 subbase. Shear flow, because of shear failure in the subgrade, contributed to the upheaval.

This document summarizes the findings from posttraffic studies conducted in the test item MFC. Test procedures and results are presented first for the layer interface profiles and the layer thickness measurements.

PAVEMENT LAYER PROFILE MEASUREMENTS.

After the completion of testing, the trench walls were cleaned to clearly expose the layer interfaces. The pavement layer profile measurements in the trench can be used to quantify the contribution of each component layer to the total pavement rutting and upheaval. The following procedure was used.

1. A level string line was run from the pavement surface at the south end of the pavement to the north end of the pavement surface along the west face of the trench.

2. The vertical distance between the string line and the P-401 top (D1), the P-401 bottom (D2), the P-209 bottom (D3), and bottom of the P-154 (D4) at 1-foot (maximum) (0.3-m) intervals was measured.

3. Within both the six- and four-wheel traffic paths, the measurements listed in step 2 (D1, D2, D3, and D4) were made at 6-inch (maximum) (0.15-m) intervals.

Figures 4a and 4b show the pavement layer profile measurements on the west face and the east face of the trench respectively. The subgrade intrusion into the P-154 base in the six-wheel traffic path and in the four-wheel traffic path is clearly visible in the figures.

Figures 5a and 5b show the comparison between the as-built and the trench pavement layer thicknesses across the pavement in the transverse direction. The layer thickness measurements were made at 5-foot (1.52-m) intervals during the construction (as-built thickness), whereas in the trench, measurements were made at 1-foot (0.3-m) intervals outside the wheel paths, and at 6-inch (0.15-m) intervals inside the wheel path. Reduction in thickness of the P-154 layer in the wheel tracks is observed. The thickness of the P-154 layer increased in the upheaval area.

P-401 ASPHALT CONCRETE SURFACE.

Four-inch diameter cores were extracted from the north wheel track and the south wheel track. Thickness measurements were made on the cores (four measurements on each core at diametrically opposite sides). The cores were inspected for delamination/separation at the interfaces between lifts and for the depth of cracks occurring in the pavement. Core locations were chosen so as to include the most severe cracks, hairline cracks, and medium-intensity cracks.

Nineteen cores were extracted. Table 2 summarizes the thickness measurements on the P-401 cores. A careful examination of these cores showed that all the cracks (except in one core from the four-wheel traffic path) initiated from the top. The maximum crack depth was 2.5 inches (63.5 mm). Only one core was cracked in the bottom lift. Delamination between the two P-401 layers was observed on the four-wheel traffic path cores. Only two cores from the six-wheel traffic path showed delamination. The P-401 core thickness varied from 4.8 inches (122 mm) to 5.6 inches (142 mm). Figure 6 gives the statistical summary of thickness measurements. Figure 7 shows a P-401 core with a crack.

Figure 8 is a photograph showing evidence of delamination in the P-401 layer. A thin layer of dust was observed between the two lifts that could have been the cause of delamination. The P-401 layer was removed using a backhoe (figure 9). During the removal, the two lifts of the P-401 layer in the four-wheel traffic path separated easily (delamination). Figure 10 shows the P-401 layer at the location of maximum rutting (center of the six-wheel traffic path). No signs of rutting in the P-401 layer were observed. Portions of chunk samples (from AC removed with a backhoe or other equipment) and cores were stored for future testing.

P-209 CRUSHED STONE BASE.

After the removal of the P-401 AC surface, the P-209 surface was exposed. In situ density was determined using the sand cone method (ASTM D 1556-90) with a 12-inch (305-mm)-diameter cone. Five tests were performed, one in each wander path (the center of the wander path is the location of maximum rutting), one on the pavement centerline, and two outside the wander path (north of the six-wheel traffic path and south of the four-wheel traffic path). Figure 11 gives the locations for test pits in the P-209 layer. These five density measurements characterize density changes from the location of maximum rutting to the location of maximum upheaval and can be compared with the density of the untrafficked area. Moisture contents were determined using ASTM D 2216-92. Figure 12 shows the trench after P-401 removal and a 12-inch (305-mm) sand cone test being performed on top of the P-209 base layer.

Table 3 shows the results from the 12-inch (305-mm) sand cone tests on the P-209 layer. The in situ dry densities in the wheel tracks were slightly higher than the dry densities in the untrafficked areas. The dry densities ranged from 152.7 pcf (2446 kg/cu.m) to 158 pcf (2531 kg/cu.m). Figure 13 shows the dry density of the P-209 layer measured in the trench. Samples were collected for determination of moisture content. Moisture contents ranged from 2.19 percent to 2.85 percent. No significant change in the dry density was observed when compared to the as-constructed dry density of 158 pcf (2531 kg/cu.m). A decrease in the moisture content was observed when compared to the as-constructed moisture content (3.6 percent). The maximum dry density and optimum moisture content obtained from the P-209 layer, using the modified Proctor test (ASTM D1557), were 154.9 pcf (2481 kg/cu.m) and 4.7 percent respectively.

P-154 SUBBASE.

Five test pits were excavated in the P-209 base to expose the surface of the P-154 subbase. CBR tests were conducted on locations inside the test pits. Each CBR test consisted of three penetrations. According to ASTM D 4429, the spacing between tests may range from 7 inches (178 mm) in plastic soils to 15 inches (381 mm) in coarse granular soils. As per the FM 5-430-00-2 (army field manual for airfield pavement design), the CBR tests should be spaced in the pit so that areas covered by the surcharge weights of the individual tests do not overlap. A minimum center-to-center spacing of 12 inches (305 mm) was used. A moisture sample was taken from the middle penetration of the CBR test. In situ density was measured using the sand cone method (ASTM D 1556-90). Five tests were performed, one at the center of each wander path, one at the pavement centerline, and two outside the wander path (north of the six-wheel traffic path and south of the four-wheel traffic path). Moisture content was determined using ASTM D 2216-92. Dynamic cone penetrometer (DCP) tests were conducted to characterize strength variation with depth. Figure 14 shows the locations of the CBR tests, the sand cone test, and the DCP tests within the test pit area. The same scheme was used for all five test pits in the P-154 layer. The order in which the tests were performed was the CBR tests first, followed by the sand cone test (figure 15) with a 6-inch (152-mm)- diameter cone, and then the DCP tests.

Table 4 and figure 16 show the results from the CBR tests on the P-154 layer. The CBR values ranged from 20 to 98. Higher CBR values were observed in the trafficked areas (61 to 98) and lower CBR values (20 to 26) were observed in the untrafficked areas. Table 5 and figure 17 show the results from sand cone tests on the P-154 layer. The dry density values ranged from 117.8 pcf (1887 kg/cu.m) to 135.1 pcf (2164 kg/cu.m). The moisture contents ranged from 3.79 percent to 4.65 percent. The dry density values were lower when compared to the as-constructed dry density of 131 pcf (2098 kg/cu.m). About a 2 percent decrease in the moisture content was observed when compared to the as-constructed moisture content (6.4 percent). The maximum dry density and optimum moisture content obtained from the P-154 layer, using the modified Proctor test (ASTM D1557), were 128.3 pcf (2055 kg/cu.m) and 6.5 percent respectively.

The locations of the DCP tests within the test pits are shown in figure 18. Tests were performed in the diagonally opposite corners inside the test pit. A total of ten DCP tests were performed using disposable cones. Figure 19 shows the test results from the DCP tests. Tests on the P-154 surface were performed using the 17.6-lb (8-kg) hammer. The results are fairly consistent.

SUBGRADE.

After completing the tests in the P-154 test pits, the base and subbase were completely excavated using a backhoe. Near the interface, material was hand excavated using shovels. Evidence of clay subgrade penetrating upward into the P-154 subbase was observed (figure 20) at the location of maximum rutting in the four-wheel traffic path (south side). Excavation was continued with careful hand digging near the location of penetration. Subgrade penetration was observed for the whole width of the trench, but of varying extent, as shown in figure 21. The maximum depth of subgrade penetration into the subbase was approximately 6 inches (152 mm) (figure 22). Figure 23 shows the lateral movement of the subbase material originating at the subbase/subgrade interface. The P-154 subbase layer is crushed stone (unbound granular material). When the tensile stress in the unbound granular layer due to applied load exceeds the residual compressive stress (developed due to initial compaction and preloading), lateral movement in the unbound granular layer may take place. This phenomenon was observed in the south side four-wheel traffic path at the location of maximum rutting. About a 2-inch (51-mm) subgrade penetration into the P-154 layer was observed in the center of the six-wheel traffic path (north side) in two places (figure 24). Subgrade penetration into base/subbase has also been observed in past full-scale airport pavement tests [1 and 2].

The subbase/subgrade interface moisture content was observed to be higher (qualitatively) than at the top of the subgrade layer. CBR tests were performed at 2-foot (0.61-m) intervals in the transverse direction (along the length of the trench). Each CBR test consisted of three penetrations. A minimum center-to-center spacing of 12 inches (305 mm) between the adjacent penetrations was used (U.S. Army Field Manual FM 5-430-00-2). Moisture samples were taken from the middle penetration of the CBR tests. Whenever a significant difference between CBR values from adjacent penetrations was observed, the test was repeated. If the difference was still significant, an additional moisture sample was collected. Table 6 summarizes the CBR test results on the subgrade surface. The CBR values (58 tests) ranged from 3.7 to 8 with a mean value of 5.7. Moisture content ranged from 33.04 percent to 34.85 percent with a mean value of 33.87 percent. Figure 25 shows the CBR test results with the location of tests. Generally, lower CBR values were observed in the trafficked areas.

After the completion of testing on the subgrade surface, five test pits (4 feet by 4 feet) (1.2 m by 1.2 m) were excavated in the subgrade at 6-inch (152-mm) depths. The location of the test pits is shown in figure 23. They were selected to get maximum information about the subgrade in critical locations (location of maximum rut depths and maximum upheaval). Figure 26 shows the locations of the tests in the test pits. In situ density was determined using the drive cylinder method (ASTM D 2937-94). The test locations were selected to characterize density changes from the location of maximum rutting to the location of maximum upheaval. Moisture content was determined using ASTM D 4959-89 or ASTM D 4643-93.

Tables 7 through 10 summarize the CBR test results inside the test pits at depths of 6 inches (152 mm), 12 inches (305 mm), 18 inches (457 mm), and 24 inches (610 mm) respectively. The CBR values range from 4.2 to 10.4. The results of the moisture content tests ranged from 30.28 percent to 33.29 percent. Figures 27 through 30 show the CBR test results and moisture contents with locations within the test pits. Figure 31 shows the variation in the CBR and moisture content with subgrade depth. The moisture content reduces with depth. The CBR values are higher at the 12-inch (305-mm) depth in the subgrade. Figure 32 shows that for the CBR tests conducted on the subgrade surface, 85 percent of the values were higher than 5.2. For all the CBR tests conducted, 85 percent of CBR values were higher than 5.2.

Drive cylinder test results are summarized in table 11 and figures 33 and 34. The dry density values ranged from 84.8 pcf (1358 kg/cu.m) to 92.9 pcf (1488 kg/cu.m) with a mean value of 89.7 pcf (1437 kg/cu.m). The moisture content values ranged from 30.2 percent to 33.4 percent with a mean value of about 32 percent. In general, the moisture content and the dry density reduced with the depth of the subgrade (figure 35). The moisture content reduced by about 2 percent at the 24-inch (610-mm) depth compared to the subgrade top. The average dry density reduced by 5 pcf (80 kg/cu.m) at the 24-inch (610-mm) depth compared to the subgrade top. From the test data collected during initial construction of the medium-strength subgrade, the mean moisture content was 30.3 percent and the mean dry density was 94 pcf (1506 kg/cu.m).

The DCP tests were performed on the surface of the subgrade and at 24 inches (610 mm) below the surface of the subgrade. The 10.12-lb (4.5-kg) hammer was used for the tests in the subgrade. Test results for the DCP tests at the subgrade surface are shown in figure 36. In general, the penetration rate values ranged from 0.2 inch/blow (5 mm/blow) to 0.7 inch/blow (18 mm/blow). Higher penetration rates were observed in the top 8 to 10 inches (203 to 254 mm) of subgrade because of the lack of confining pressure developed due to the overburden. For the DCP tests performed at 24 inches (610 mm) below the subgrade surface (figure 37), a larger variation in penetration rates was observed. The DCP data will be examined in more detail later if time permits.

Two-inch (51-mm)- diameter, thin-wall tube samples were extracted by University of Illinois personnel from the surface of the subgrade and at a depth of 24 inches (610 mm) from the surface of the subgrade for additional testing.

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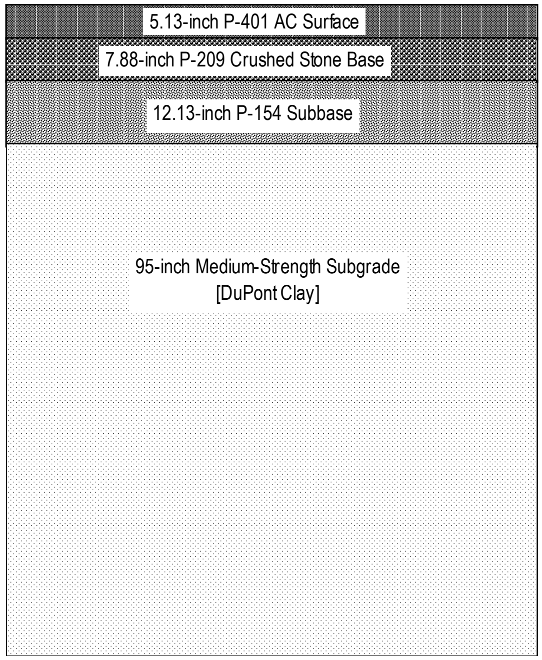

FIGURE 1. CROSS-SECTIONAL DETAILS OF TEST ITEM MFC

FIGURE 2. COMPLETED TRENCH IN MFC

FIGURE 3. PAVEMENT LAYER PROFILE MEASUREMENTS

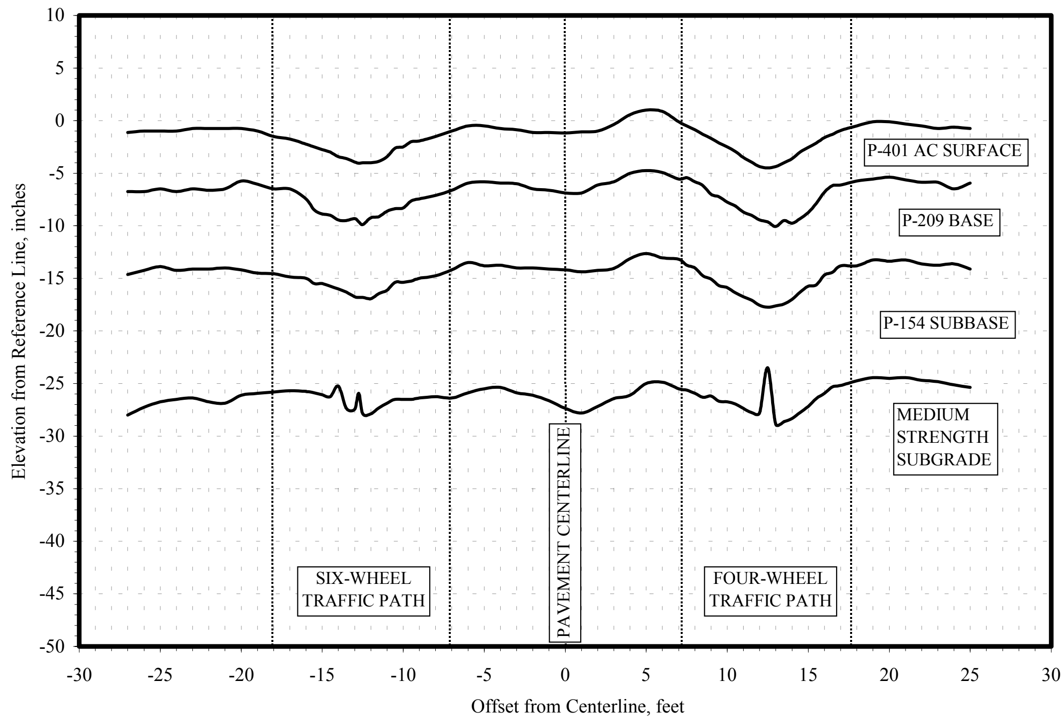

FIGURE 4a. PAVEMENT LAYER PROFILE MEASUREMENTS IN THE MFC TRENCH (WEST FACE)

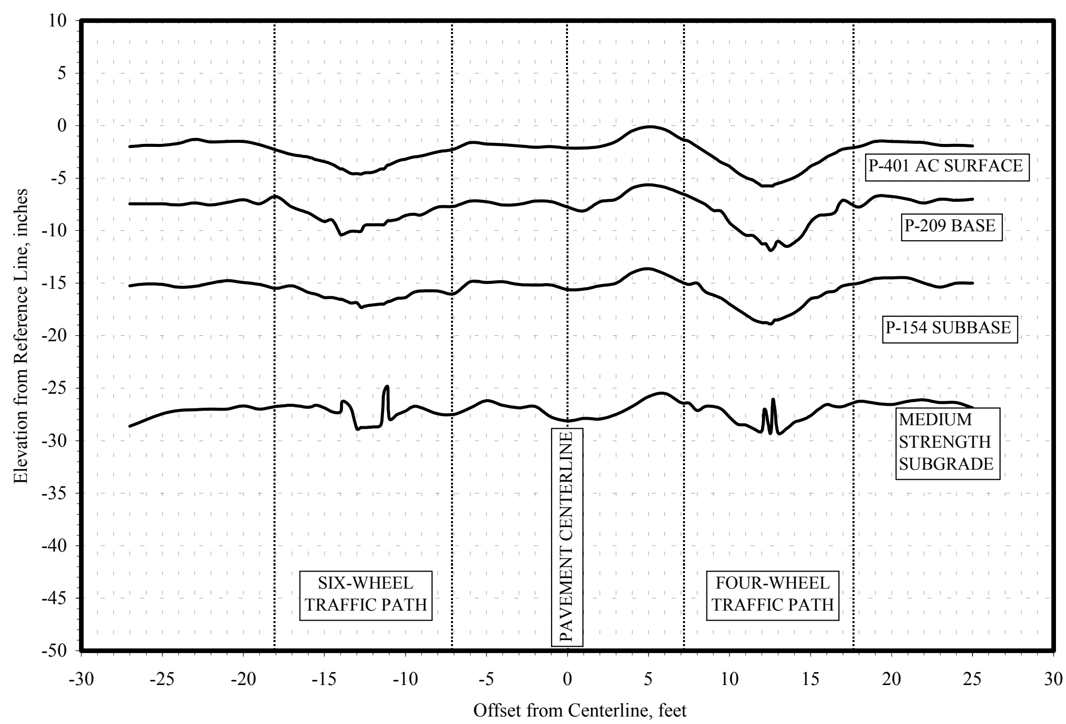

FIGURE 4b. PAVEMENT LAYER PROFILE MEASUREMENTS IN THE MFC TRENCH (EAST FACE)

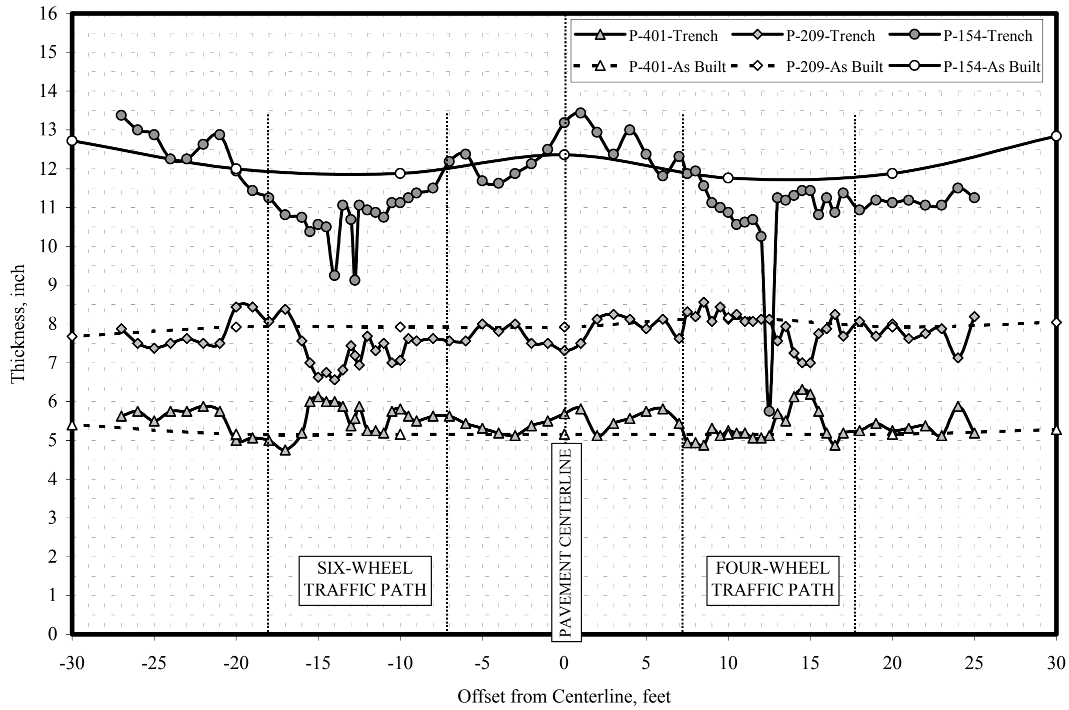

FIGURE 5a. PAVEMENT LAYER THICKNESSES IN THE MFC TRENCH (WEST FACE)

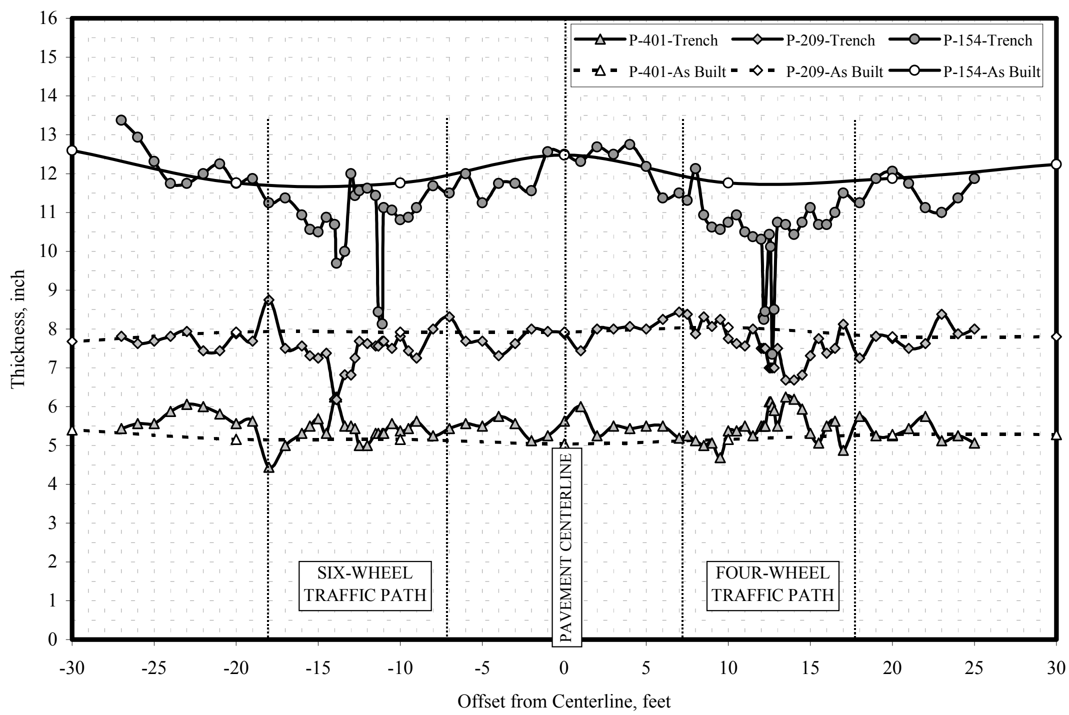

FIGURE 5b. PAVEMENT LAYER THICKNESSES IN THE MFC TRENCH (EAST FACE)

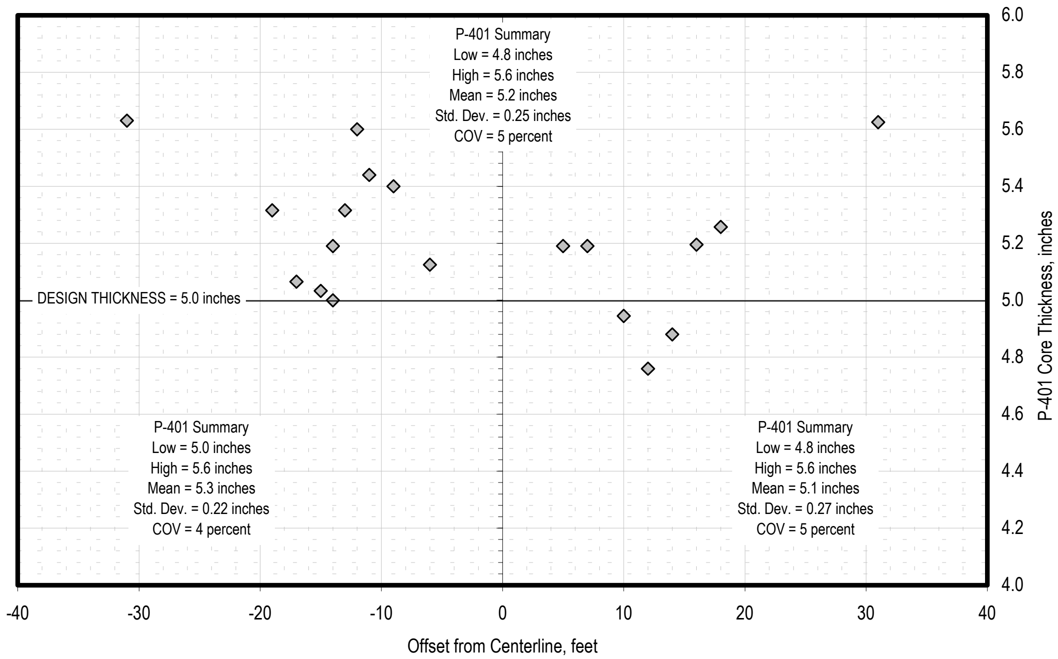

FIGURE 6. THICKNESS MEASUREMENT RESULTS ON P-401 CORES

FIGURE 7. P-401 CORE SHOWING CRACK LOCATION

F1GURE 8. P-401 SURFACE EXHIBITING DELAMINATION

FIGURE 9. P-401 REMOVAL

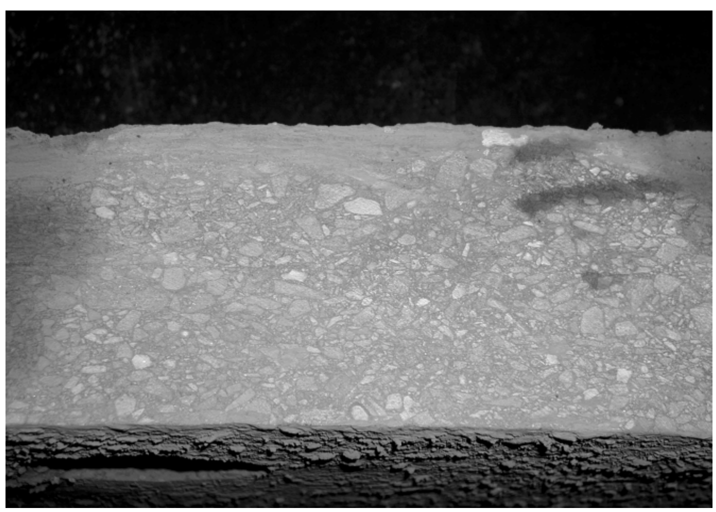

FIGURE 10. P-401 FROM MAXIMUM RUTTING LOCATION IN SIX-WHEEL TRAFFIC PATH

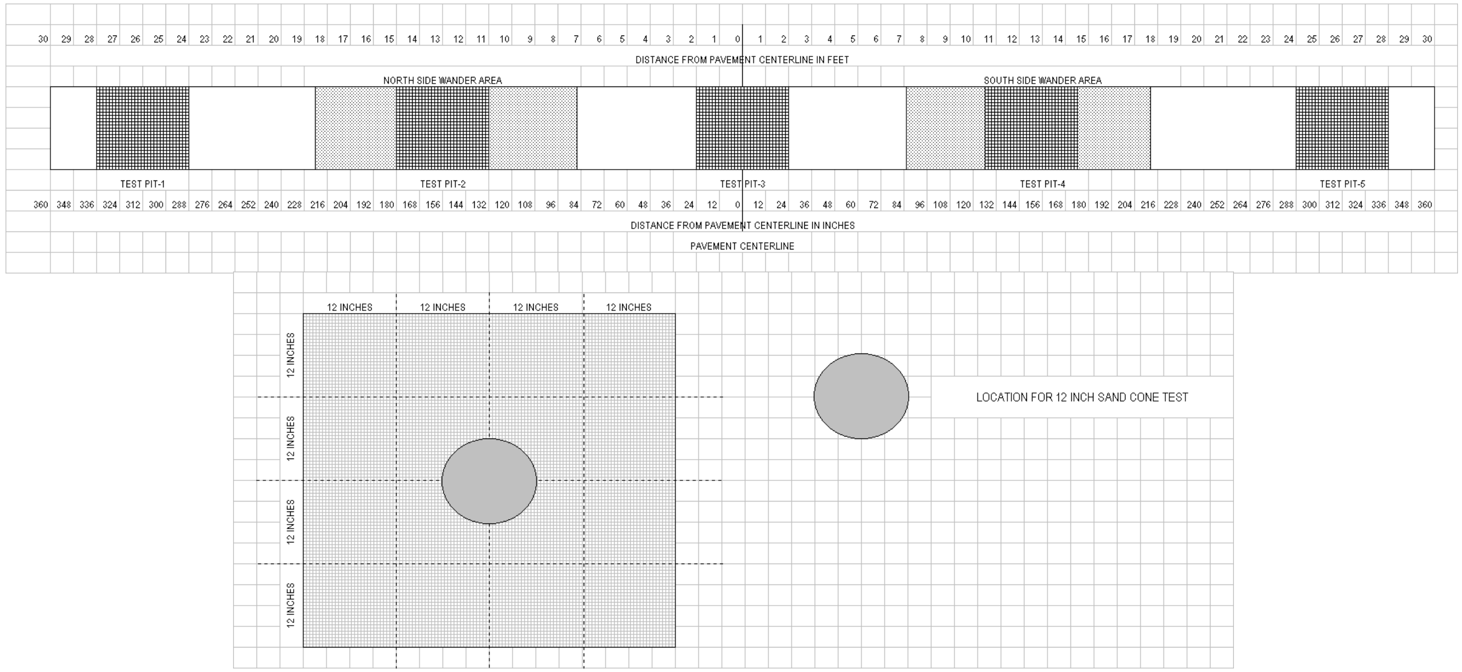

FIGURE 11. LOCATION OF 12-inch SAND CONE DENSITY TESTS IN P-209 CRUSHED STONE BASE

FIGURE 12. TWELVE-inch SAND CONE DENSITY TESTS IN P-209 CRUSHED STONE BASE

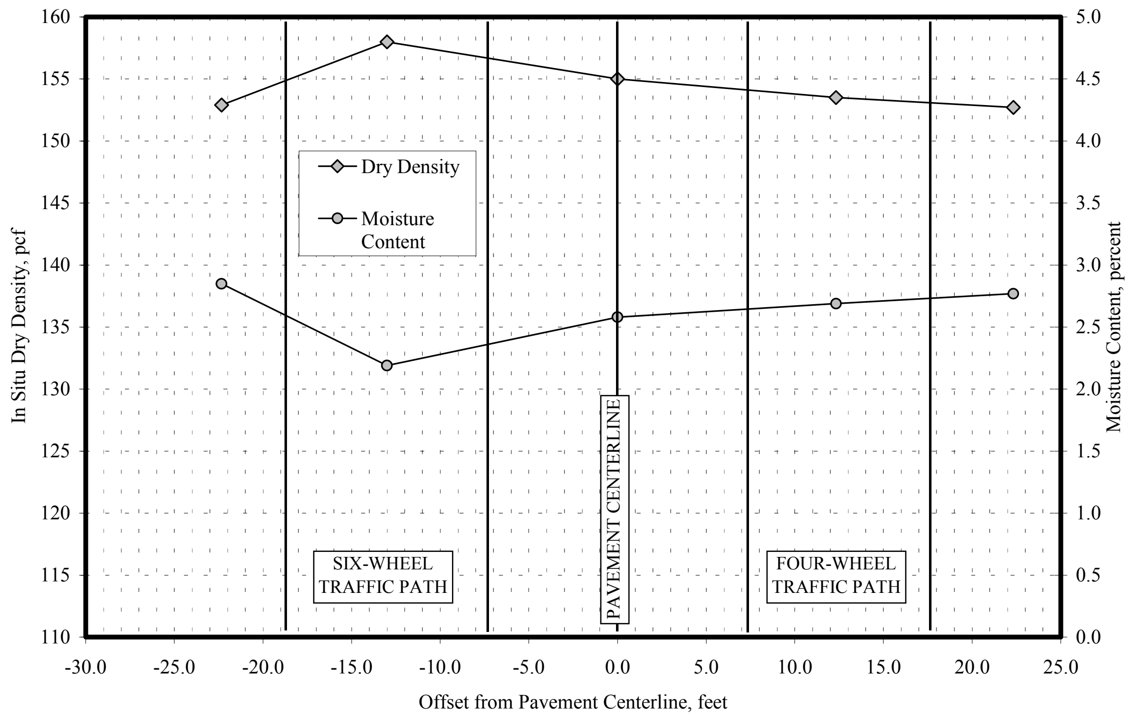

FIGURE 13. RESULTS FROM SAND CONE DENSITY TESTS ON P-209 CRUSHED STONE BASE

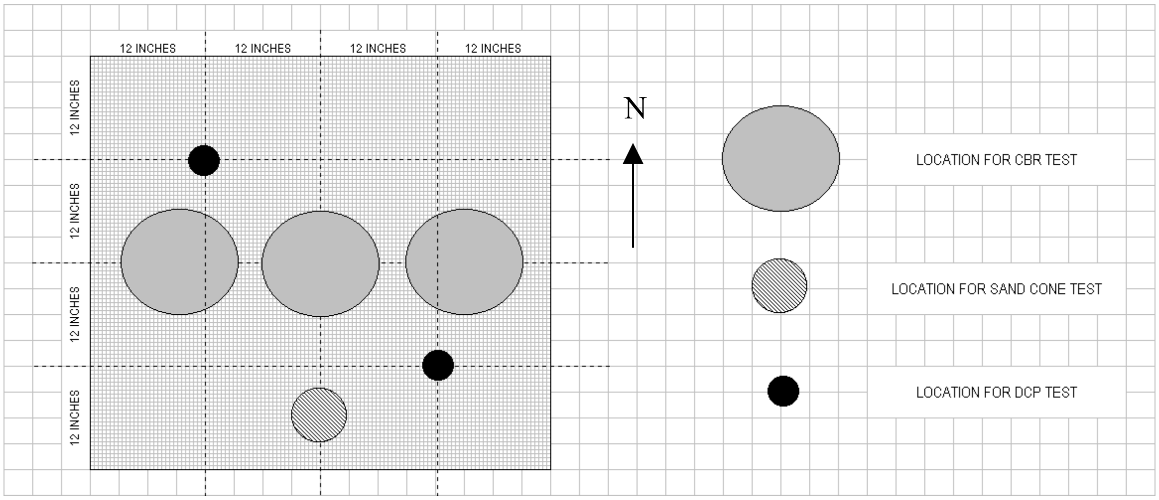

FIGURE 14. SCHEMATIC OF TEST LOCATIONS INSIDE THE TEST PITS IN P-154 LAYER

FIGURE 15. SIX-inch SAND CONE TESTS IN P-154 TEST PITS

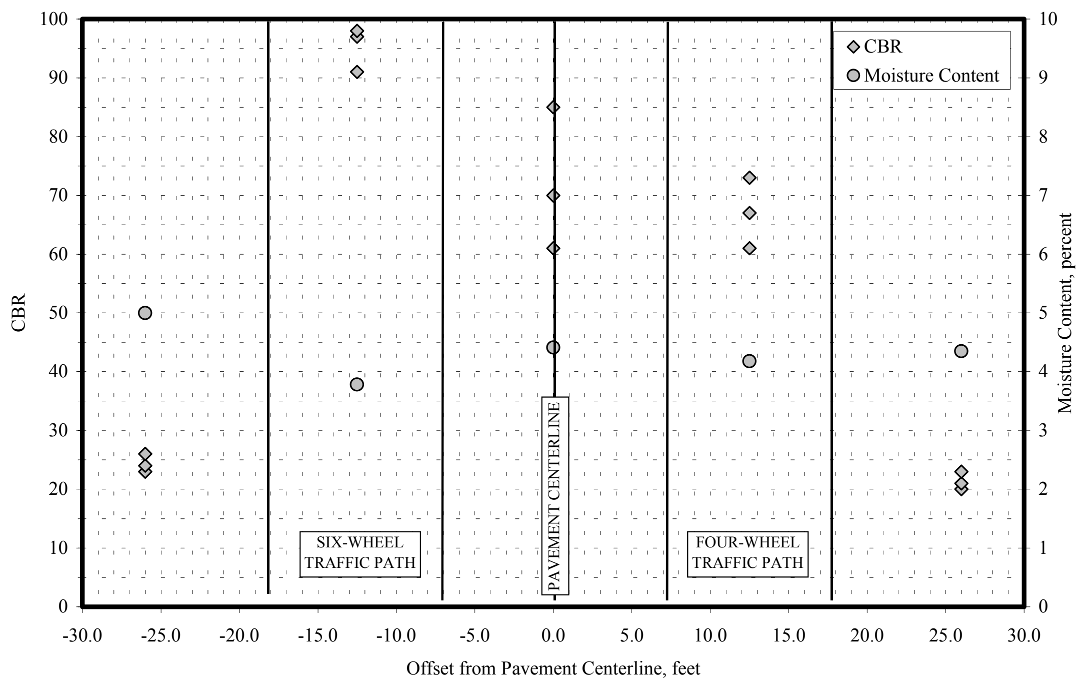

FIGURE 16. POSTTRAFFIC CBR TEST RESULTS ON P-154 SUBBASE

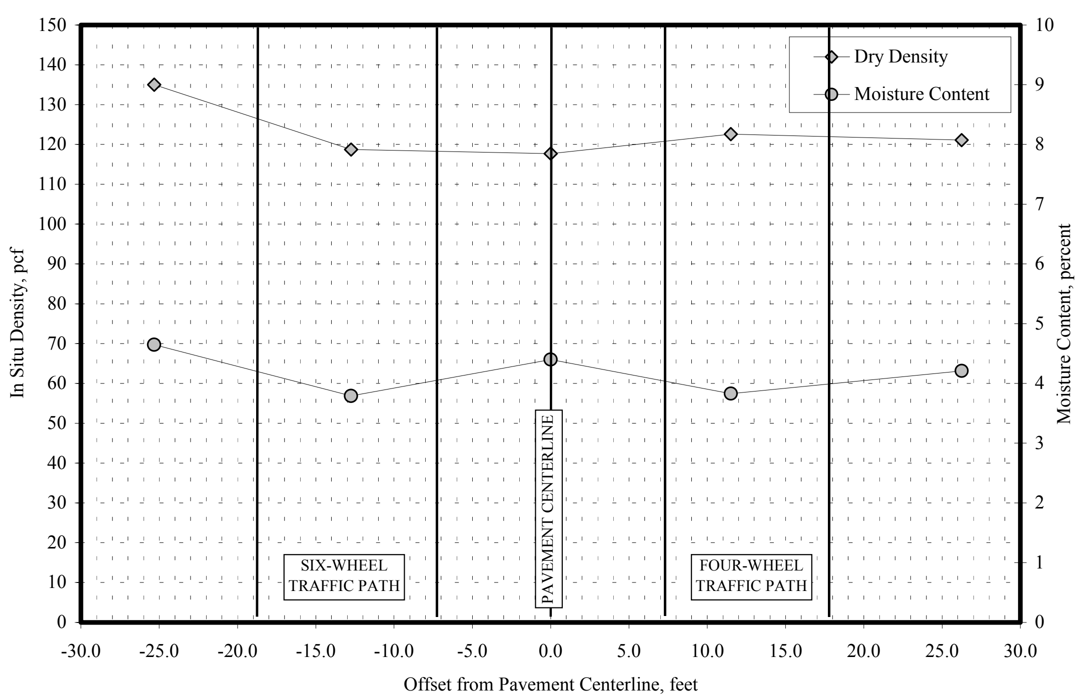

FIGURE 17. RESULTS FROM SAND CONE DENSITY TESTS ON P-154 SUBBASE

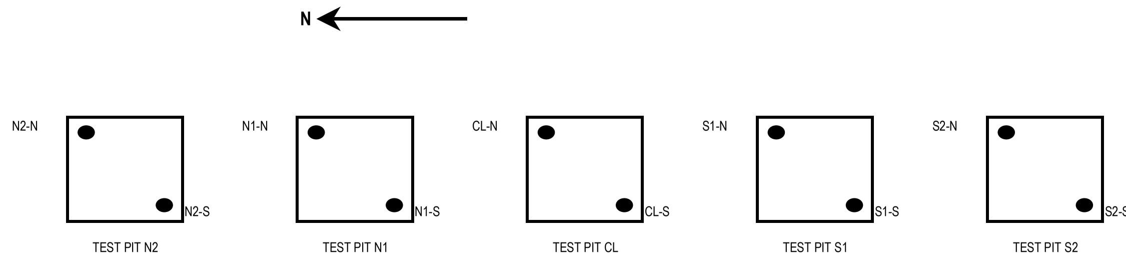

FIGURE 18. LOCATION OF DCP TESTS ON P-154 LAYER

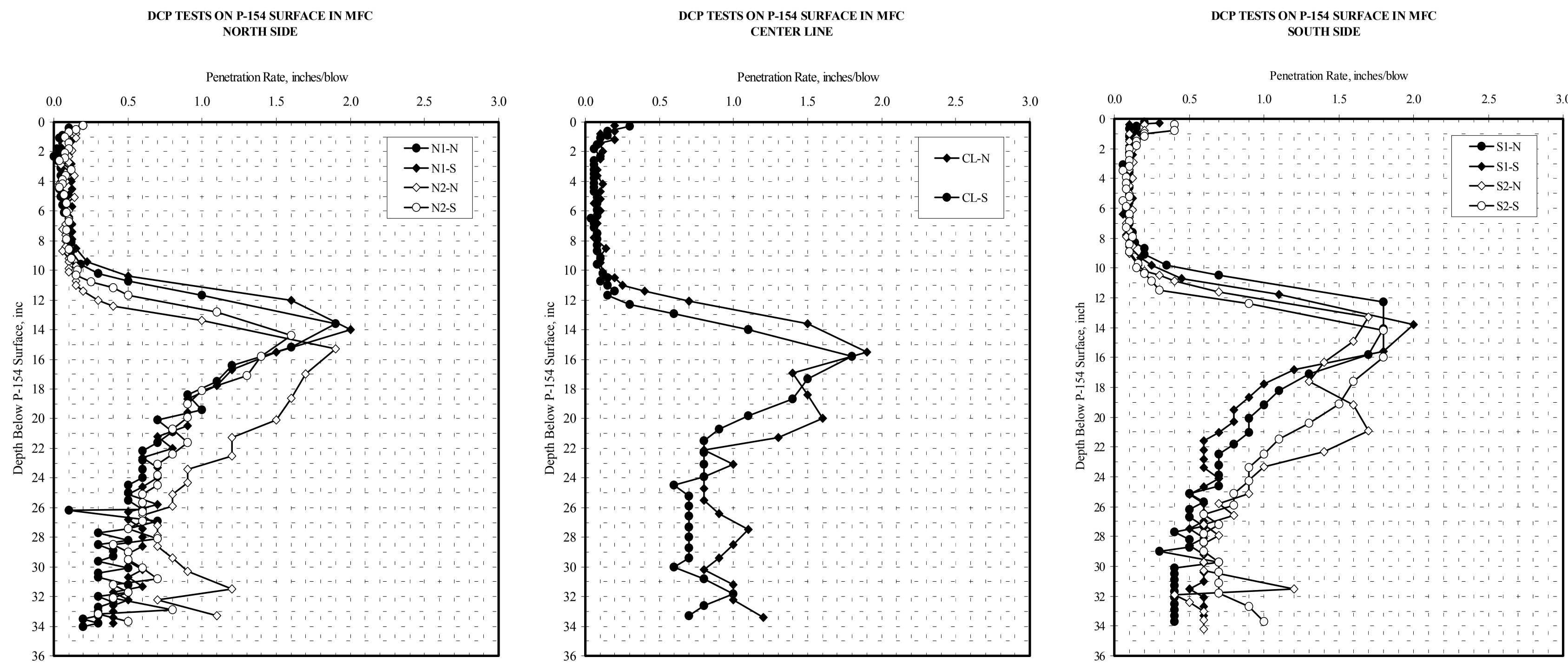

FIGURE 19. DCP TEST RESULTS ON P-154 LAYER

FIGURE 20. CLAY SUBGRADE PENETRATING INTO P-154 SUBBASE ON THE SOUTH SIDE (FOUR-WHEEL TRAFFIC PATH)

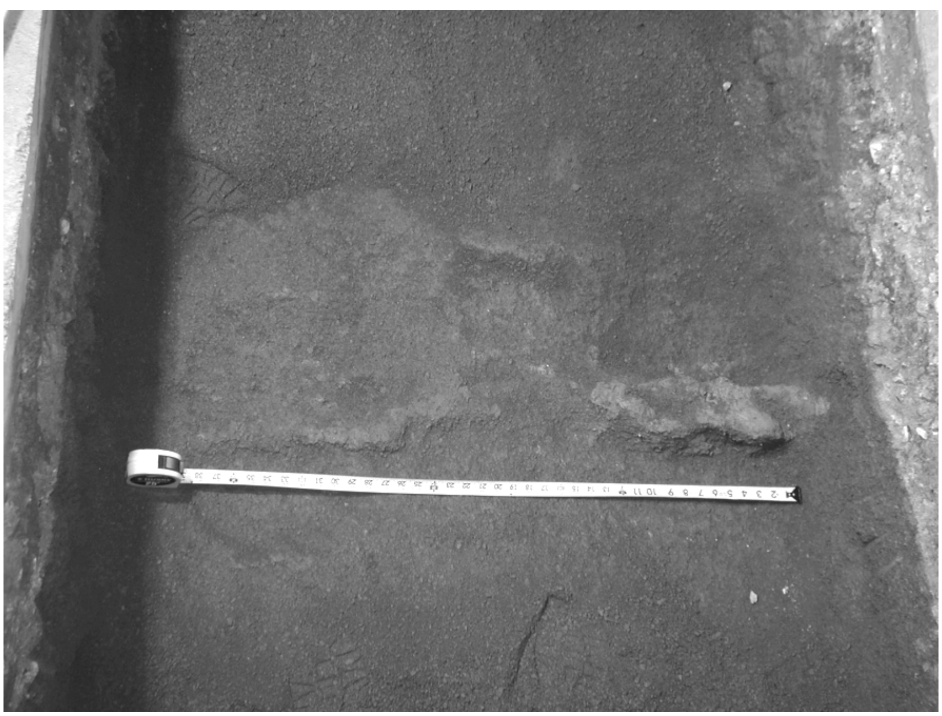

FIGURE 21. SUBGRADE PENETRATING INTO P-154 SUBBASE FOR THE ENTIRE TRENCH WIDTH ON THE SOUTH SIDE (FOUR-WHEEL TRAFFIC PATH)

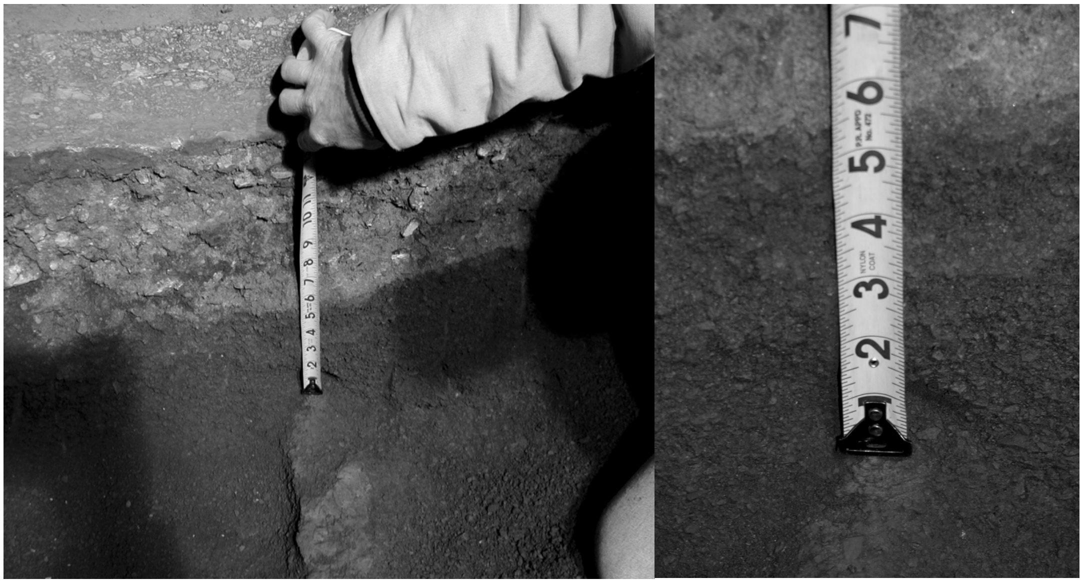

FIGURE 22. SUBGRADE PENETRATION INTO THE P-154 LAYER

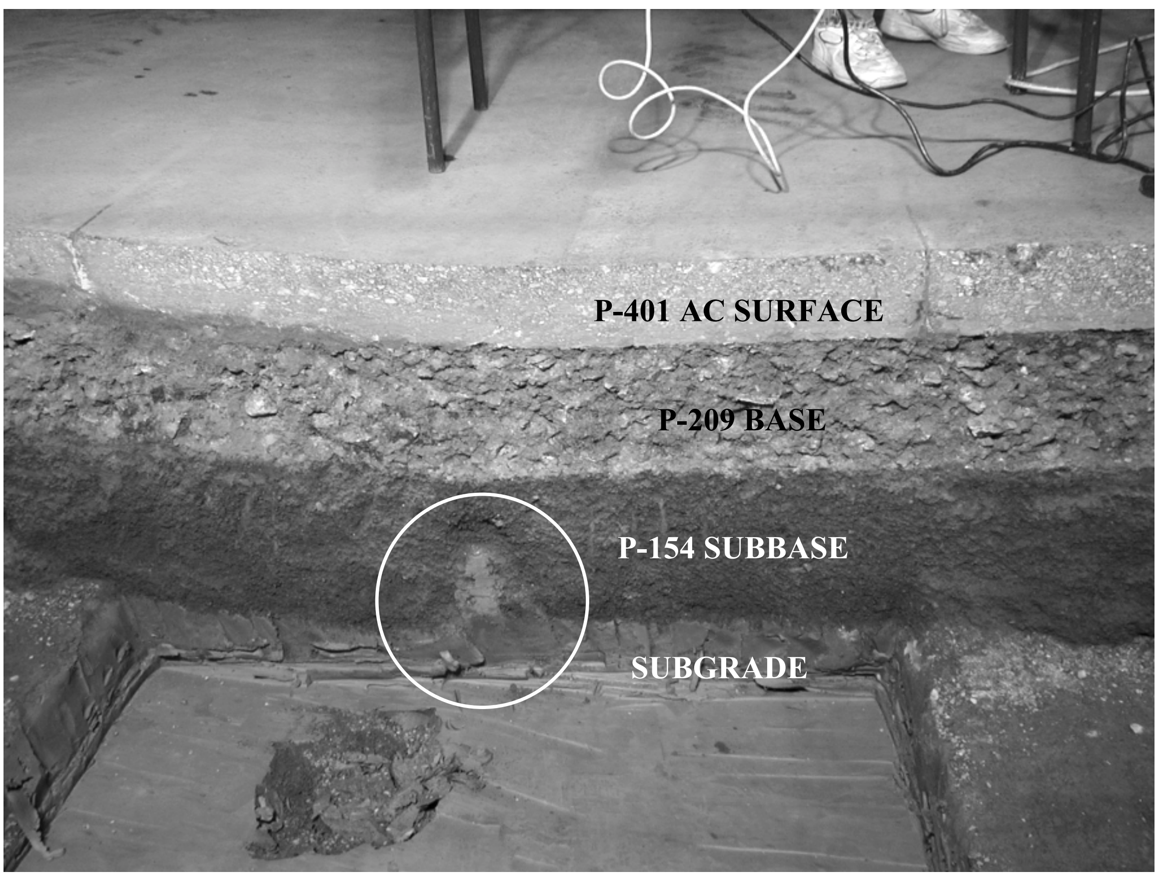

FIGURE 23. LATERAL MOVEMENT IN P-154 SUBBASE ORIGINATING AT THE SUBBASE/SUBGRADE INTERFACE IN FOUR-WHEEL TRAFFIC PATH

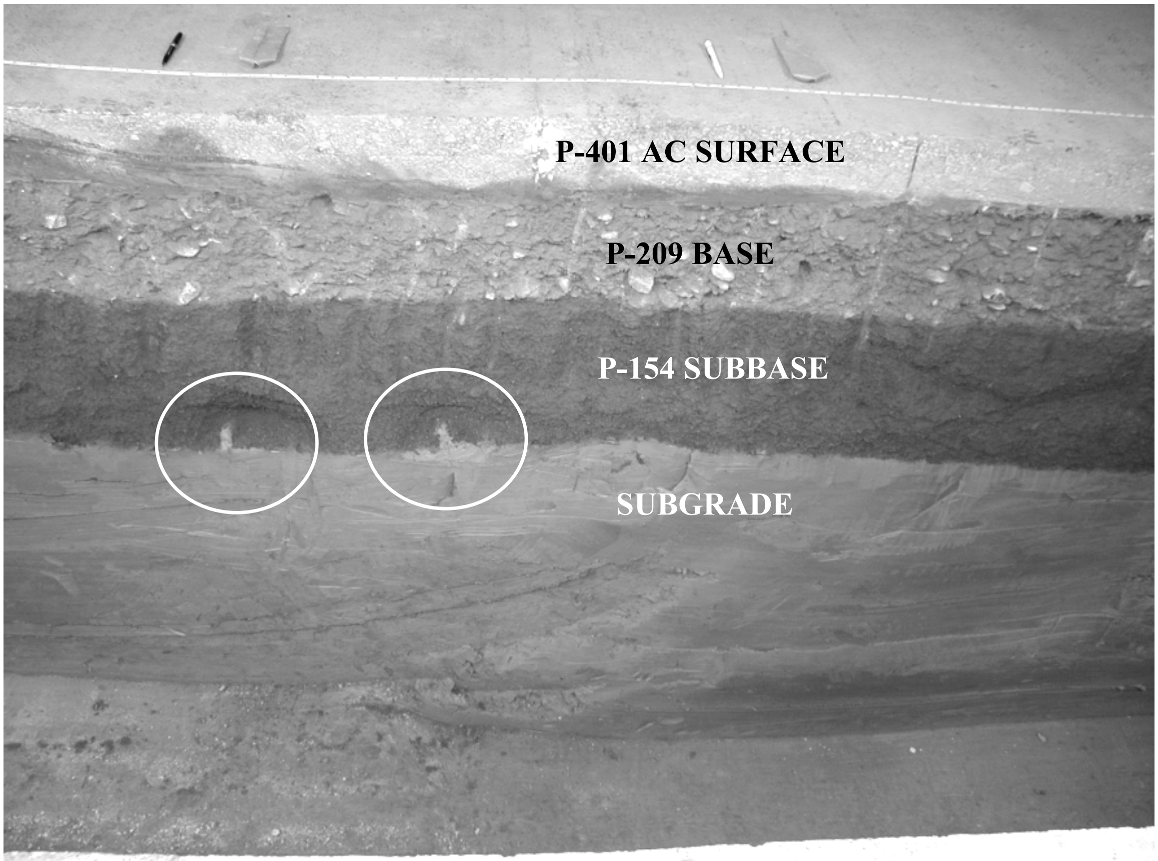

FIGURE 24. LATERAL MOVEMENT IN P-154 SUBBASE ORIGINATING AT THE SUBBASE/SUBGRADE INTERFACE IN SIX-WHEEL TRAFFIC PATH

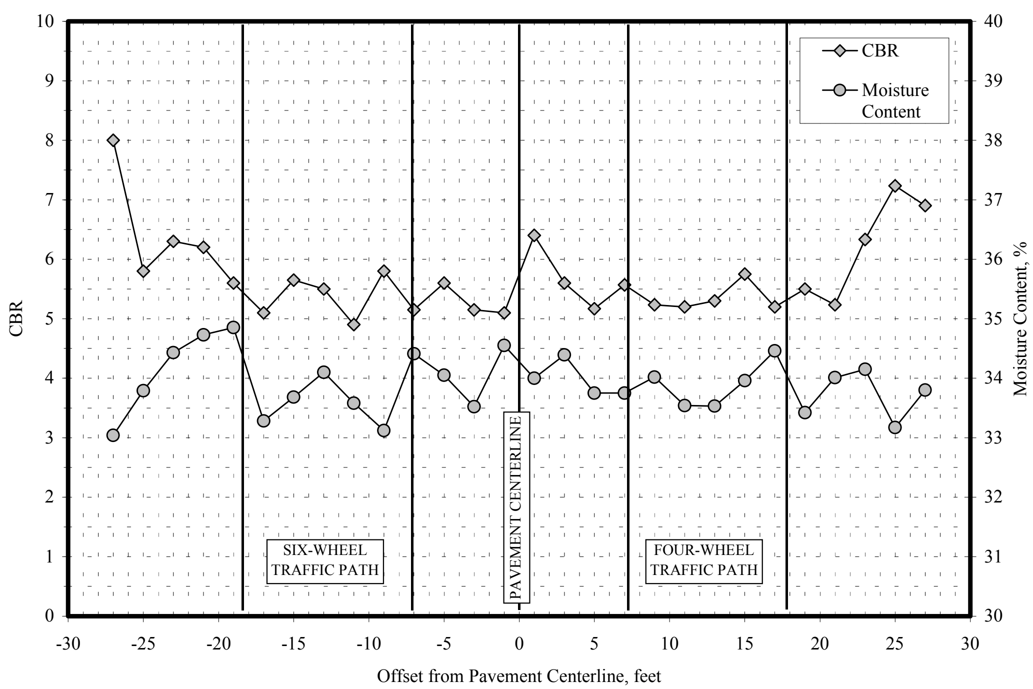

FIGURE 25. RESULTS FROM POSTTRAFFIC CBR TESTS ON SUBGRADE SURFACE

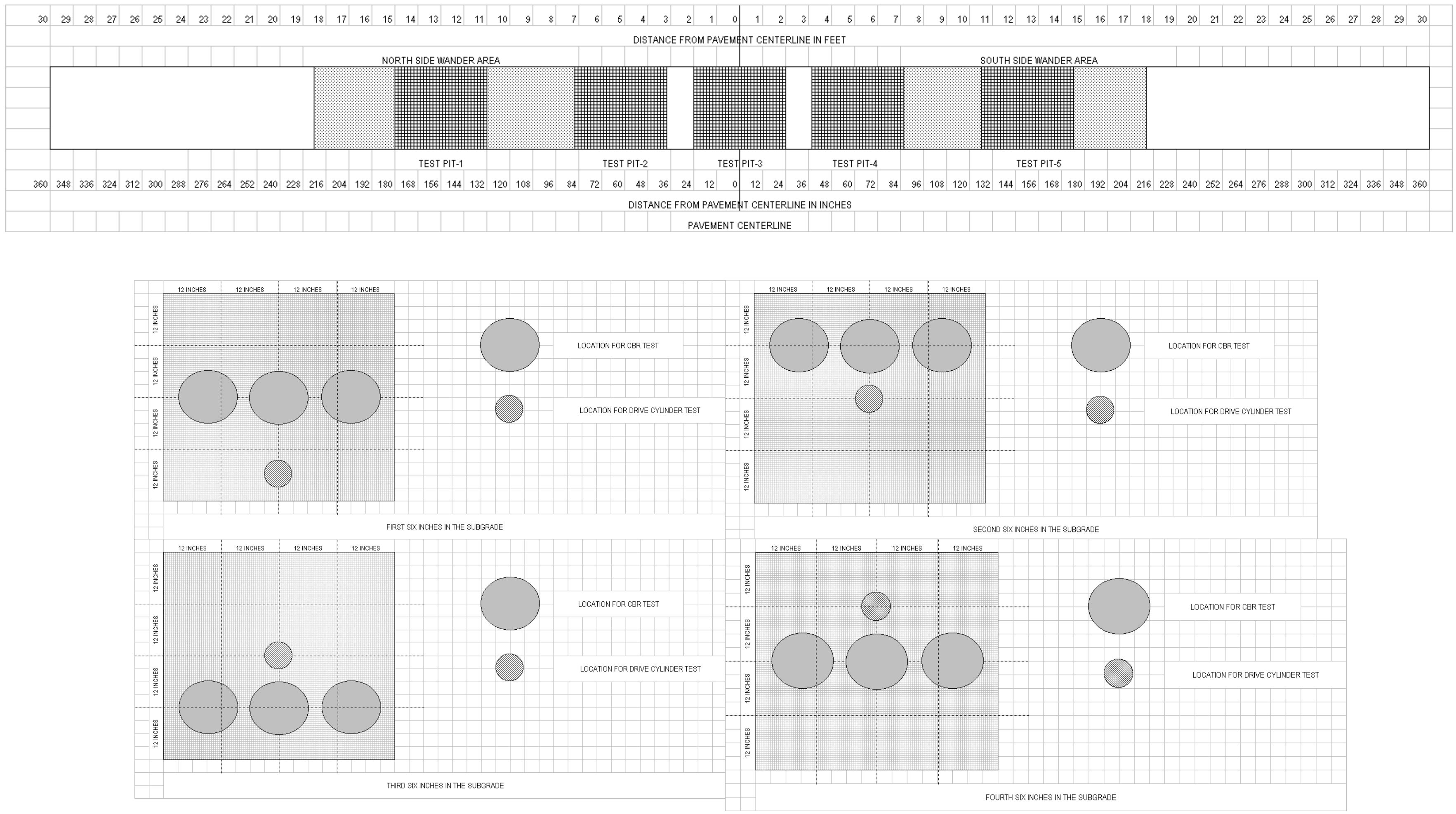

FIGURE 26. TEST PIT LOCATIONS AND TEST LOCATIONS WITHIN THE TEST PITS IN SUBGRADE

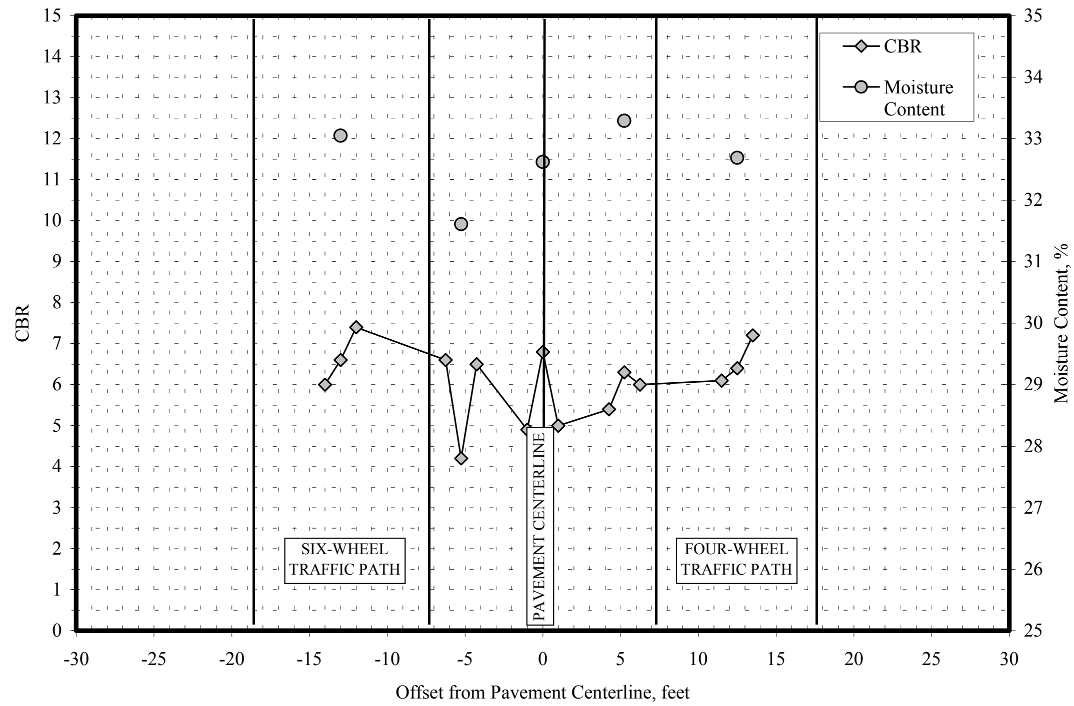

FIGURE 27. RESULTS FROM POSTTRAFFIC CBR TESTS AT A 6-inch DEPTH BELOW SUBGRADE SURFACE

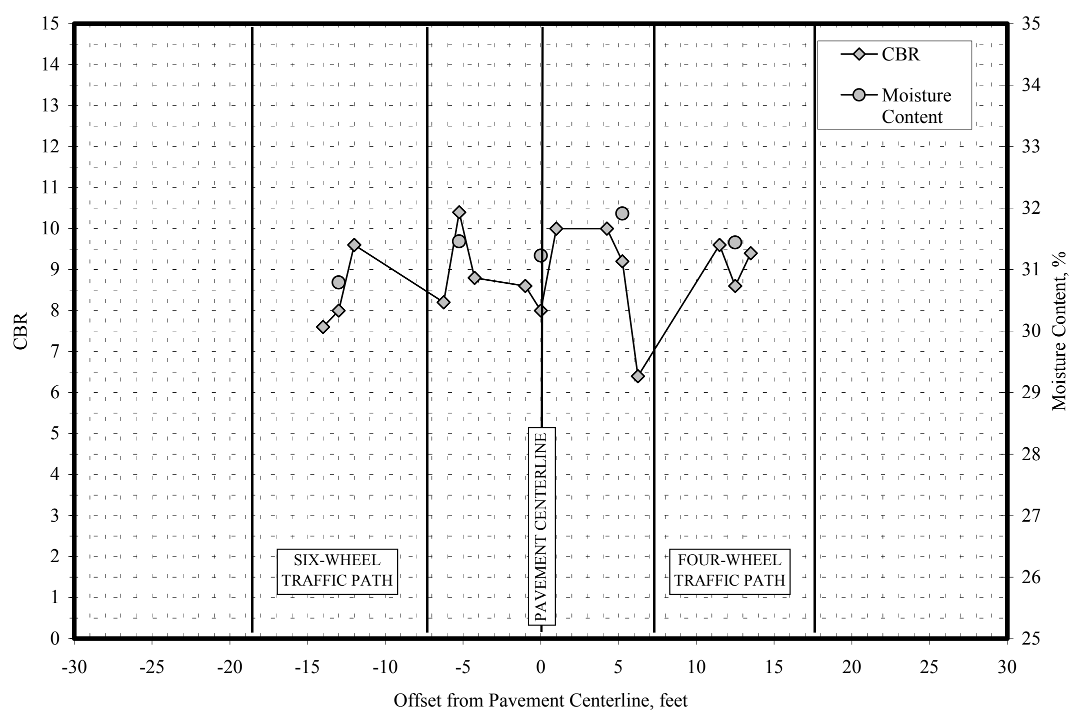

FIGURE 28. RESULTS FROM POSTTRAFFIC CBR TESTS AT A 12-inch DEPTH BELOW SUBGRADE SURFACE

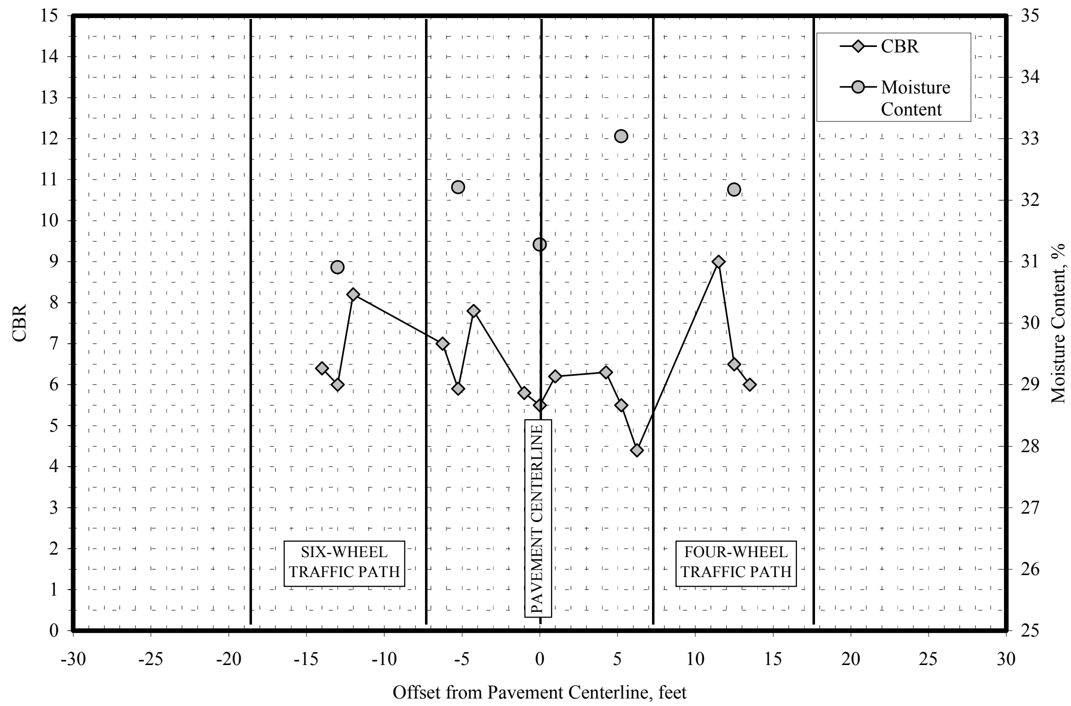

FIGURE 29. RESULTS FROM POSTTRAFFIC CBR TESTS AT AN 18-inch DEPTH BELOW SUBGRADE SURFACE

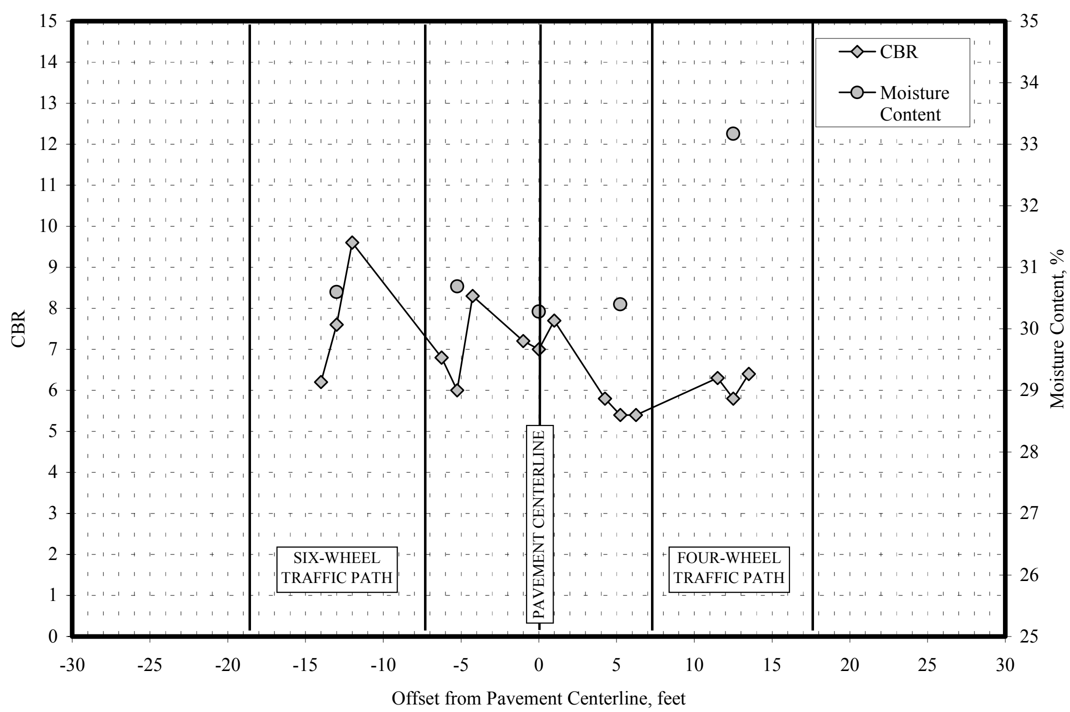

FIGURE 30. RESULTS FROM POSTTRAFFIC CBR TESTS AT A 24-inch DEPTH BELOW SUBGRADE SURFACE

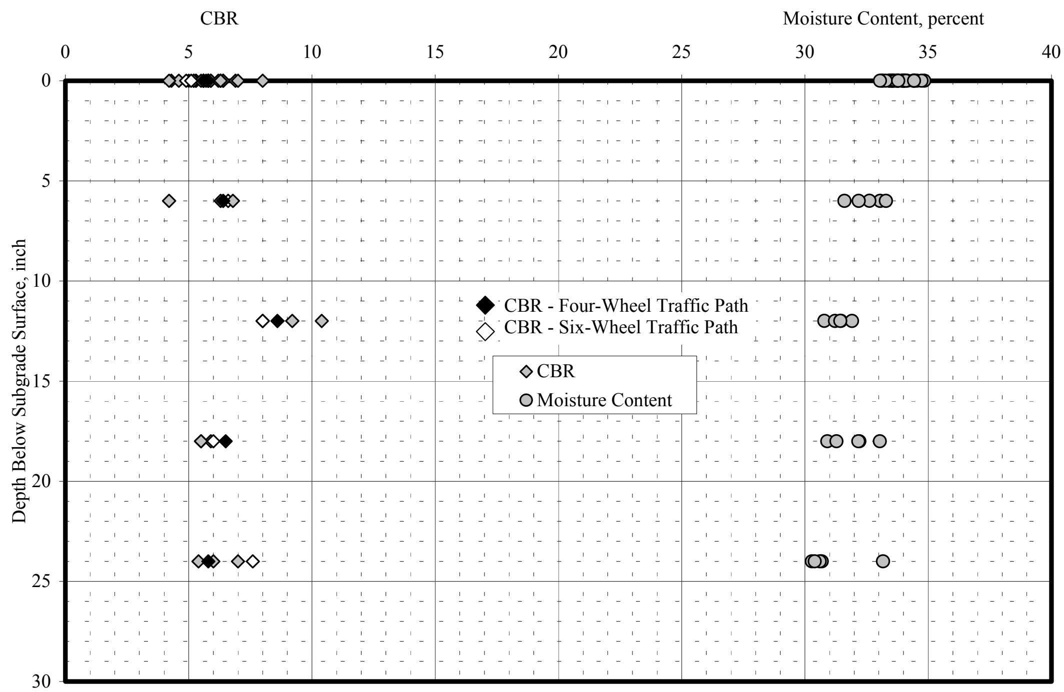

FIGURE 31. VARIATION IN SUBGRADE CBR AND MOISTURE CONTENT WITH DEPTH

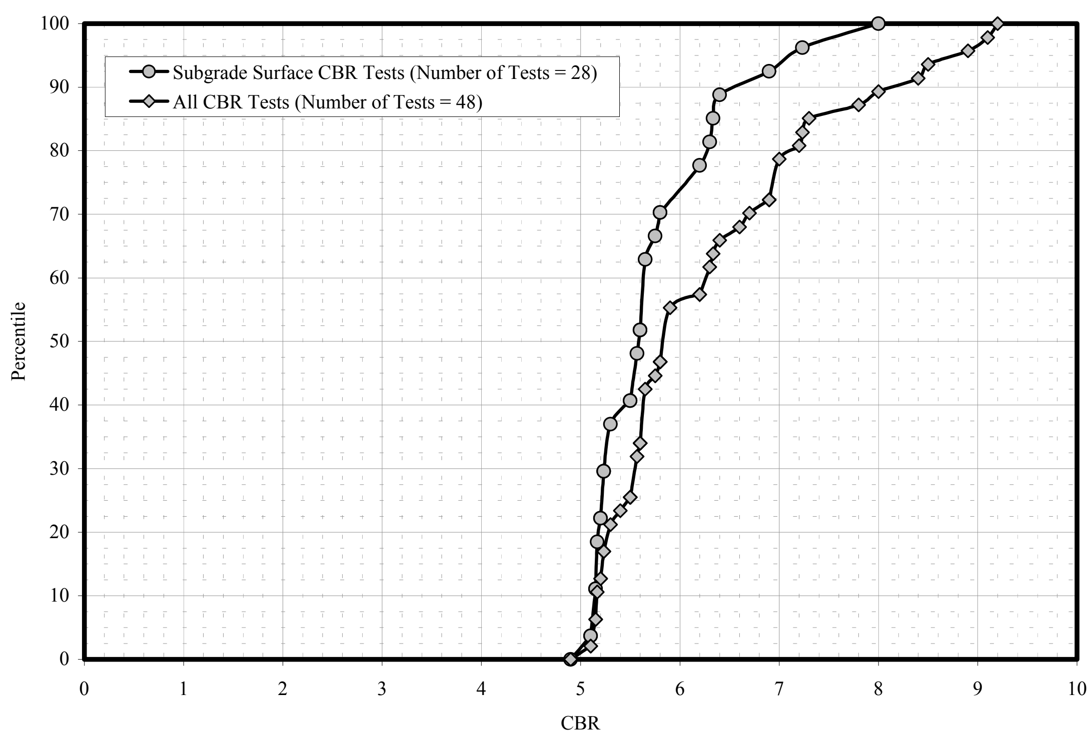

FIGURE 32. SUBGRADE CBR TEST RESULTS

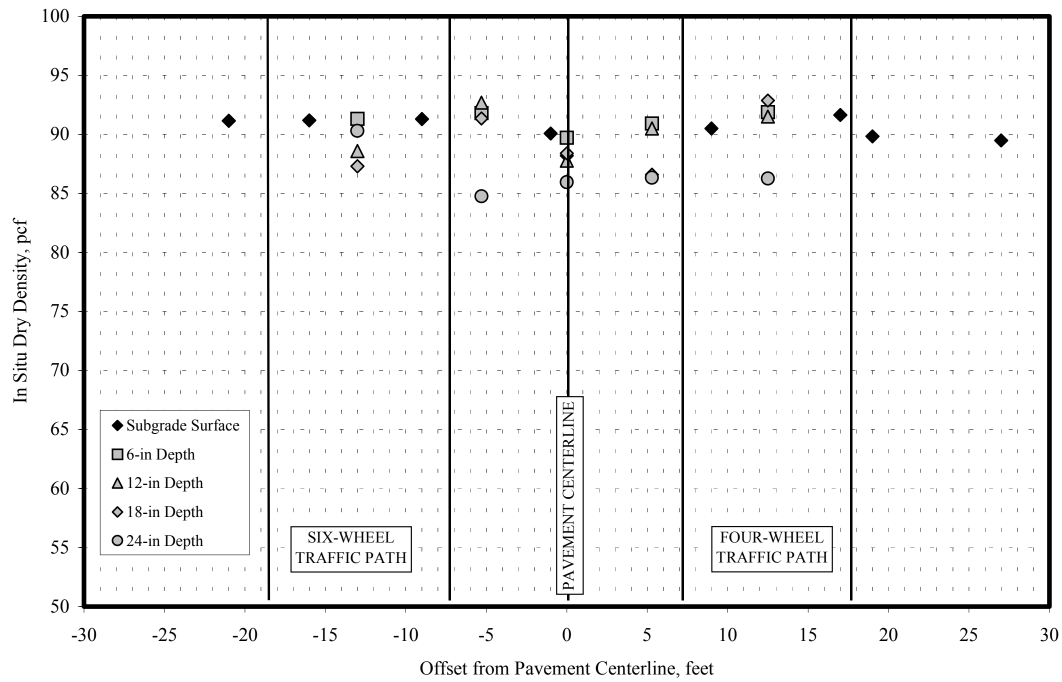

FIGURE 33. RESULTS FROM DRIVE CYLINDER DENSITY TESTS ON SUBGRADE

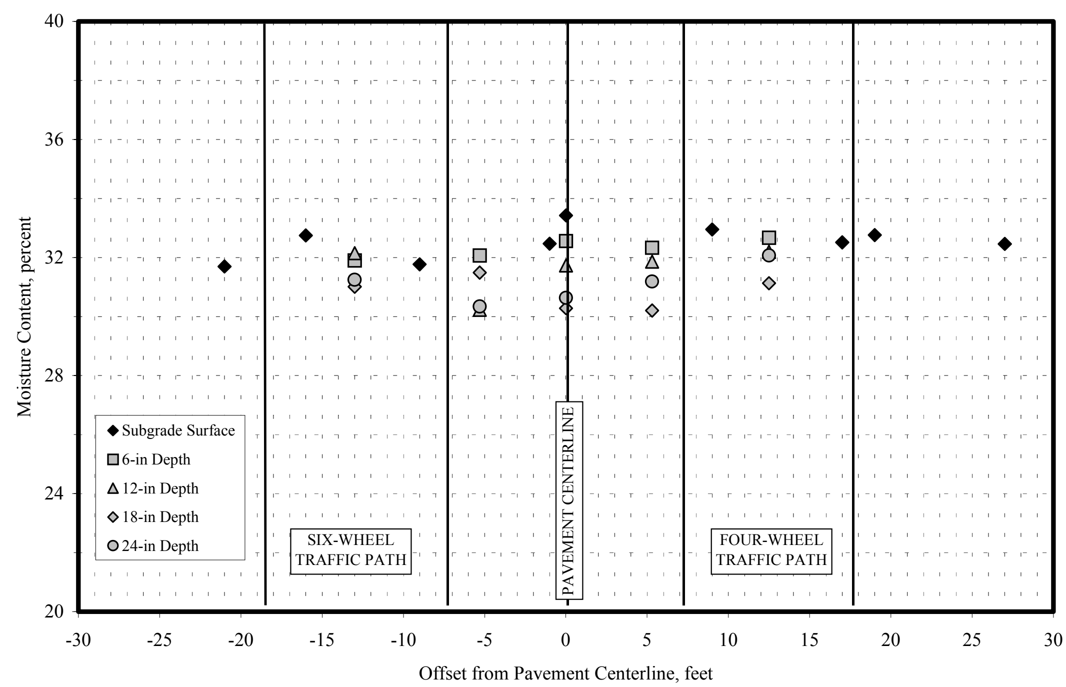

FIGURE 34. SUBGRADE MOISTURE CONTENT FROM POSTTRAFFIC DRY CYLINDER DENSITY TESTS

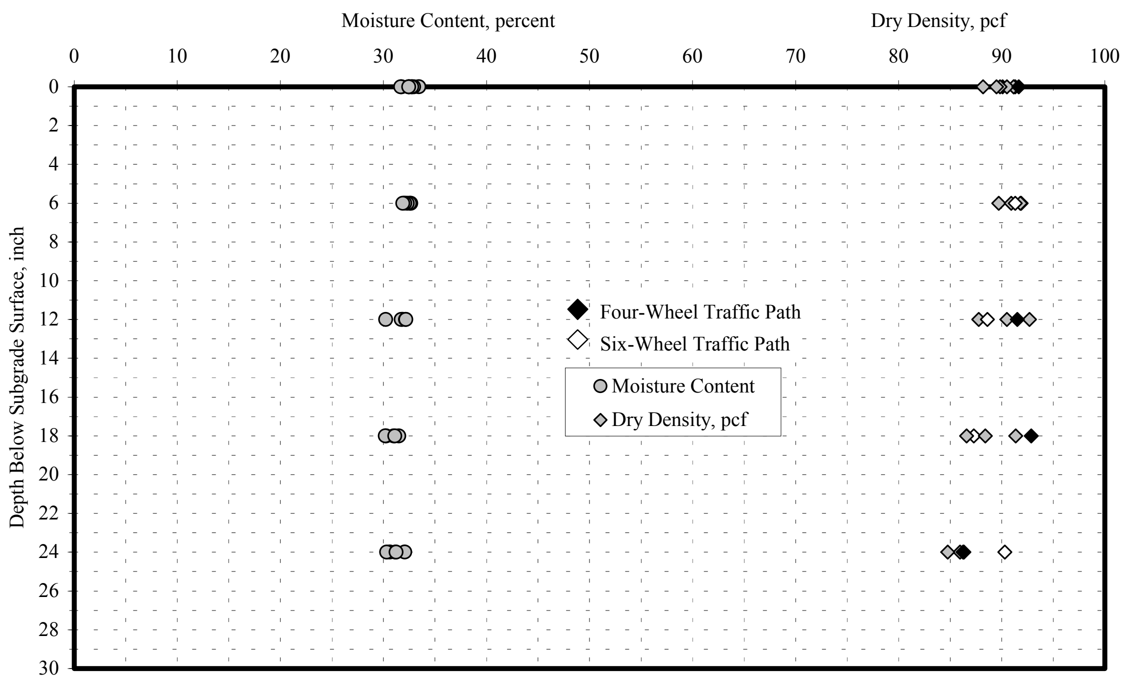

FIGURE 35. VARIATION IN SUBGRADE DRY DENSITY AND MOISTURE CONTENT WITH DEPTH

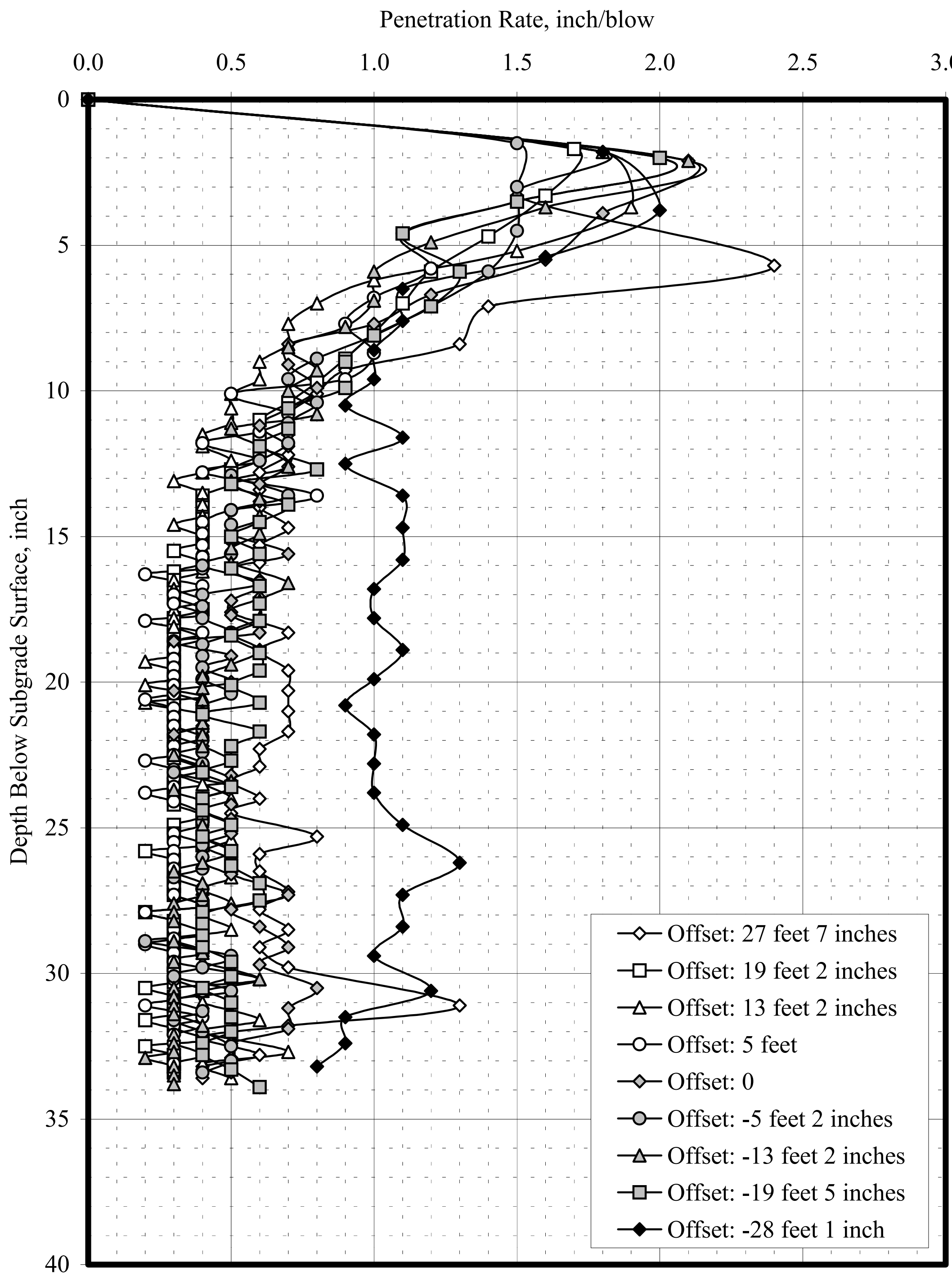

FIGURE 36. DCP TEST RESULTS AT SUBGRADE SURFACE

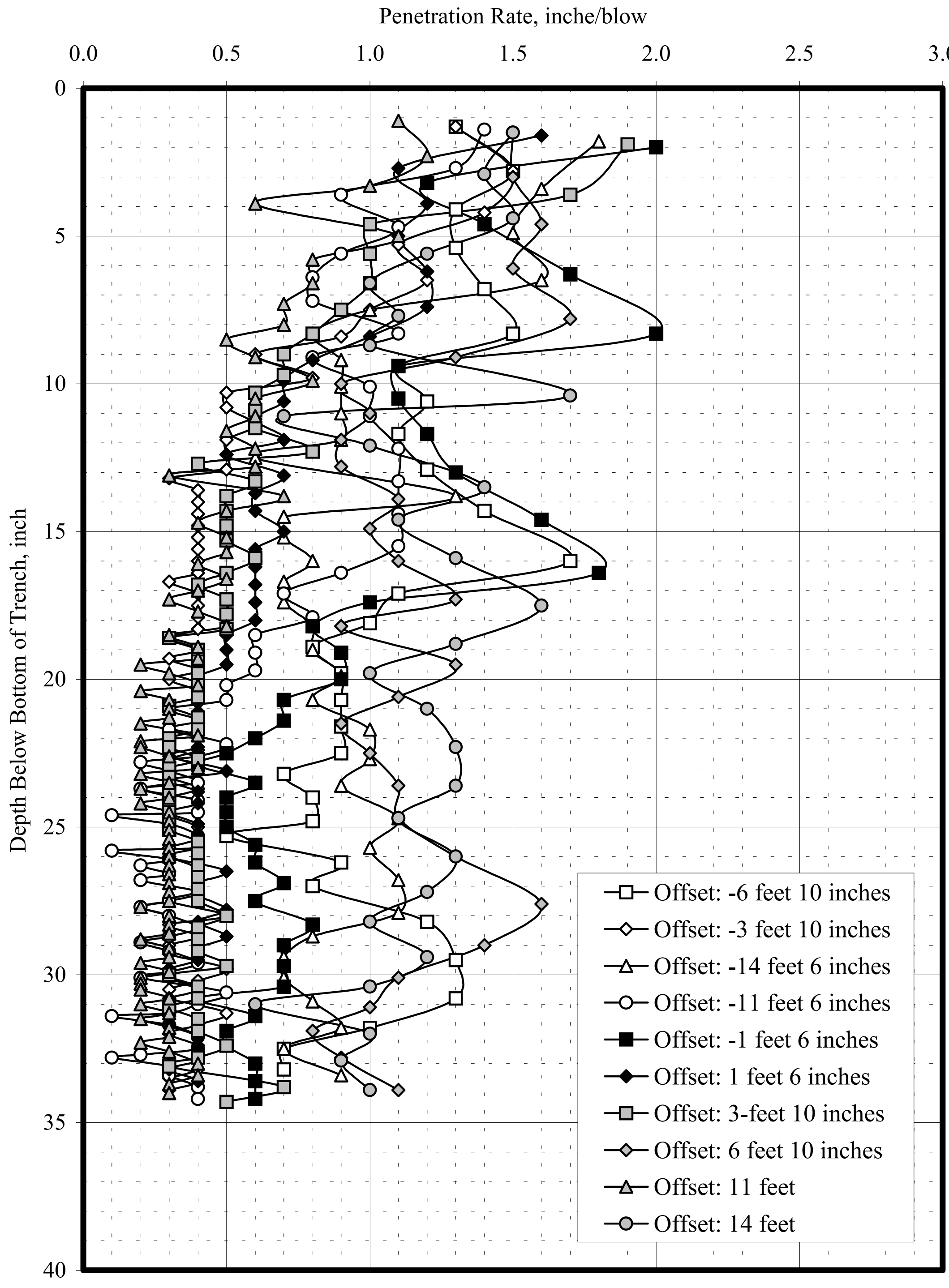

FIGURE 37. DCP TEST RESULTS AT THE 24-inch DEPTH BELOW THE SUBGRADE SURFACE

TABLE 1. EVENT SCHEDULE

Day	Date	Activity
1	01/24/01	Contractor removes HMA layer only.
2	01/25/01	FAA Testing: 5-12″ sand cone tests
3	01/26/01	Contractor excavates 5 test pits through P-209 layer.
4 5 6	01/29/01 01/30/01 01/31/01	FAA Testing: 15 CBR Tests; 5-6″ sand cone tests; 10 DCP tests
7	02/01/01	Contractor removes remainder of P-209 and P-154 layers.
8 9 10 11 12	02/02/01 02/05/01 02/06/01 02/07/01 02/08/01	FAA Testing: 58 CBR tests 17 Drive Cylinder tests 9 DCP tests
13	02/09/01	Contractor hand excavates five pits (first 6 inches). FAA Testing: 15 CBR tests 5 Drive Cylinder tests
14	02/12/01	Contractor hand excavates five pits (second 6 inches). FAA Testing: 15 CBR tests 5 Drive Cylinder tests
15	02/13/01	Contractor hand excavates five pits (third 6 inches). FAA Testing: 15 CBR tests 5 Drive Cylinder tests
16	02/14/01	Contractor hand excavates five pits (fourth 6 inches). FAA Testing: 15 CBR tests 5 Drive Cylinder tests

TABLE 2. P-401 CORE DETAILS

Core No.	Core ID	Core Location (feet) Station	Core Location (feet) Offset From CL	P-401 Thickness (inch)	Comments
1	N0	367'	-30'7"	5.6	Core intact; no cracks
2	N1	367'	-19'	5.3	Core intact; no cracks
3	N2	367'	-17'2.5"	5.1	Core intact; no cracks
4	N3	368'	-15'3"	5.0	Core intact; crack width-125 mils; crack depth-2.5 in; crack initiated from top
5	N4	367'	-14'1"	5.2	Core intact; crack width-40 mils; crack depth-0.5 in; crack initiated from top
6	N5	365'9"	-14'	5.0	Core intact; crack width-80 mils; crack depth-0.5 in; crack initiated from top
7	N6	367'	-13'0.5"	5.3	Core intact; no cracks
8	N7T	367'	-12'	5.6	Core separated; no cracks
8	N7B	367'	-12'		Core separated; no cracks
9	N8	367'	-10'9"	5.4	Core intact; crack width-40 mils; crack depth-0.5 in; crack initiated from top
10	N9T	367'	-9'	5.4	Core separated; hairline crack at top
10	N9B	367'	-9'		Core separated; no cracks
11	N10	367'	-5'9.5"	5.1	Core intact; no cracks
12	S1T	367'	17'11.5"	5.3	Core separated; no cracks
12	S1B	367'	17'11.5"		Core separated; no cracks
13	S2T	367'	16'1"	5.2	Core separated; no cracks
13	S2B	367'	16'1"		Core separated; no cracks
14	S3T	367'	13'11"	4.9	Core separated; no cracks
14	S3B	367'	13'11"		Core separated; no cracks
15	S4T	367'	12'	4.8	Core separated; no cracks
15	S4B	367'	12'		Core separated; cracked the entire depth of bottom lift
16	S5T	367'	9'10.5"	4.9	Core separated; no cracks
16	S5B	367'	9'10.5"		Core separated; no cracks
17	S6	367'	7'	5.2	Core separated; no cracks
18	S7	367'	4'11"	5.2	Core separated; no cracks
19	S0	367'	30'7"	5.6	Core separated; no cracks

1 foot = 0.3048 m; 1 inch = 25.4 mm

TABLE 3. SAND CONE DENSITY TEST RESULTS ON P-209 BASE

Test No.	Test Date	ASTM Standard	Offset from Centerline (feet)	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	1/25/01	D 1556-90	-22.3	157.30	2.85	152.9	98.7
2	1/25/01		-13.0	161.40	2.19	158.0	102.0
3	1/25/01		0.0	159.00	2.58	155.0	100.1
4	1/25/01		12.3	157.70	2.69	153.5	101.8
5	1/25/01		22.3	156.90	2.77	152.7	98.6

1 feet = 0.3048 m; 1 pcf = 16.01846 kg/m^3

TABLE 4. POSTTRAFFIC CBR TEST RESULTS ON P-154 SUBBASE

Test No.	Date	Test ID	Y (feet)	Z (inch)	Offset* (inch)	ASTM Standard	CBR	Moisture Content (%)
1	1/30/01	T1P1S2	26.0	13.0	36.0	D 4429	20	4.35
2	1/30/01	T1P2S2	26.0	13.0	24.0		21	
3	1/30/01	T1P3S2	26.0	13.0	12.0		23	
4	1/30/01	T2P1S1	12.5	13.0	36.0		61	4.18
5	1/30/01	T2P2S1	12.5	13.0	22.0		67	
6	1/30/01	T2P3S1	12.5	13.0	12.0		73	
7	1/30/01	T3P1CL	0.0	13.0	36.5		85	4.41
8	1/30/01	T3P2CL	0.0	13.0	24.0		61	
9	1/30/01	T3P2CL	0.0	13.0	13.0		70	
10	1/30/01	T4P1N1	-12.5	13.0	38.0		91	3.78
11	1/30/01	T4P2N1	-12.5	13.0	24.0		97	
12	1/30/01	T4P3N1	-12.5	13.0	14.0		98	
13	1/30/01	T5P1N2	-26.0	13.0	35.0		23	5.00
14	1/30/01	T5P2N2	-26.0	13.0	24.0		24	
15	1/30/01	T5P3N2	-26.0	13.0	11.0		26	

* Offset is from the east face of trench (in inches)
1 foot = 0.3048 m; 1 inch = 25.4 mm

TABLE 5. SAND CONE DENSITY TEST RESULTS ON P-154 SUBBASE

Test No.	Test Date	ASTM Standard	Offset from Centerline (feet)	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	1/31/01	D 1556-90	26.25	126.20	4.21	121.1	94.4
2	1/31/01		11.50	127.30	3.83	122.6	95.6
3	1/31/01		0.00	122.90	4.4	117.8	91.8
4	1/31/01		-12.75	123.20	3.79	118.7	92.5
5	1/31/01		-25.33	141.30	4.65	135.1	105.3

1 foot = 0.3048 m; 1 pcf = 16.01846 kg/m^3

TABLE 6. POSTTRAFFIC CBR TEST RESULTS ON THE SUBGRADE SURFACE

Test No.	Depth From Pavement Surface (inch)	Offset From CL (feet)	Moisture Content (%) Offset From East Face of Trench			CBR Offset From East Face of Trench			CBR Mean	CBR Std. Dev.	CBR COV (%)
			12″	24″	36″	12″	24″	36″			
1	26.0	27		33.80			6.9	6.9	6.9	0.00	0.0
2	26.0	25		33.17		7.2	7.0	7.5	7.2	0.25	3.5
3	25.0	23		34.15		7.1	6.3	5.6	6.3	0.75	11.9
4	25.5	21		34.01		5.6	6.4	3.7	5.2	1.39	26.5
5	25.0	19	33.42	33.42	33.92	4.3	5.8	6.4	5.5	1.08	19.7
6	25.0	17		34.46	33.59	4.1	5.8	5.7	5.2	0.95	18.3
7	24.5	15			33.96	5.6		5.9	5.8	0.21	3.7
8	24.0	13		33.53		5.1	5.3	5.5	5.3	0.20	3.8
9	25.0	11		33.54		5.0	5.6	5.0	5.2	0.35	6.7
10	26.0	9	34.02			4.4	5.0	6.3	5.2	0.97	18.6
11	26.0	7		33.75		5.9	5.6	5.2	5.6	0.35	6.3
12	26.0	5		33.75		5.3	4.6	5.6	5.2	0.51	9.9
13	27.0	3		34.39		6.2	5.2	5.4	5.6	0.53	9.4
14	27.0	1	34.00				6.3	6.5	6.4	0.14	2.2
15	26.5	-1		34.55			4.2	6.0	5.1	1.27	25.0
16	25.5	-3		33.52			5.3	5.0	5.2	0.21	4.1
17	25.0	-5		34.05			5.6	5.6	5.6	0.00	0.0
18	26.0	-7		34.41			5.2	5.1	5.2	0.07	1.4
19	25.0	-9		33.12			5.8		5.8		
20	24.5	-11		33.58			4.9		4.9		
21	25.0	-13		34.10			5.5		5.5		
22	24.5	-15		33.68		5.4	5.9		5.7	0.35	6.3
23	25.0	-17		33.28			5.1		5.1		
24	26.0	-19		34.85			5.6		5.6		
25	26.0	-21		34.73			6.2		6.2		
26	26.0	-23		34.43			6.3		6.3		
27	26.0	-25		33.79			5.8		5.8		
28	27.5	-27		33.04			8.0		8.0		

1 foot = 0.3048 m; 1 inch = 25.4 mm

SUMMARY: SUBGRADE SURFACE

Moisture Content
Minimum: 33.04
Maximum: 34.85
Overall Mean: 33.87
Overall Standard Deviation: 0.47
Overall Coefficient of Variation (%): 1.40

CBR
Minimum: 3.7
Maximum: 8.0
Overall Mean: 5.7
Overall Standard Deviation: 0.84
Overall Coefficient of Variation (%): 14.8

TABLE 7. POSTTRAFFIC CBR TEST RESULTS AT A 6-inch DEPTH BELOW THE SUBGRADE SURFACE

Test No.	Test ID	Depth From Pavement Surface (inch)	Offset From CL (feet)	CBR	Moisture Content (%)
1	S2-T1	29.75	13.5	7.2	
2	S2-T2	29.25	12.5	6.4	32.19
3	S2-T3	29.75	11.5	6.1	
4	S1-T1	32.00	6.3	6.0	
5	S1-T2	32.00	5.3	6.3	33.29
6	S1-T3	32.00	4.3	5.4	
7	CL-T1	31.00	1.0	5.0	
8	CL-T2	31.00	0.0	6.8	32.62
9	CL-T3	31.00	-1.0	4.9	
10	N1-T1	31.00	-4.3	6.5	
11	N1-T2	31.50	-5.3	4.2	31.61
12	N1-T3	31.25	-6.3	6.6	
13	N2-T1	30.00	-12.0	7.4	
14	N2-T2	29.50	-13.0	6.6	33.05
15	N2-T3	29.50	-14.0	6.0	

1 foot = 0.3048 m; 1 inch = 25.4 mm

SUMMARY: 6 inches BELOW SUBGRADE SURFACE

Moisture Content
Minimum: 31.61
Maximum: 33.29
Overall Mean: 32.55
Overall Standard Deviation: 0.67
Overall Coefficient of Variation (%): 2.07

CBR
Minimum: 4.2
Maximum: 7.4
Overall Mean: 6.1
Overall Standard Deviation: 0.88
Overall Coefficient of Variation (%): 14.5

TABLE 8. POSTTRAFFIC CBR TEST RESULTS AT A 12-inch DEPTH BELOW THE SUBGRADE SURFACE

Test No.	Test ID	Depth From Pavement Surface (inch)	Offset From CL (feet)	CBR	Moisture Content (%)
1	S2-T1	35.50	13.5	9.4	
2	S2-T2	35.50	12.5	8.6	31.44
3	S2-T3	35.50	11.5	9.6	
4	S1-T1	39.00	6.3	6.4	
5	S1-T2	38.50	5.3	9.2	31.91
6	S1-T3	38.50	4.3	10.0	
7	CL-T1	38.00	1.0	10.0	
8	CL-T2	37.75	0.0	8.0	31.23
9	CL-T3	38.00	-1.0	8.6	
10	N1-T1	37.00	-4.3	8.8	
11	N1-T2	37.00	-5.3	10.4	31.46
12	N1-T3	37.00	-6.3	8.2	
13	N2-T1	36.00	-12.0	9.6	
14	N2-T2	36.00	-13.0	8.0	30.79
15	N2-T3	36.75	-14.0	7.6	

1 foot = 0.3048 m; 1 inch = 25.4 mm

SUMMARY: 12 inches BELOW SUBGRADE SURFACE

Moisture Content	CBR
Minimum: 30.79	Minimum: 6.4
Maximum: 31.91	Maximum: 10.4
Overall Mean: 31.37	Overall Mean: 8.8
Overall Standard Deviation: 0.41	Overall Standard Deviation: 1.07
Overall Coefficient of Variation (%): 1.30	Overall Coefficient of Variation (%): 12.20

TABLE 9. POSTTRAFFIC CBR TEST RESULTS AT AN 18-inch DEPTH BELOW THE SUBGRADE SURFACE

Test No.	Test ID	Depth From Pavement Surface (inch)	Offset From CL (feet)	CBR	Moisture Content (%)
1	S2-T1	42.25	13.5	6.0	
2	S2-T2	41.25	12.5	6.5	32.17
3	S2-T3	42.50	11.5	9.0	
4	S1-T1	45.25	6.3	4.4	
5	S1-T2	44.75	5.3	5.5	33.04
6	S1-T3	44.50	4.3	6.3	
7	CL-T1	44.25	1.0	6.2	
8	CL-T2	42.00	0.0	5.5	31.28
9	CL-T3	42.00	-1.0	5.8	
10	N1-T1	43.00	-4.3	7.8	
11	N1-T2	43.00	-5.3	5.9	32.21
12	N1-T3	43.50	-6.3	7.0	
13	N2-T1	42.00	-12.0	8.2	
14	N2-T2	42.00	-13.0	6.0	30.91
15	N2-T3	43.00	-14.0	6.4	

1 foot = 0.3048 m; 1 inch = 25.4 mm

SUMMARY: 18 inches BELOW SUBGRADE SURFACE

Moisture Content	CBR
Minimum: 30.91	Minimum: 4.4
Maximum: 33.04	Maximum: 9.0
Overall Mean: 31.92	Overall Mean: 6.4
Overall Standard Deviation: 0.84	Overall Standard Deviation: 1.16
Overall Coefficient of Variation (%): 2.63	Overall Coefficient of Variation (%): 18.10

TABLE 10. POSTTRAFFIC CBR TEST RESULTS AT A 24-inch DEPTH BELOW THE SUBGRADE SURFACE

Test No.	Test ID	Depth From Pavement Surface (inch)	Offset From CL (feet)	CBR	Moisture Content (%)
1	S2-T1	49.50	13.5	6.4	
2	S2-T2	49.00	12.5	5.8	33.17
3	S2-T3	49.50	11.5	6.3	
4	S1-T1	52.00	6.3	5.4	
5	S1-T2	52.00	5.3	5.4	30.40
6	S1-T3	51.25	4.3	5.8	
7	CL-T1	51.00	1.0	7.7	
8	CL-T2	50.75	0.0	7.0	30.28
9	CL-T3	50.75	-1.0	7.2	
10	N1-T1	49.75	-4.3	8.3	
11	N1-T2	49.00	-5.3	6.0	30.69
12	N1-T3	49.75	-6.3	6.8	
13	N2-T1	49.00	-12.0	9.6	
14	N2-T2	49.25	-13.0	7.6	30.60
15	N2-T3	49.00	-14.0	6.2	

1 foot = 0.3048 m; 1 inch = 25.4 mm

SUMMARY: 24 inches BELOW SUBGRADE SURFACE

Moisture Content	CBR
Minimum: 30.28	Minimum: 5.4
Maximum: 33.17	Maximum: 9.6
Overall Mean: 31.03	Overall Mean: 6.8
Overall Standard Deviation: 1.21	Overall Standard Deviation: 1.17
Overall Coefficient of Variation (%): 3.90	Overall Coefficient of Variation (%): 17.20

TABLE 11. POSTTRAFFIC DRIVE CYLINDER TEST RESULTS ON THE SUBGRADE

Test No.	Test Date	Offset From Centerline (feet)	Depth From Subgrade Surface (inch)	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction	Summary Dry Density	
1	2/8/01	-1.0	0.0	119.33	32.47	90.08	77.39	Minimum	88.2
2	2/8/01	-9.0	0.0	120.32	31.77	91.31	78.45	Maximum	91.6
3	2/8/01	-16.0	0.0	121.04	32.75	91.18	78.34	Mean	90.4
4	2/8/01	-21.0	0.0	120.05	31.70	91.16	78.32	Std. Dev.	1.10
5	2/8/01	0.0	0.0	117.68	33.43	88.19	75.78	COV, %	1.2
6	2/8/01	9.0	0.0	120.32	32.95	90.50	77.75		
7	2/8/01	17.0	0.0	121.44	32.51	91.65	78.74		
8	2/8/01	19.0	0.0	119.26	32.76	89.83	77.18		
9	2/8/01	27.0	0.0	118.54	32.46	89.49	76.89		
10	2/9/01	12.5	6	121.90	32.67	91.88	78.94	Minimum	89.7
11	2/9/01	0.0	6	118.93	32.56	89.72	77.09	Maximum	91.9
12	2/9/01	5.3	6	120.32	32.33	90.92	78.12	Mean	91.1
13	2/9/01	-5.3	6	121.24	32.07	91.80	78.87	Std. Dev.	0.88
14	2/12/01	-13.0	6	120.45	31.90	91.32	78.46	COV, %	1.0
15	2/12/01	5.3	12	119.33	31.86	90.50	77.75	Minimum	87.8
16	2/12/01	0.0	12	115.63	31.73	87.78	75.42	Maximum	92.7
17	2/12/01	-5.3	12	120.71	30.23	92.69	79.64	Mean	90.2
18	2/13/01	-13.0	12	117.08	32.15	88.60	76.12	Std. Dev.	2.03
19	2/13/01	12.5	12	120.98	32.19	91.52	78.63	COV, %	2.2
20	2/13/01	-13.0	18	114.38	31.01	87.30	75.01	Minimum	86.6
21	2/13/01	0.0	18	115.17	30.28	88.40	75.95	Maximum	92.9
22	2/13/01	-5.3	18	120.12	31.49	91.35	78.49	Mean	89.3
23	2/13/01	5.3	18	112.73	30.20	86.58	74.39	Std. Dev.	2.70
24	2/13/01	12.5	18	121.77	31.13	92.86	79.79	COV, %	3.0
25	2/14/01	0.0	24	112.27	30.63	85.94	73.84	Minimum	84.8
26	2/14/01	5.3	24	113.26	31.19	86.33	74.17	Maximum	90.3
27	2/14/01	12.5	24	113.92	32.07	86.25	74.11	Mean	86.7
28	2/14/01	-5.3	24	110.48	30.34	84.77	72.83	Std. Dev.	2.10
29	2/14/01	-13.0	24	118.54	31.25	90.31	77.60	COV, %	2.4
			Minimum	110.5	30.2	84.8	72.8		
			Maximum	121.9	33.4	92.9	79.8		
			Mean	118.2	31.8	89.7	77.0		
			Std. Dev.	3.26	0.89	2.21	1.90		
			COV, %	2.8	2.8	2.5	2.5		

1 foot = 0.3048 m; 1 inch = 25.4 mm; 1 pcf = 16.01846 kg/m^3