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Bureau of Materials and Physical Research

INTERIM REPORT

HIGHWAY INSULATING MATERIAL EVALUATION

Project IHD-8

By

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A Product Evaluation Project by
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in cooperation with
U.S. Department of Transportation
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16. Abstract

This report describes background data, laboratory and field test programs, experimental design, testing procedures, and findings of an earlier trial installation and a full scale experimental project in the use of All-weather Crete HI-45 as a highway insulating material. Several thicknesses and compaction densities of AWC were used under a bituminous concrete pavement and a portland cement concrete pavement.

Preliminary findings indicated that four inches of AWC compacted to 24 pounds per cubic foot is effective in controlling penetration of freezing subsurface temperatures and frost action in the subgrade under a 10-inch PCC pavement in northern Illinois. Other thicknesses and compaction densities of AWC tried in this study were ineffective after two years of observation.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

HIGHWAY INSULATING MATERIAL EVALUATION

INTRODUCTION

Purpose

The general concept of the frost action phenomenon in soil is well established and understood. This phenomenon which occurs in certain types of soil is the result of the movement of soil moisture to form ice lenses in the presence of freezing temperature. In essence, three conditions must exist simultaneously at a site for frost-heaving to occur: (1) frost susceptible soil must be present, (2) freezing temperatures must penetrate into the soil, and (3) a water source must be available.

Earlier methods used to control frost action in the subgrade were to replace frost-susceptible soil with a non-frost-susceptible one, provide adequate subsurface drainage systems, and/or lower the elevation of the ground water table. Sometimes these methods may prove uneconomical due to additional excavation and long haul to obtain good backfill material.

This field study is concerned with the evaluation of an insulating material used extensively for roof decks and parking ramps. The material is commercially known as All-weather Crete HI-45. AWC was recommended by the manufacturer Silbrico Corporation, Hodgkins, Illinois, to serve the structural function of a pavement subbase as well as an insulation for the subgrade.

The Silbrico Corporation describes AWC as a thermo-setting insulating fill consisting primarily of a hot bituminous mixture of expanded perlite (volcanic glass) and a roofing grade asphalt. It claims that AWC placed beneath a pavement structure can prevent frost penetration and weakening of the underlying subgrade soil. In addition to its thermal efficiency, AWC is claimed strong enough to withstand construction traffic when applied over a stable subgrade.

The objectives of this experimental study are to evaluate the effectiveness of AWC as a highway insulating material to control frost penetration and to determine what effects the inclusion of AWC in the pavement structure has on pavement performance.

Preliminary Evaluation

In 1968 the Illinois Division of Highways (now Department of Transportation), constructed an experimental insulated pavement using expanded polystyrene plastic foam under a 10-inch nonreinforced PCC pavement to control frost penetration in the subgrade. After three years of monitoring thermocouple readings and recording variations of surface elevations, the result of the study indicated that the 1 1/2-inch plastic foam is effective in preventing freezing temperatures from penetrating the subgrade.

The success in using insulation to control frost action in the subgrade prompted the Division of Highways to investigate and evaluate "All-weather Crete HI-45," which has not only good insulating properties but also considerable structural strength. This material has been used extensively in the building industry for some time. The estimated cost of AWC insulation treatments is approximately equal to polystyrene plastic foam insulation treatments and more economical than the conventional method of excavating and replacing frost-susceptible soil with granular material overlayed with four inches of bituminous aggregate mixture (BAM) subbase. Although the AWC mixture requires about double the amount of asphalt binder that BAM does, net savings are realized by the elimination of the need for removal of the frost-susceptible soil and replacement with granular material.

The possible problem of local frost or ice formation on insulated pavements due to differential pavement surface temperatures is of some concern; however, it was not investigated as part of this study other than to monitor reports of pavement conditions and reports of accidents. To date there have not been any reports of frost or ice on the experimental pavement or of accidents that might be attributable to such conditions. Also, there have not been any reported incidents of local frost or ice or of accidents that might be attributed to such conditions on the earlier expanded polystyrene project.

In December 1969, the manufacturer of AWC, with the cooperation of the Division's research engineers, constructed a short trial installation in their company compound in Hodgkins, just west of Chicago. The installation consisted of three test sections of AWC and one control section having no insulation under a three-inch bituminous concrete pavement. Early results from this study indicated that with proper design consideration for thickness and density, AWC can be used to control penetration of freezing temperature in the subgrade. "Trial installation" as used in this report refers to this construction by the Silbrico Corp. on Silbrico Corp. property.

In October 1970, the Division of Highways constructed a fully instrumented AWC experimental project on two lanes of the major four-lane State highway (Illinois 43-Harlem Avenue) in Tinley Park just southwest of Chicago. The project includes five AWC test sections of different thicknesses and densities and two control sections under a 10-inch standard reinforced PCC pavement. After two fall-winter-spring seasons of observations and monitoring instrument readings, the data indicate that AWC can be designed to provide the thermal insulation requirement to control frost action in the subgrade and thus prevent the dangerous, and structurally damaging, uneven heaving of the pavement. "Experimental Project" as used in this report refers to this construction by the State of Illinois on a State highway in Tinley Park.

Scope

The experimental project includes four 300-foot test sections and one 200-foot test section and two 300-foot control sections in the northbound roadway of Harlem Avenue between 143rd Street and 159th Street, Tinley Park, Cook County. The test sections have either two or four inches of AWC compacted at 24, 28, or 32 pounds per cubic foot densities. The control sections have no insulation but have the standard four inches of bituminous aggregate mixture base. All the sections were paved with a 10-inch standard reinforced PCC pavement.

The inclusion of the different thicknesses and compaction densities of AWC was significant as density directly influences the thermal and load-bearing characteristics of the insulating material.

The project was instrumented with frost gages and thermocouples to measure frost penetration and temperatures above and below the pavement structure. These instruments were monitored twice a month during the fall-winter-spring seasons.

Frost heave measurements were taken once a month during the cold seasons. Relative elevation changes of pavement cross sections were computed from the differential leveling field data taken immediately after construction and subsequent measurements.

Conclusions

After two years of observation and monitoring field data to determine the effectiveness and performance of the AWC insulation, the following conclusions appear to be warranted:

Trial installtation

(1) The three-inch AWC subbase under a three-inch bituminous concrete pavement was not thick enough to control frost action in all test sections.

(2) The depth of frost penetration in the test sections ranged from 9 to 15 inches below the pavement surface and increased to 29 inches in the control section. This indicates that AWC helped to reduce the depth of frost penetration.

(3) Rigid control of field density during construction was very critical as density directly influenced the thermal efficiency of AWC.

(4) It was difficult to determine precisely the depth of frost penetration due to differences in the type and condition of underlying subgrade soil.

Experimental Project

(1) Test Section No. 2, which contained four inches of AWC (24 pounds per cubic foot) subbase under a 10-inch PCC pavement, was effective in controlling penetration of freezing subsurface temperature and frost action in the subgrade.

(2) Test Sections No. 1 and No. 3, which contained four inches of AWC (28 pounds per cubic foot and 32 pounds per cubic foot respectively) subbase under a 10-inch PCC pavement, had recorded freezing subsurface temperatures up to 17 inches below the pavement surface (3 inches below the subgrade).

(3) Although freezing subsurface temperatures were recorded in Test Sections No. 1 and No. 3, the resistance reading of electrodes in these sections did not indicate the presence of frost in the subgrade. This may be attributed to lack of available free moisture needed for frost action.

(4) Test Sections No. 4 and No. 5, which contained two inches of AWC (24 pounds per cubic foot and 28 pounds per cubic foot) subbase under a 10-inch PCC pavement, were not thick enough to control penetration of freezing subsurface temperature.

(5) Test Sections No. 4 and No. 5 indicated the presence of frost up to 21 inches below the pavement surface (7 inches below the subgrade).

(6) The large differences in resistance for the electrodes that were recorded in the two control sections indicated the presence of frost up to 31 inches below the pavement surface (17 inches below the subgrade).

(7) The result of frost heave measurements indicated no significant change of pavement cross section in any of the sections.

<u>Recommendation</u>

The AWC subbase is recommended for experimental use as part of the pavement structure where frost heaving is anticipated to be a problem or for experimental use as a remedial measure to correct frost heaving problems in an existing pavement structure. The experimental AWC subbase should have a minimum thickness of four inches and be compacted to a field density of not more than 24 pounds per cubic foot when placed under a 10-inch PCC pavement in northern Illinois. Also, it is recommended that the collection of data on this project be continued for two more winter seasons to confirm the observations to date.

LABORATORY TEST PROGRAM

The materials used in the AWC experimental project were recommended by the manufacturer to obtain the required compaction densities and thermal properties. All of the materials were tested to meet the following specifications:

Mineral Aggregate: (Perlite)	ASTM C-332-66, Group 1
Bituminous Binder:	ASTM D-312-64 Federal Specification SS-A-0066 Type III, Class A

Bituminous Primer: Illinois Standard Specification for Road and Bridge Construction Section 713.10, RC-70

Bituminous Sealer: Federal Specification with modification Mil. C-450B, Type II, Kinematic Viscosity 10-20 C.S. at 140°F

The mixing formula for the composition of the AWC mixture was in strict accordance with the manufacturer's direction and is shown in Table 1.

TABLE 1

AWC BITUMINOUS MIXTURE DESIGN MIX

Sieve Size	Percent by Weight of Total Aggregate
Passing No. 8	85-100
Passing No. 16	40-85
Passing No. 100	0-10
Bitumen	50 percent by weight of total mix

Minimum values for the compressive resistance of the loose aggregate were also suggested. The Perlite Institute Test No. 306 - Friability test was used to determine the compressive resistance. The suggested minimum values are shown in Table 2.

LABORATORY TEST RESULTS

Samples of the perlite aggregates and the bituminous materials used in the AWC bituminous mixtures were taken at the jobsite before and during construction. The sieve analysis and friability tests of the perlite aggregates were conducted at the manufacturer's quality control laboratory, and the bituminous materials were tested at the Bureau of Materials' laboratory in Springfield.

Results of the sieve analysis and friability tests indicated that the eight pounds per cubic foot perlite aggregate did not meet the requirements for the portion of material passing No. 16 sieve or the compressive resistance. However, the discrepancies were considered not large enough to drastically affect the performance of the AWC insulation.

TABLE 2

MINIMUM COMPRESSIVE RESISTANCE* OF
LOOSE PERLITE AGGREGATE

Loose Aggregate Density (lb./cu.ft.)	Compressive Resistance (psi)
7	70
8	77
9	84

*Perlite Institute Test No. 306 - Friability test

The results of the tests are shown in Tables 3 and 4.

Typical test results of bituminous binder used in the AWC bituminous mixture are shown in Table 5. The binder was made of an asphalt with 15 to 35 penetration at $77^{o}F$ used for waterproofing roof decks. The test results indicate a close adherence to the requirements of the specifications.

An RC-70 liquid asphalt was specified for use on the subgrade soil as a bituminous primer. The results of tests indicated that the primer failed to meet the specification requirements for Kinematic Viscosity and Residue from distillation to $680^{o}F$ percent volume by difference. Whether or not these deficiencies will reduce the insulating properties of the AWC depends upon whether they increase the amount of moisture that the AWC can absorb from the subgrade. The test results of bituminous primer are shown in Table 6.

The bituminous material that was used to seal the AWC subbase was manufactured by Trumbull Asphalt Company, Summit, Illinois. The Specified sealer was similar to an asphalt compound used primarily by the military for coating the surfaces of ammunition cavities prior to filling with explosives. However, some internal modification was made in the sealer's formulation by the manufacturer to obtain the necessary protection from surface moisture that may penetrate the AWC subbase. The result of tests shown in Table 7 indicated that the sealer had a higher viscosity than specified. This variation was not considered significant enough to change materially the performance of the sealer. The purpose in using a lower viscosity material was to allow the sealer to penetrate and seal the voids near the surface of the AWC subbase.

TABLE 3

SIEVE ANALYSIS OF PERLITE AGGREGATE

Sieve Passing	Perlite Aggregate 7 lb./cu. ft.	Perlite Aggregate 8 lb./cu. ft.	Perlite Aggregate 9 lb./cu. ft.	Specification
No. 4	100.0	100	100	100
No. 8	97.3	93.7	97.0	85-100
No. 16	59.4	34.4	51.5	40-85
No. 20	41.5	21.1	33.3	
No. 30	26.5	13.4	20.7	
No. 50	11.6	7.2	9.5	
No. 100	3.6	3.7	3.4	0-10

TABLE 4

RESULTS OF FRIABILITY TEST*

Loose Density of Perlite		Compressive Resistance	
Specification (lb./cu. ft.)	Sample (lb./cu. ft.)	Specification (psi)	Sample (psi)
7	7.1	70	73.7
8	7.6	77	74.6
9	8.9	84	94.7

*Perlite Institute Test No. 306

TABLE 5

TYPICAL TEST RESULTS OF BITUMINOUS BINDER*

	Sample	Specification Minimum	Specification Maximum
Specific Gravity at 60°/60° F	1.001	-	-
Flash Point (Open Cup)	580	437	-
Penetration at 77° F, 100 g., 5 sec.	25	15	35
Ductility at 77° F, cm.	3.1	3	-
Softening Point (Ring and Ball)	199	180	200
Bitumen Soluble in Carbon Tetrachloride, percent	99.6	99.5	-
Loss at 325° F, 50 g., 5 hrs., percent	0.03	-	1
Penetration at 77° F, 100 g., 5 sec., of residue after heating at 325° F, 5 hrs., as compared with penetration before heating	88.0	60	-
Ash, percent	0.01	-	1

*Asphalt for roofing, ASTM D 312-64 Type III, Class A

TABLE 6

TEST RESULTS OF BITUMINOUS PRIMER*

	Sample	Specification
Viscosity, Kinematic at 140° F, cs	23	70-140
Distillate, percent volume of total		
Distillate to 374° F	53.6	10+
Distillate to 437° F	82.3	50+
Distillate to 500° F	90.6	70+
Distillate to 600° F	97.9	85+
Residue from Distillation to 680° F, percent volume by difference	54.2	55+
Tests on Residue from Distillation to 680° F		
Penetration at 77° F, 100 g, 5 sec.	110	80-120
Ductility, 77° F, cm	150+	100+
Bitumen soluble in carbon tetrachloride, percent	99.7	99.5+

*RC-70 liquid asphalt
This material fails to meet the specification requirements for Kinematic Viscosity and Residue from Distillation to 680° F percent volume by difference.

TABLE 7

TEST RESULTS OF BITUMINOUS SEALER*

	Sample	Specification Minimum	Specification Maximum
Water, percent	0.0		0.5
Viscosity, Kinematic at 140°F, cs	28	10	20
Insoluble in Carbon Tetra-chloride, percent	0.2	-	0.5
Total Solids, percent	45.05	45	55
Drying Time: Free from after tack, hr.	1.0	-	1.0
Mineral Matter, percent	0.02	-	1.0

*Coating Compound, Bituminous Solvent Type, Black (for Ammunition) Federal Specification with some modification, Mil. C-450 B, Type II

This material fails to meet the specification requirements for Kinematic Viscosity at 140°F

FIELD TEST PROGRAM

Trial Installation

On December 17, 1969, the Silbrico Corporation constructed a short AWC trial installation in the company compound. The installation was located in a section (120 feet long by 15 feet wide) adjacent to the parking area of semi-tractor trailers loaded with perlite aggregates.

The experimental design of the installation consisted of three test sections and one control section. The three test sections contained three inches of AWC subbase compacted to 24, 28, and 32 pounds per cubic foot and 1 1/2 inches of bituminous binder and 1 1/2 inches of surface course, Class I. The control section contained three inches of bituminous binder course, Class I, as subbase, 1 1/2 inches of bituminous binder and 1 1/2 inches of surface course, Class I. Each section was 30 feet long and 15 feet wide. A layout of the installation is shown in Figure 1.

Thermocouples and frost gages were installed in the center of the lane, near the pavement edge, and at the pavement edge. After all the instrumentations were accomplished, the granular subgrade was primed with an RC-0 liquid asphalt. The AWC bituminous mixture was then placed and compacted to the required densities and thickness by a light tandem steel roller (about 1,000 pounds) and a heavy tandem steel roller (8-10 tons). The temperature of the AWC mixture when placed was over 350^{o}F.

On December 18, 1969, the bituminous binder and surface courses, Class I, were placed on the finished AWC and binder subbases. The

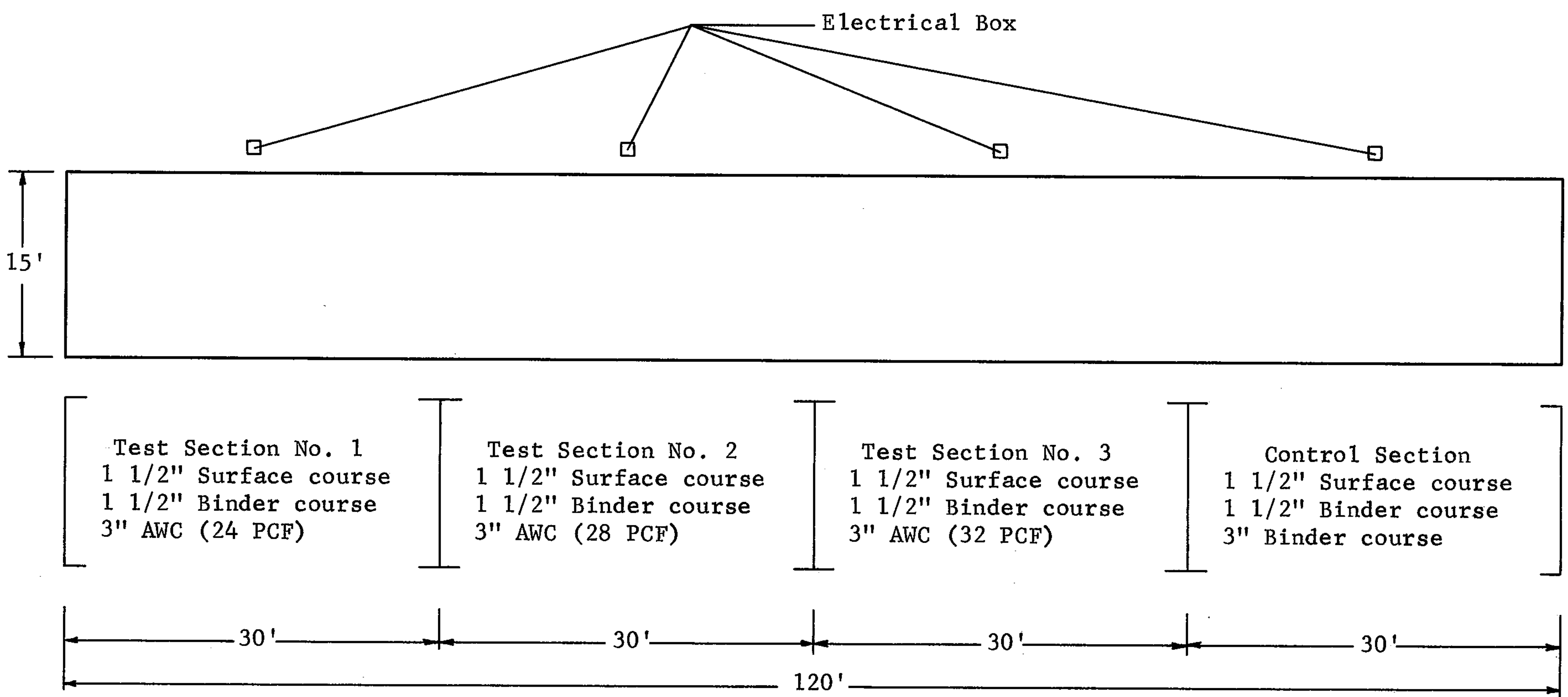


Figure 1. Layout of AWC insulation trial installation (Silbrico Corporation compound).

temperature of the bituminous mixtures ranged from 280 to 320^{o}F. Rolling was accomplished by the heavy tandem steel roller. The typical cross section for the test and control section is shown in Figures 2 and 3.

Experimental Project

The research phase of this study consists of five test sections and two control sections totaling 2,000 feet in length; all are in the northbound roadway and part of the construction of FA Route 42 (Ill 43-Harlem Avenue), Section 3127-1, Cook County.

The experimental design of the project included 10 inches of standard PCC pavement placed over two thicknesses (2- and 4-inch thick) and three compaction densities (24, 28, and 32 pounds per cubic foot) of AWC and/or bituminous aggregate mixture subbase. The embankment under the subbase was classified as an A-7-6(15) soil type. A layout of the installation is shown in Figure 4.

The inclusion of the different thicknesses and compaction densities of the AWC subbase was deemed significant as they directly influence the thermal and load-bearing characteristics of the material.

The project was fully instrumented with thermocouples and frost gages to measure periodically the frost penetration in the structural component of the pavement. The thermocouple electrodes were spaced six inches apart, while the frost gage electrodes were spaced one inch apart. These instruments were placed at various depths below the pavement in the center of each lane and along the outer edge of the insulation in the shoulder. Also, a 36-inch instrument was placed horizontally below the curb to determine the thermal gradient.

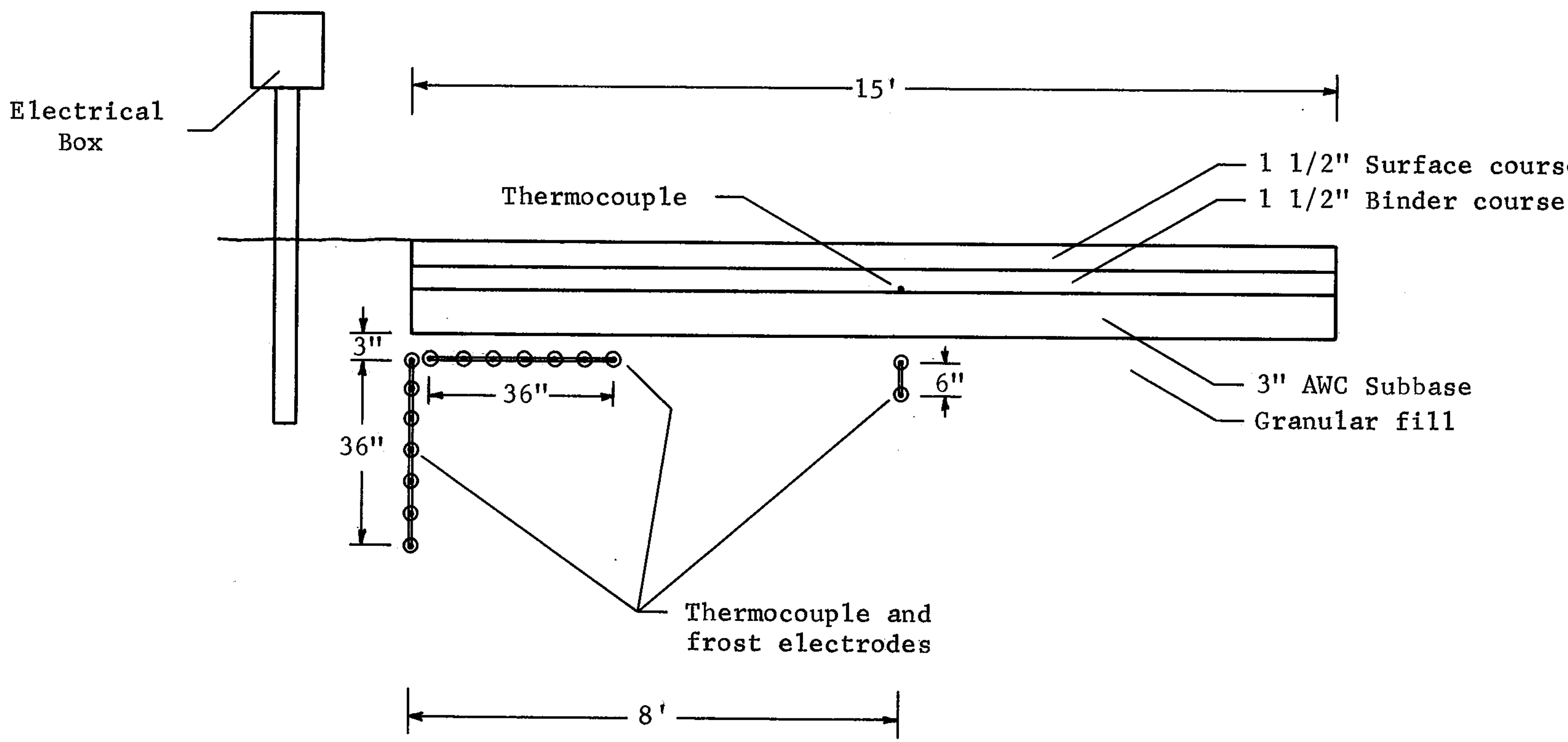


Figure 2. Typical cross section for Test Sections Nos. 1 to 3.

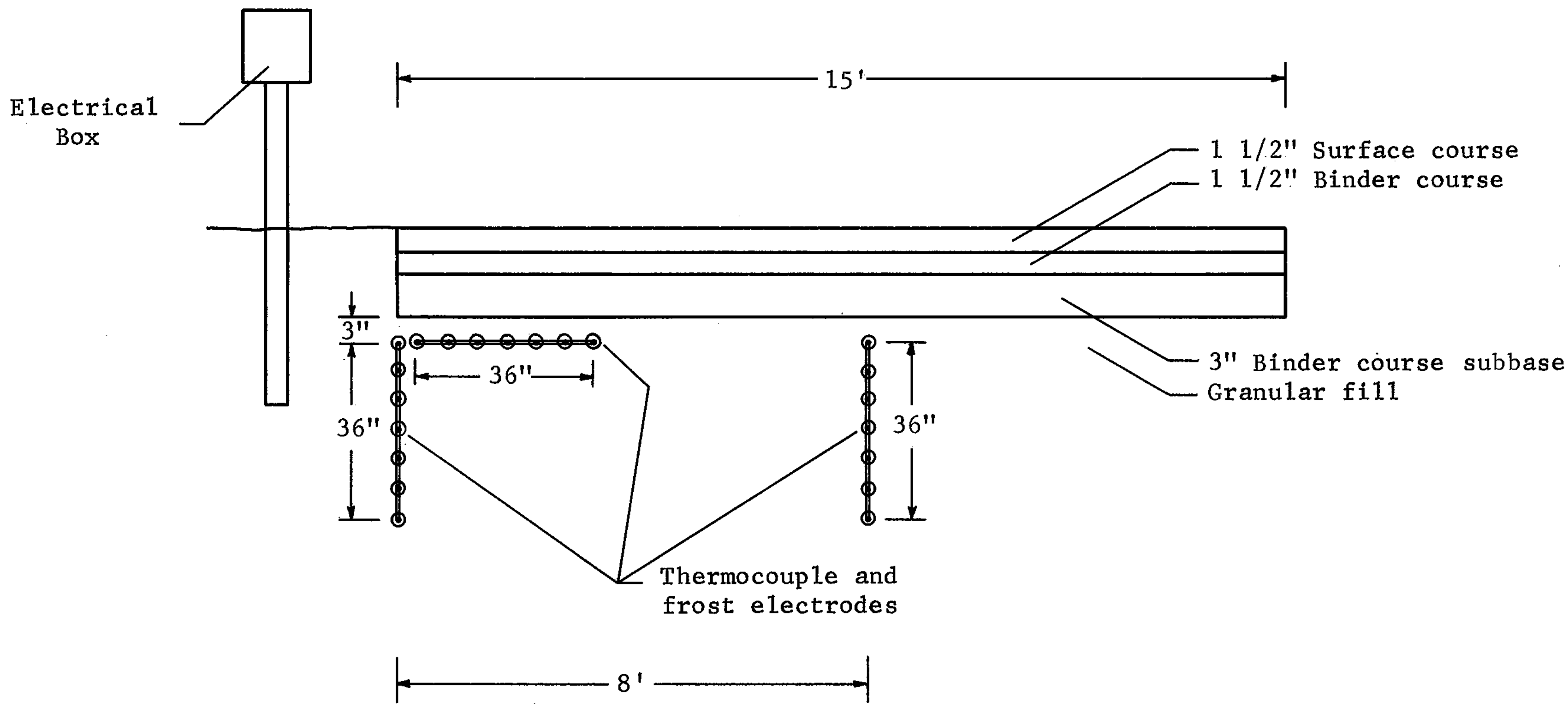


Figure 3. Typical cross section for Control Section.

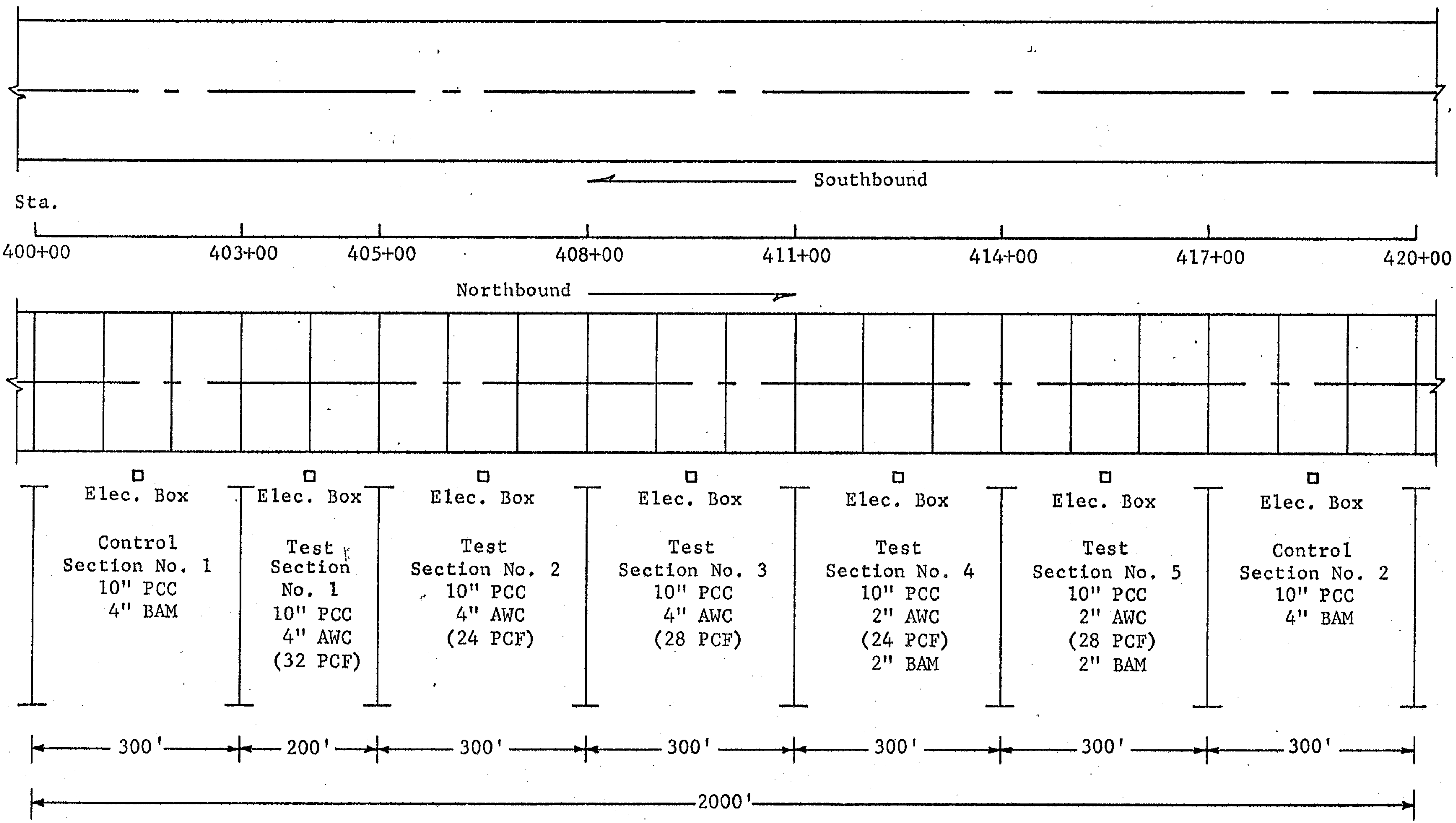


Figure 4. Layout of AWC insulation experimental project.

The typical cross sections showing the relative locations of the instruments are shown in Figure 5 to 9.

The construction of the experimental project was started in the summer and was completed in the late fall of 1970. The work involved the preparation of the subgrade, placing of the AWC and/or bituminous aggregate subbase, and paving with a standard PCC pavement.

The AWC bituminous mixture was mixed at the jobsite by a small pugmill type mixer attached to the rear of an asphalt tank truck. The AWC aggregate and the asphalt binder were mixed at temperatures over 400°F. The mixture contained about 50 percent bitumen by weight of total mix.

The hot mix AWC mixture was placed one lane at a time on the subgrade or BAM subbase by small motorized loaders. The thickness of the spread was controlled by adjustable metal bars placed on each side of the lane and a wooden screed pulled along the top of the bars.

Compaction of the AWC mixture was accomplished by two tandem steel rollers (one 2,000-pound roller and one 800-pound roller) for Test Sections No. 2 to No. 5 and by a 12-ton vibratory tandem steel roller for Test Section No. 1. The use of different roller weights was necessary in order to obtain the specified compaction densities.

After the compacting operations were completed, a CMI subgrading machine was used to bring the AWC subbase to grade. The finished sections were then open to carry construction and local traffic. However, because of the heavy rain that saturated the

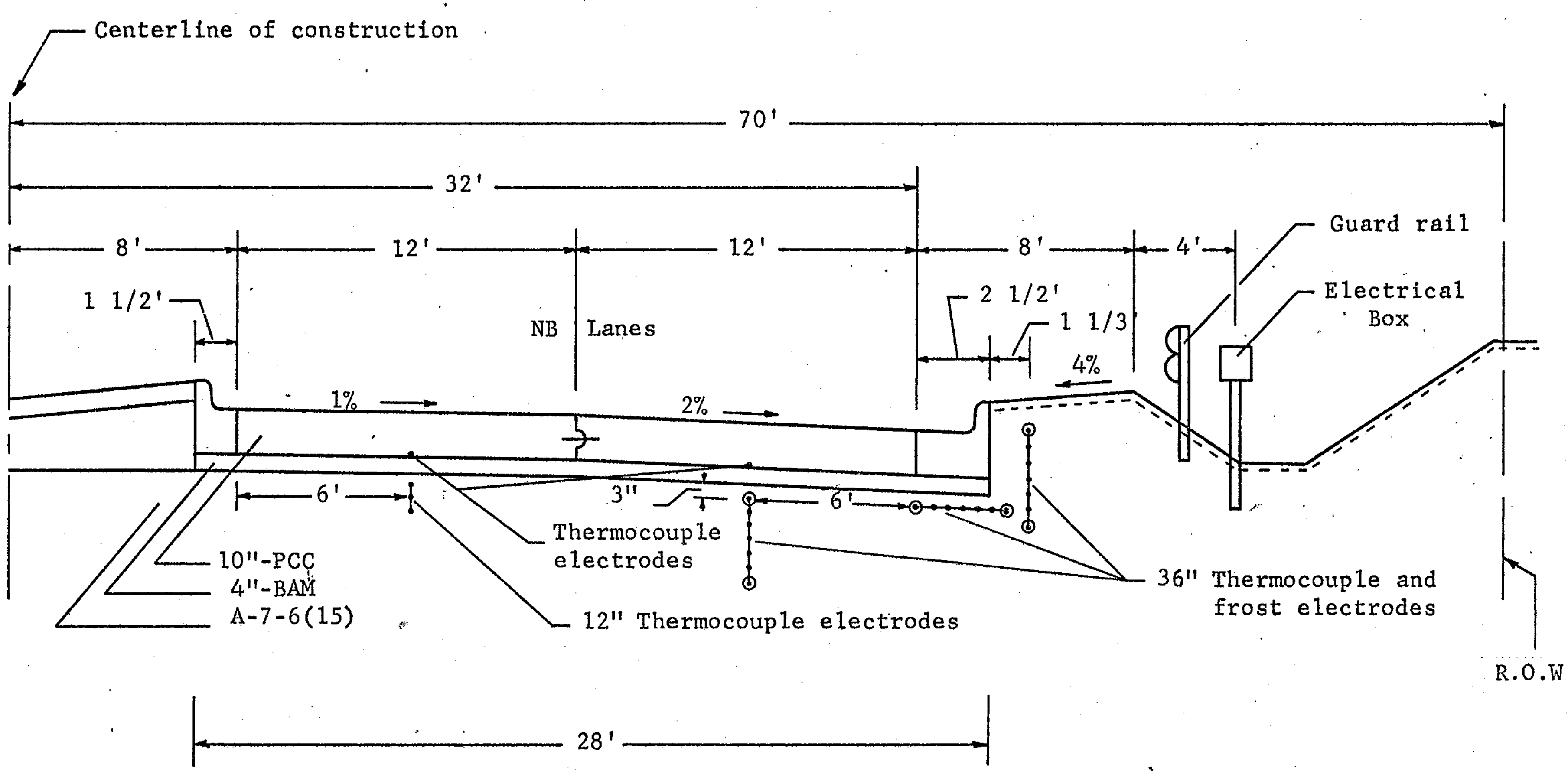


Figure 5. Typical cross section for Control Sections Nos. 1 and 2.

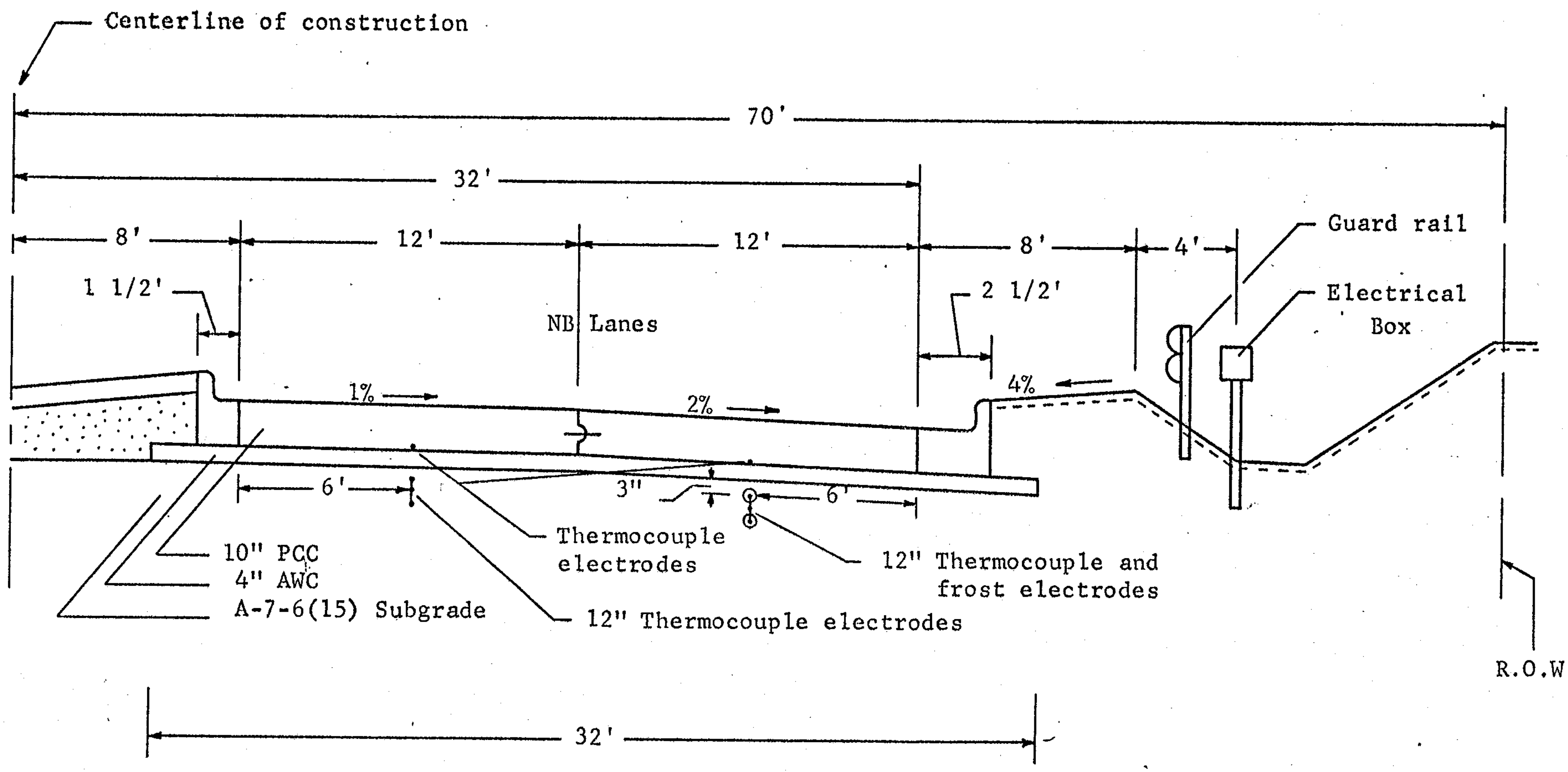


Figure 6. Typical cross section for Test Sections Nos. 1 and 3.

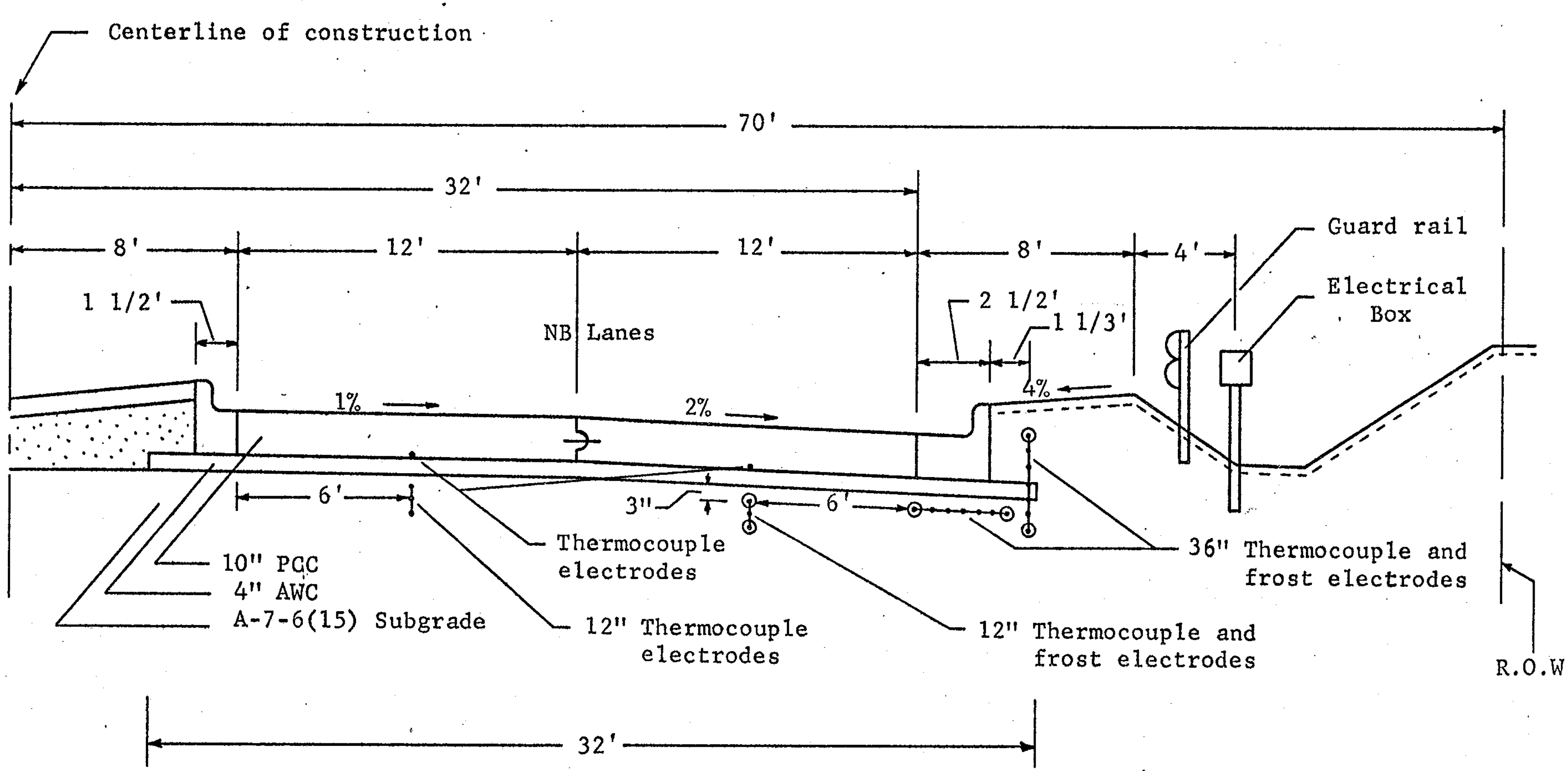


Figure 7. Typical cross section for Test Section No. 2.

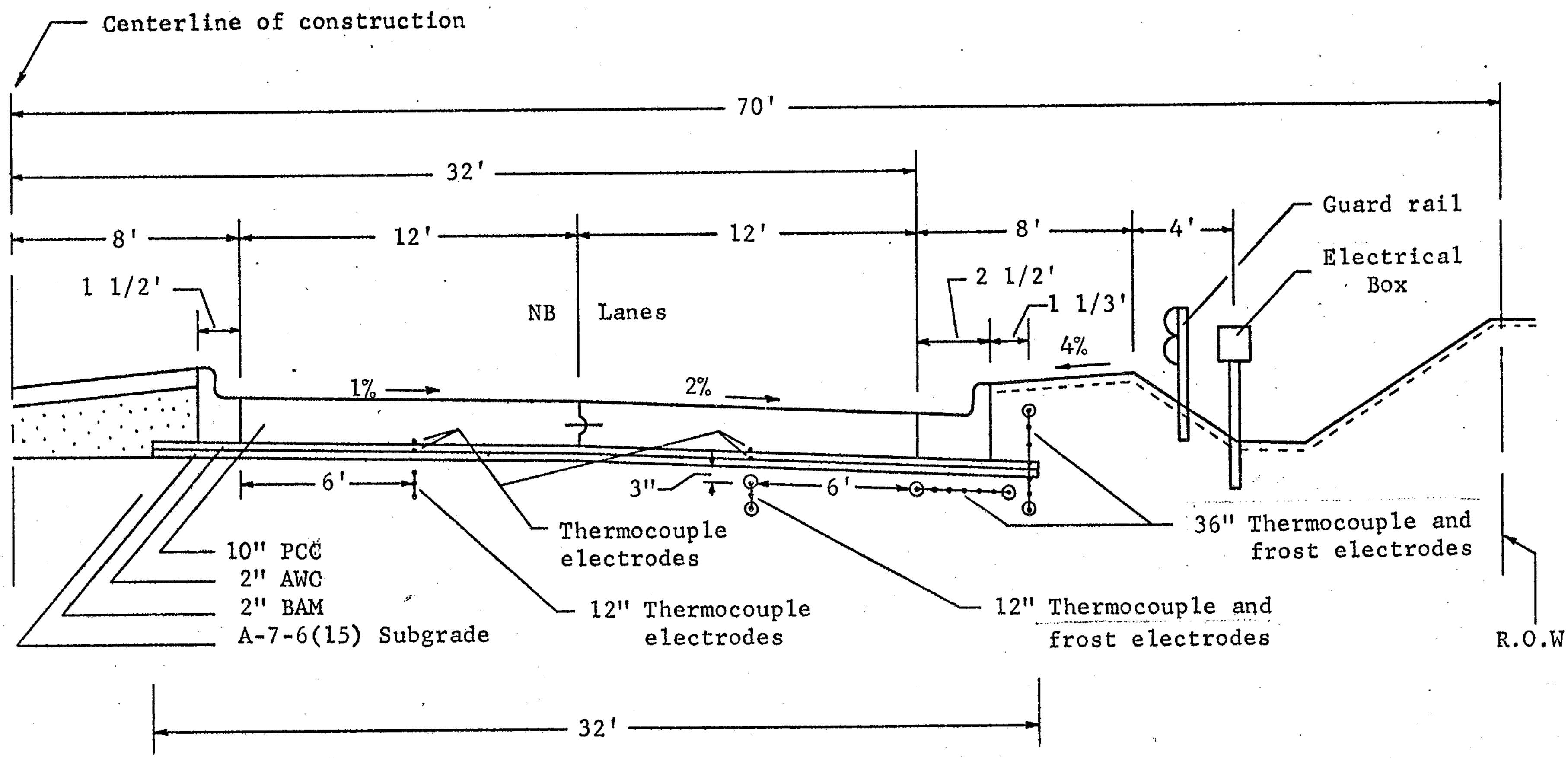


Figure 8. Typical cross section for Test Section No. 4.

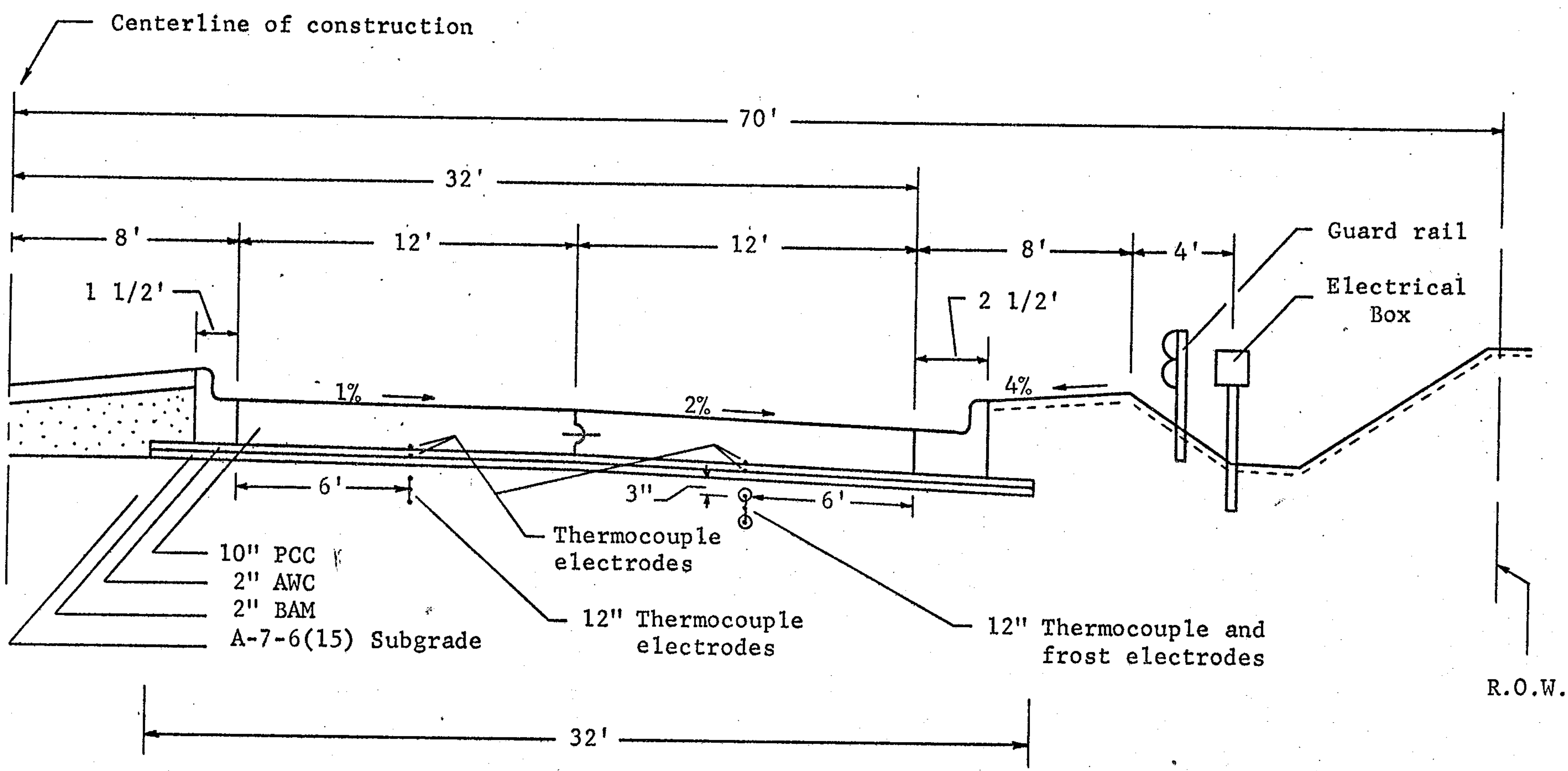


Figure 9. Typical cross section for Test Section No. 5.

subgrade and the delay in placing the concrete pavement, alligator cracks were noted in the AWC subbase in most sections. Rutting also developed in a few days and had to be removed when it became worse. It was obvious that, for this type of work, placing of concrete should follow immediately after the AWC subbase is completed.

Weather Station Data

The cold seasons of 1970-1971 and 1971-1972 were below normal for the Chicago area in regard to the design freezing index based on U.S. Weather Bureau data. The Corps of Engineers defines the design freezing index value as the cumulative degree-days of air temperature below 32°F for the coldest year in a ten-year cycle. The degree-days for any one day equals the difference between the average daily air temperature and 32°F.

The freezing index for the 1970-1971 cold season was 690 degree-days and for the 1971-1972 season it was 660 degree-days. The design freezing index for the area as defined by the Corps of Engineers was about 900 degree-days. The determination of the freezing index for the cold seasons of 1970-1971 and 1971-1972 are shown in Figure 10 and Figure 11, respectively.

FIELD TEST RESULTS

Trial Installation

Prior to placing of the bituminous binder and surface courses, Class I, over the AWC subbase, core samples were taken of the subbase in each test section to determine its field density and thermal property. The test results of field samples are shown in Table 8.

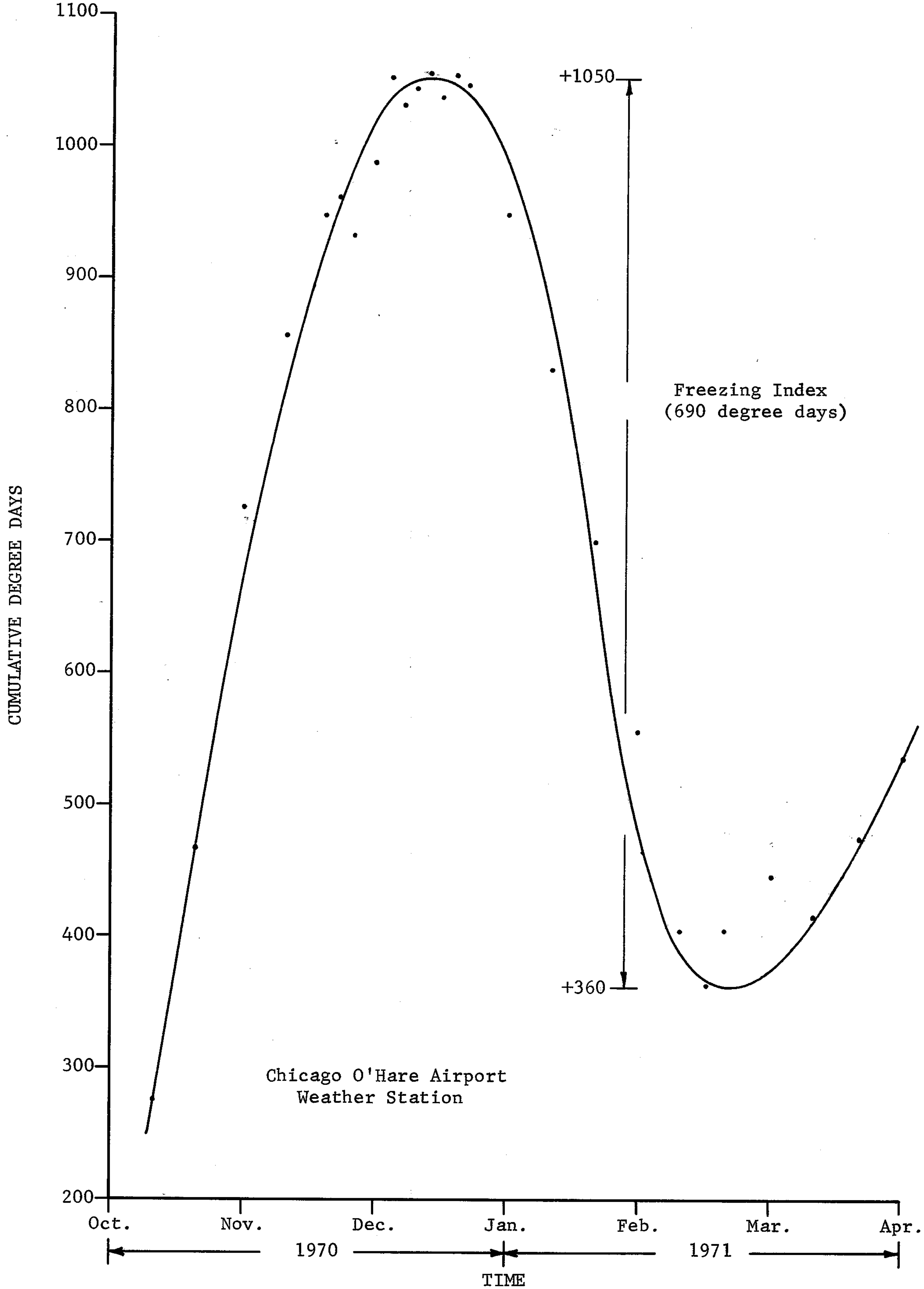


Figure 10. Determination of Freezing Index, 1970-1971.

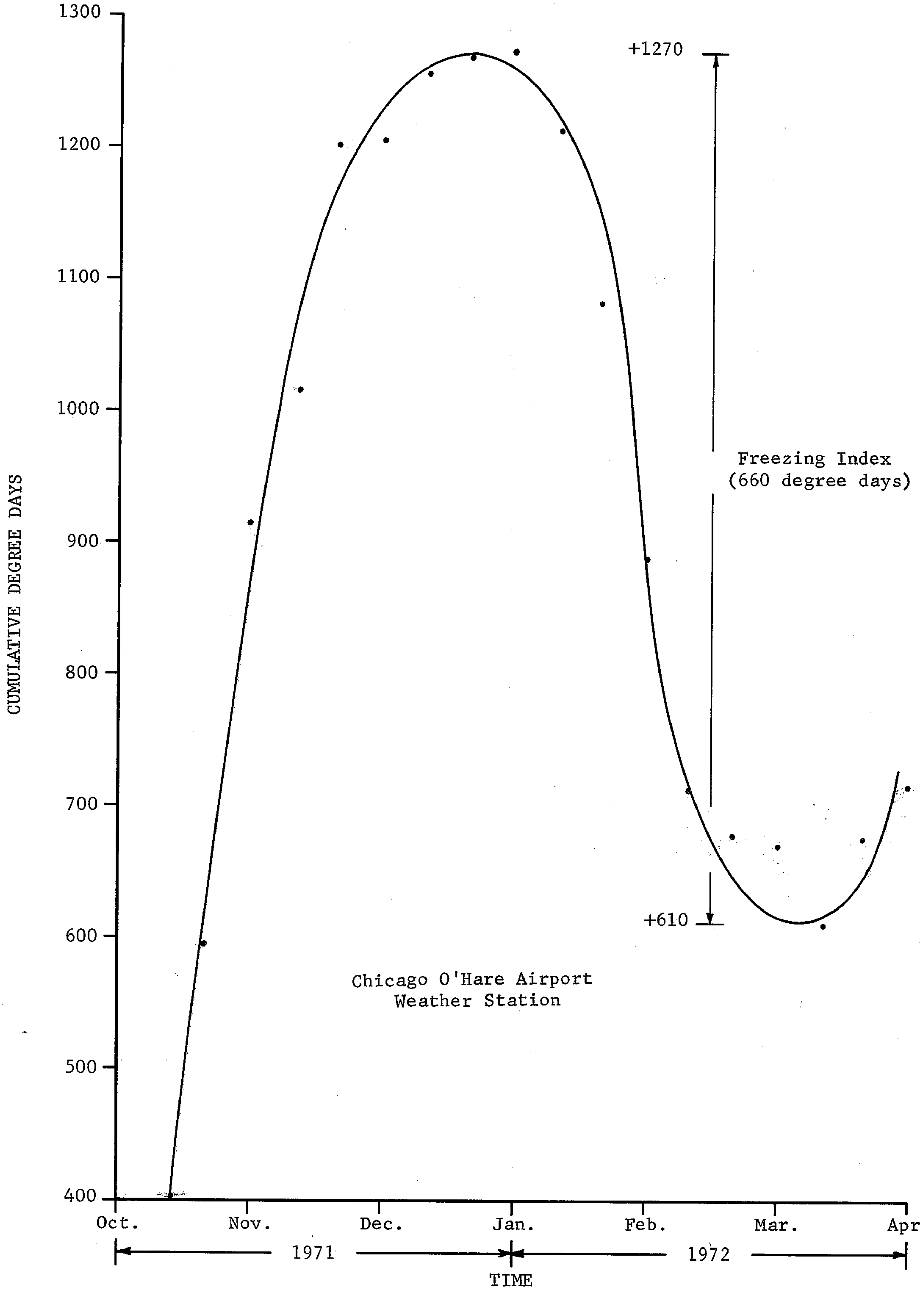


Figure 11. Determination of Freezing Index, 1971-1972.

From Table 8 the results indicated higher density value than specified for Test Section 1 but within tolerable limits for Test Sections 2 and 3. The thermal conductivity (K) value was about the same for Test Sections 1 and 2 (K=.58 and .59) and much higher (K=0.65) for Test Section 3. This also indicates that the K value of an insulating material increases with its density which in effect will reduce its ability to control frost penetration.

TABLE 8

TEST RESULTS OF FIELD SAMPLES
(AWC Trial Installation)

Section	Loose Density AWC Aggregate lb./cu.ft.	Core Sample Density Specified lb./cu.ft.	Core Sample Density Actual lb./cu.ft.	Thermal Conductivity* K Value Btu-in.hr.ft.^{2}/F
1	7.6	24	29.2	0.58
2	8.4	28	27.8	0.59
3	9.4	32	30.5	0.65
Control	-	-	144.8	-

*ASTM C 177-63, Thermal Conductivity of Materials by Means of the Guarded Hot Plate, at a mean temperature of 75°F. This test was performed at the Silbrico Corporation laboratory.

Thermocouple and frost gage readings were recorded twice a month during the cold seasons of 1971-1972. The result of these readings are presented in Figures A-1 to A-26 in Appendix A. The information in the figures shows the depth-temperature and the depth-resistance relationships in each section. The depth-temperature data were tabulated in Table 9 to summarize the maximum penetration of freezing subsurface temperatures.

From Table 9 the results indicate that during the first year of observation no freezing temperatures penetrated the AWC subbase in all test sections, while in the Control Section freezing temperatures were recorded up to 33 inches below the pavement surface. However, during the second year of monitoring thermocouple data, freezing temperatures were recorded below the AWC in all test sections (up to 15 inches below the surface) with Test Section No. 1 registering the least penetration (nine inches). In the Control Section, freezing temperatures were recorded up to 29 inches below the surface.

TABLE 9

SUMMARY OF MAXIMUM PENETRATION OF FREEZING SUBSURFACE TEMPERATURES (AWC Trial Installation)

Section	Depth Below Pavement Surface (inches) First Year (1971) CL (1)	First Year (1971) PE (2)	Second Year (1971-1972) CL (1)	Second Year (1971-1972) PE (2)
Test No. 1	3	0	9	15
Test No. 2	3	0	15	21
Test No. 3	0	21	15	15
Control	33	21	29	27

Note: 1) CL - Center of lane
2) PE - Pavment edge

Figures A-25 and A-26 in Appendix A show the typical soil depth-resistance relationships (1971-1972) for all sections. The large increase in resistance for the electrode indicates the formation of ice crystals in that level. However, the minimum resistance reading needed to form these crystals varied from one section to another. This variation may be attributable to differences in the type and condition of soil used to build up the whole area which was formerly swampy. It was difficult to determine precisely what resistance value signifies the boundary in which water changes from the liquid to solid phase.

There were instances in which freezing subsurface temperatures were recorded, but the resistance in the electrode remained low. These instances merely indicate that there was no ice formation or frost in the soil due to lack of free moisture. As the moisture becomes available and intercepts the freezing zone, the resistance value would drastically increase to indicate the presence of frost. From both Figures A-25 and A-26, the results indicated the presence of frost under the AWC subbase in all test sections.

Experimental Project

After the AWC subbase was placed and compacted, core samples were taken to determine its field density, thickness, and thermal conductivity values. The results of tests on the samples are tabulated in Table 10.

From Table 10 the results indicated that the project was constructed close to the thickness tolerance of $\pm$ 1/4 inch of the thickness specified in the plan. Although there were no tolerance

TABLE 10

TEST RESULTS OF FIELD SAMPLES
(AWC EXPERIMENTAL PROJECT)

SECTION	Loose Density AWC Aggregate lb/cu ft.	Core Sample* Thickness Inch	Core Sample* Density lb/cu ft.	Thermal Conductivity** K value Btu - In/hr. ft.^{2}/F
Control No. 1	-----	4.25 (4)	143.5	-----
Test No. 1	8.9 (9)	4.47 (4)	35.2 (32)	0.65
Test No. 2	7.1 (7)	3.75 (4)	25.9 (24)	0.56
Test No. 3	7.6 (8)	4.28 (4)	30.6 (28)	0.64
Test No. 4	7.1 (7)	1.90 (2)	25.4 (24)	0.53
Test No. 5	7.6 (8)	1.97 (2)	27.8 (28)	0.53
Control No. 2	-----	4.58 (4)	137.9	-----

* Average of 9 samples
() Values in parenthesis are spcified values
** ASTMC 177-63, Thermal Conductivity of Materials by Means of the Guarded Hot Plate, at mean temperature of 75F. This test was performed at Silbrico Corporation laboratory

limits specified for the loose density (aggregate) and compacted density of AWC, the slight variations obtained from the samples were considered within tolerable practical limits. These variations reflect on the manufacturer's rigid quality control procedures in the plant and long experience in roof deck construction. The thermal conductivity (K) values obtained were within the values recommended by the manufacturer in regard to the insulating properties of AWC. As with the previous AWC trial installation, the K value increases with the density.

Instrumentation recordings included reading of thermocouple and frost gage electrodes twice a month during the cold seasons of 1970-1971 and 1971-1972. The results of these readings are presented in Appendix B. Figures B-1 to B-36 show the depth-temperature data of all sections included in the experimental project. These data were tabulated and presented in Table 11 to summarize the maximum penetration of freezing subsurface temperatures.

From Table 11 the results indicated that after two years of observation no freezing temperatures has penetrated the AWC subbase in either the inner or outer lanes of Test Section No. 2. Also, no freezing temperatures were recorded under the AWC subbase in the inner lane of Test Sections No. 1 and No. 3. However, in the outer lane of these sections, freezing temperatures penetrated the AWC subbase up to 17 inches below the pavement surface or three inches below the subgrade. The rest of the test sections had recorded freezing temperatures ranging from 12 inches to 22 inches

TABLE 11

SUMMARY OF MAXMUM PENETRATION OF
FREEZING SUBSURFACE TEMPERATURES
(AWC EXPERIMENTAL PROJECT)

DEPTH BELOW PAVEMENT SURFACE (Inches)

SECTION	First Year (1970 - 1971)			Second Year (1971 - 1972)		
	ILC (1)	OLC (2)	OLS (3)	ILC (1)	OLC (2)	OLS (3)
Control No. 1	40	40	No	31	28	25
Test No. 1	10	20	Readings	10	17	---
Test No. 2	10	10		10	10	12
Test No. 3	10	10		10	17	---
Test No. 4	29	29		12	17	14
Test No. 5	26	17		12	22	---
Control No. 2	39	37		29	28	20

NOTE:

(1) ILC - Inner lane center
(2) OLC - Outer lane center
(3) OLS - Outer lane shoulder

below the pavement surface.

Both Control Sections 1 and 2 recorded freezing temperatures very much deeper in the subgrade than in the test sections. It ranged from 37 to 40 inches below the pavement surface during the first year and from 28 to 31 inches in the second year.

The summary in Table 11 indicates the effectiveness of the AWC subbase in controlling penetration of freezing temperatures in Test Section No. 2.

Figures B-37 to B-40 in Appendix B show the typical soil depth-resistance relationships (1971-1972) for all sections in the project. The large differences in resistance for the electrode at each level in Control Sections No. 1 and No. 2 clearly indicate the presence of ice crystals or frost in the subgrade. The depth of frost penetration was about 31 inches and 28 inches for Control Sections No. 1 and No. 2, respectively.

The resistance for the electrode at each level in Test Sections No. 1, No. 2, and No. 3 did not indicate much difference, which was interpreted as indicating no frost in the subgrade, although it was previously stated that freezing temperatures had penetrated the AWC in Test Sections No. 1 and No. 3. This is probably due to the lack of available free moisture needed to form the ice crystals.

In Test Sections No. 4 and No. 5, the differences in resistance were high at the 21-inch and 17-inch level electrodes, respectively. These large differences indicate the presence of frost at those levels.

Frost heave measurements were conducted once a month during the cold seasons to determine any changes in the pavement cross section. An Engineer's level was used in the differential leveling to take these measurements at predetermined locations in each section. Changes in profile from the initial level taken immediately after construction indicate the relative heaving or settlement of the pavement structure. These changes are presented in the tables in Appendix C. The result of the level measurements indicated no significant changes of pavement cross section in either the test or control sections after two years of observation. However, there was one measurement in Control Section No. 1 where the relative change was +0.10 foot. Subsequent measurements were less than half that value--an indication that probably an error might have existed in reading the level rod. A summary of maximum elevation changes in all sections is shown in Table 12.

TABLE 12

SUMMARY OF RELATIVE MAXIMUM ELEVATION CHANGES OF PAVEMENT CROSS SECTION

Section	Station	Maximum Elevation Change (feet)							
		2/10/71	3/12/71	4/14/71	11/9/71	12/7/71	1/4/72	2/1/72	3/7/72
Control 1	401+00	+.09	-.03	-.03	+.02	+.05	+.04	+.03	+.02
	401+50	+.09	-.02	-.03	+.02	+.04	+.02	-.02	-.02
	402+00	+.10	-.02	-.04	+.02	+.02	+.01	+.01	-.03
Test 1	403+50	-.05	-.03	-.03	+.01	-.05	-.01	-.02	-.02
	404+00	-.04	-.02	-.03	+.01	-.04	+.01	-.01	-.02
	404+50	-.04	-.02	-.02	+.01	-.03	0	-.03	-.02
Test 2	406+00	-.02	-.02	-.01	-.01	0	+.01	-.02	-.02
	406+50	-.03	-.03	-.03	-.01	-.01	+.01	-.03	-.03
	407+00	-.02	-.03	-.02	-.02	-.04	+.01	+.02	-.03
Test 3	409+00	-.02	-.03	-.03	-.01	-.06	-.01	-.06	+.03
	409+50	-.03	-.04	-.04	-.02	-.06	-.02	-.02	-.03
	410+00	-.01	-.03	-.02	-.02	-.04	-.02	-.01	-.02
Test 4	412+00	+.04	+.04	+.05	0	+.02	+.02	+.02	-.02
	412+50	-.03	-.03	-.02	+.01	+.03	+.03	-.04	-.03
	413+00	-.03	-.01	-.01	+.02	+.03	+.04	+.04	-.02
Test 5	415+00	+.01	-.01	+.01	+.02	-.06	+.05	+.03	-.02
	415+50	-.02	-.02	-.01	+.01	-.05	+.03	-.02	-.03
	416+00	+.01	+.02	-.01	-.01	-.05	+.02	-.03	-.03
Control 2	418+00	+.01	+.01	-.01	-.01	+.02	+.01	+.02	-.02
	418+50	+.01	-.01	-.02	-.02	+.02	+.02	+.01	-.02
	419+00	+.03	+.01	-.02	-.02	+.03	+.03	+.03	-.01

APPENDIX A

DEPTH-TEMPERATURE AND DEPTH-RESISTANCE RELATIONSHIPS IN THE AWC TRIAL INSTALLATION

Figures A-1 to A-24 show the depth-temperature data in Test Sections No. 1 to No. 3 and in a control section. These data were taken from thermocouple readings in the center of lane, near pavement edge, and pavement edge. Figures A-25 and A-26 show the typical soil depth-resistance relationships in the center of lane of the test and control sections. The encircled numbers in the figures correspond to the dates the thermocouple and frost gage readings were recorded. The corresponding numbers and dates are as follow:

Number	1971 Cold Season
1	February 24, 1971
2	March 10, 1971
3	March 24, 1971
4	April 8, 1971
5	April 20, 1971

Number	1971-1972 Cold Season
1	October 20, 1971
2	November 10, 1971
3	November 24, 1971
4	December 8, 1971
5	December 22, 1971
6	January 19, 1972

7	February 2, 1972
8	February 23, 1972
9	March 8, 1972
10	March 22, 1972

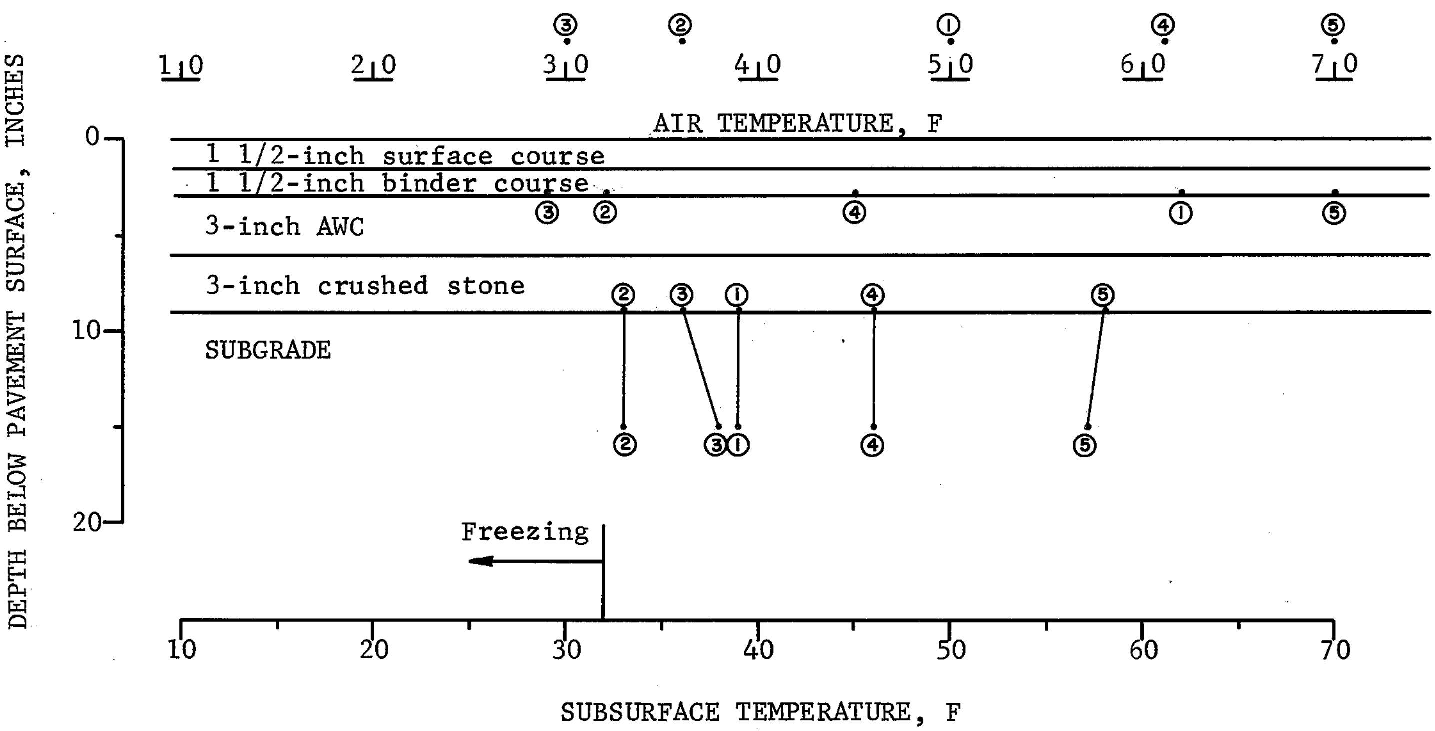


Figure A-1. Depth-temperature data in Test Section No. 1, center of lane (1971).

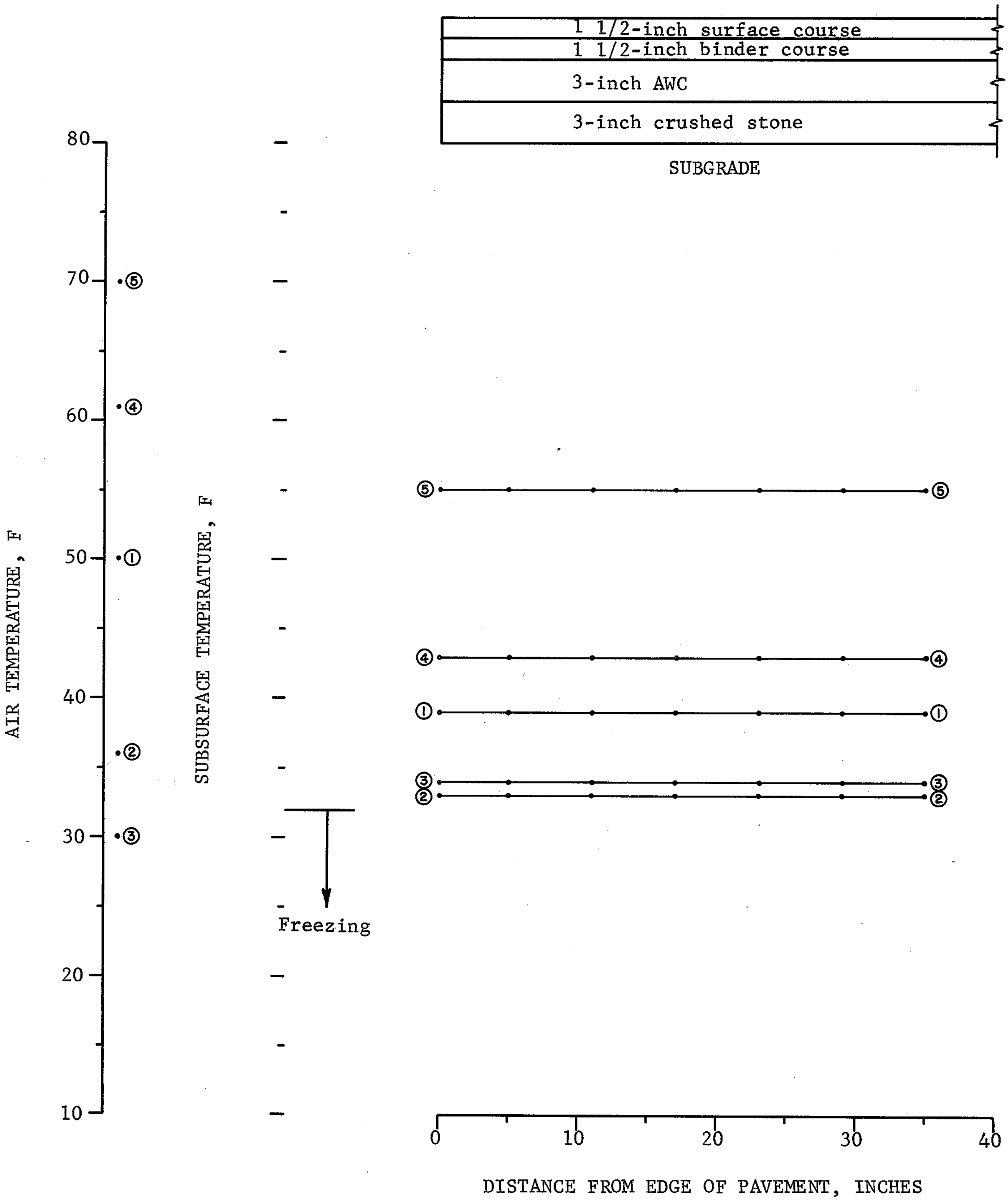


Figure A-2. Distance-temperature data in Test Section No. 1, near pavement edge (1971).

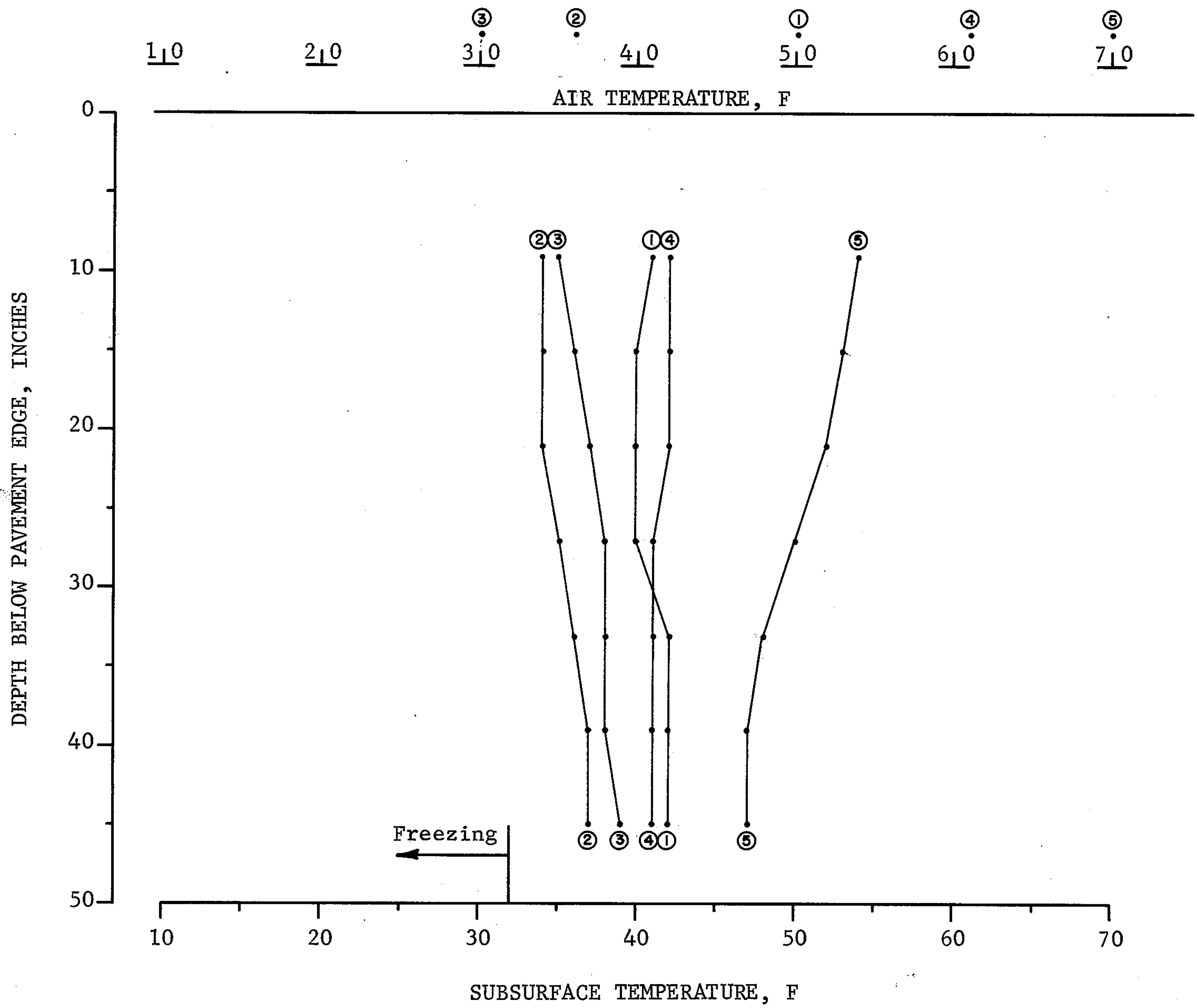


Figure A-3. Depth-temperature data in Test Section No. 1, pavement edge (1971).

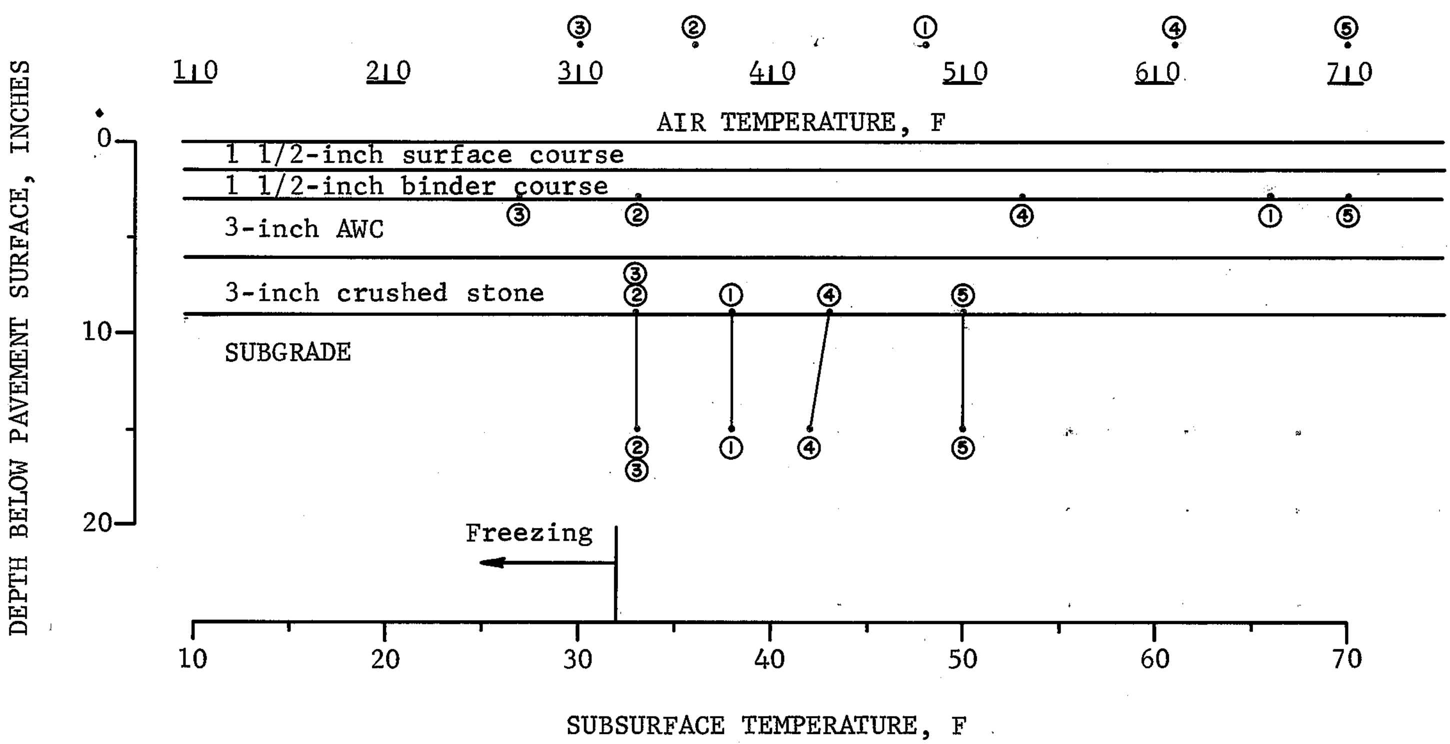


Figure A-4. Depth-temperature data in Test Section No. 2, center of lane (1971).

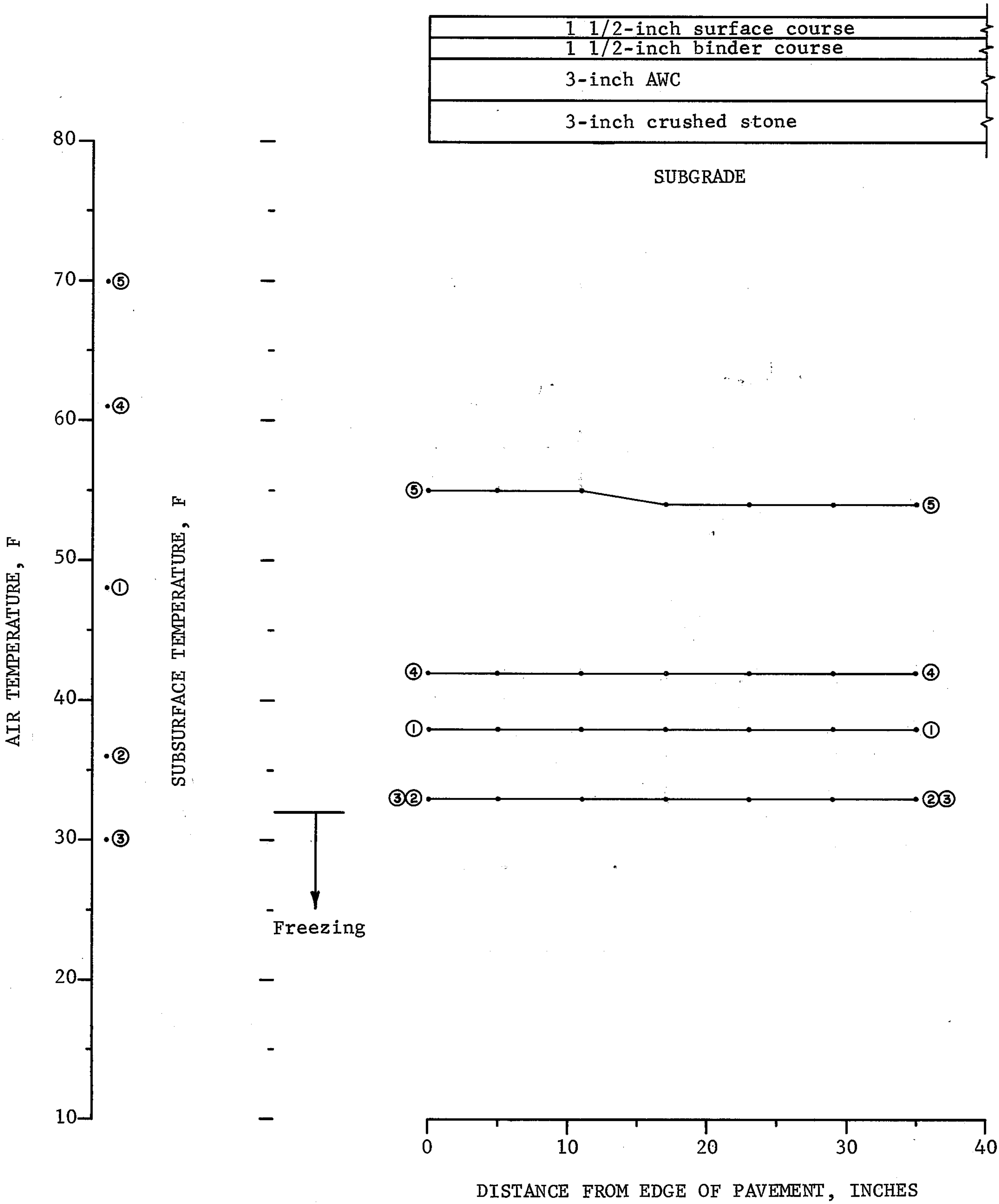


Figure A-5. Distance-temperature data in Test Section No. 2, near pavement edge (1971).

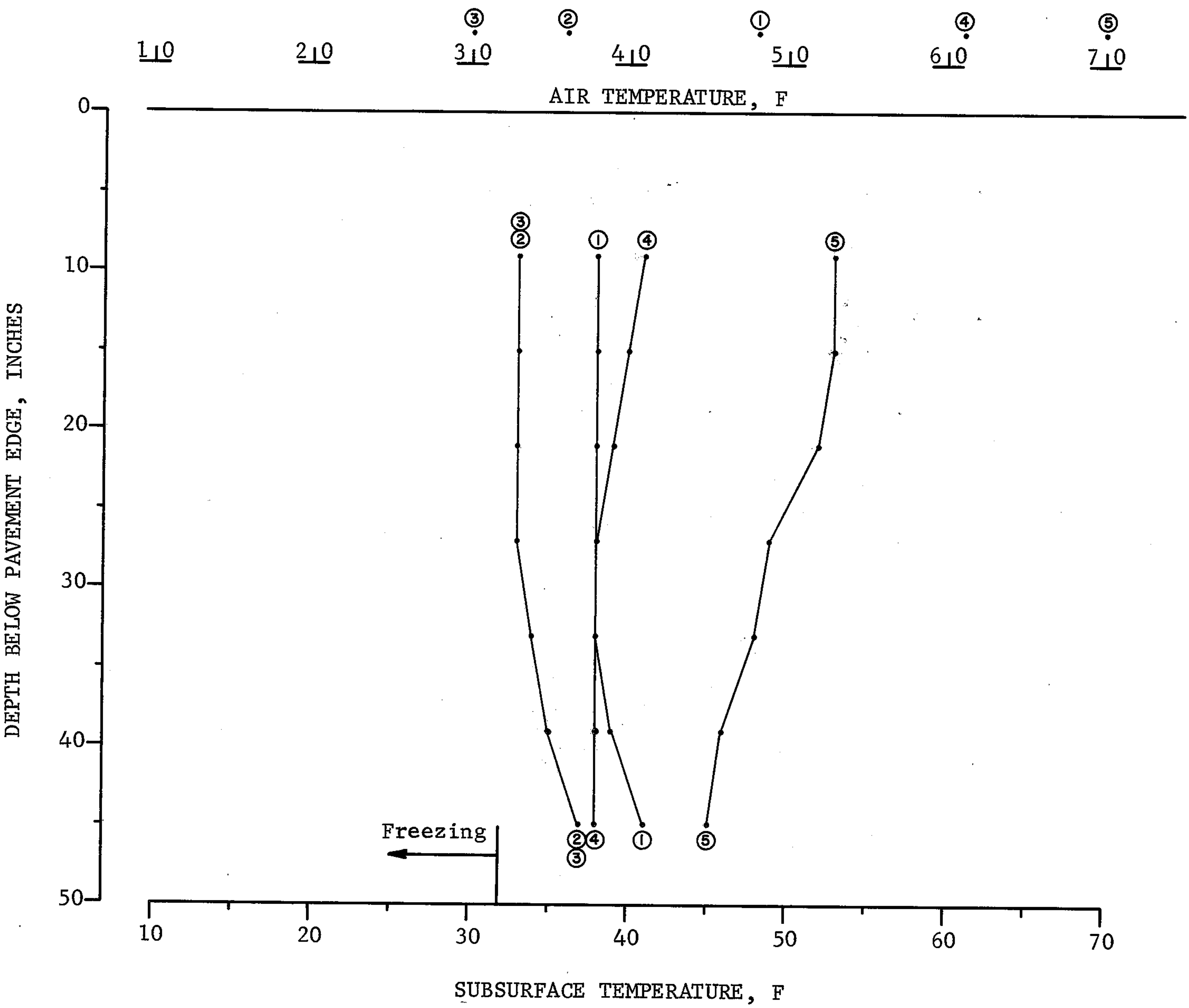


Figure A-6. Depth-temperature data in Test Section No. 2, pavement edge (1971).

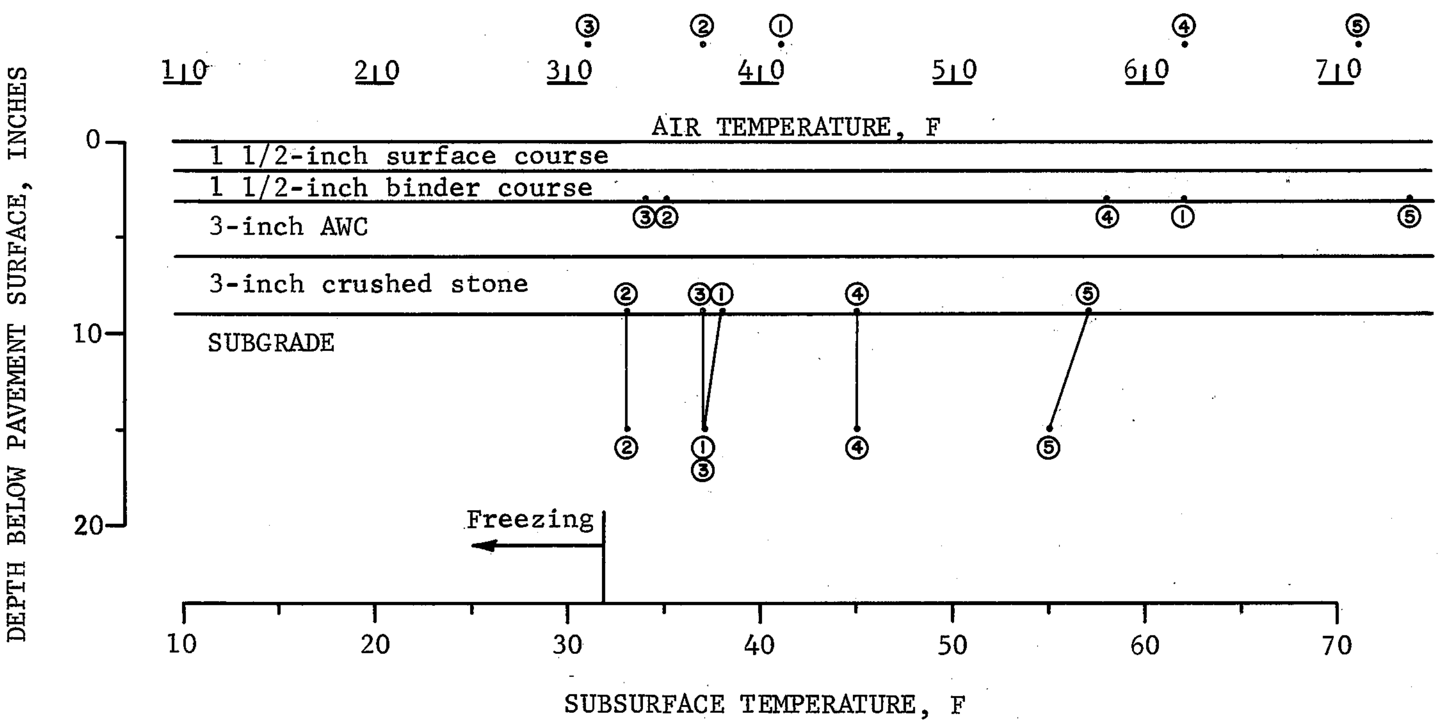


Figure A-7. Depth-temperature data in Test Section No. 3, center of lane (1971).

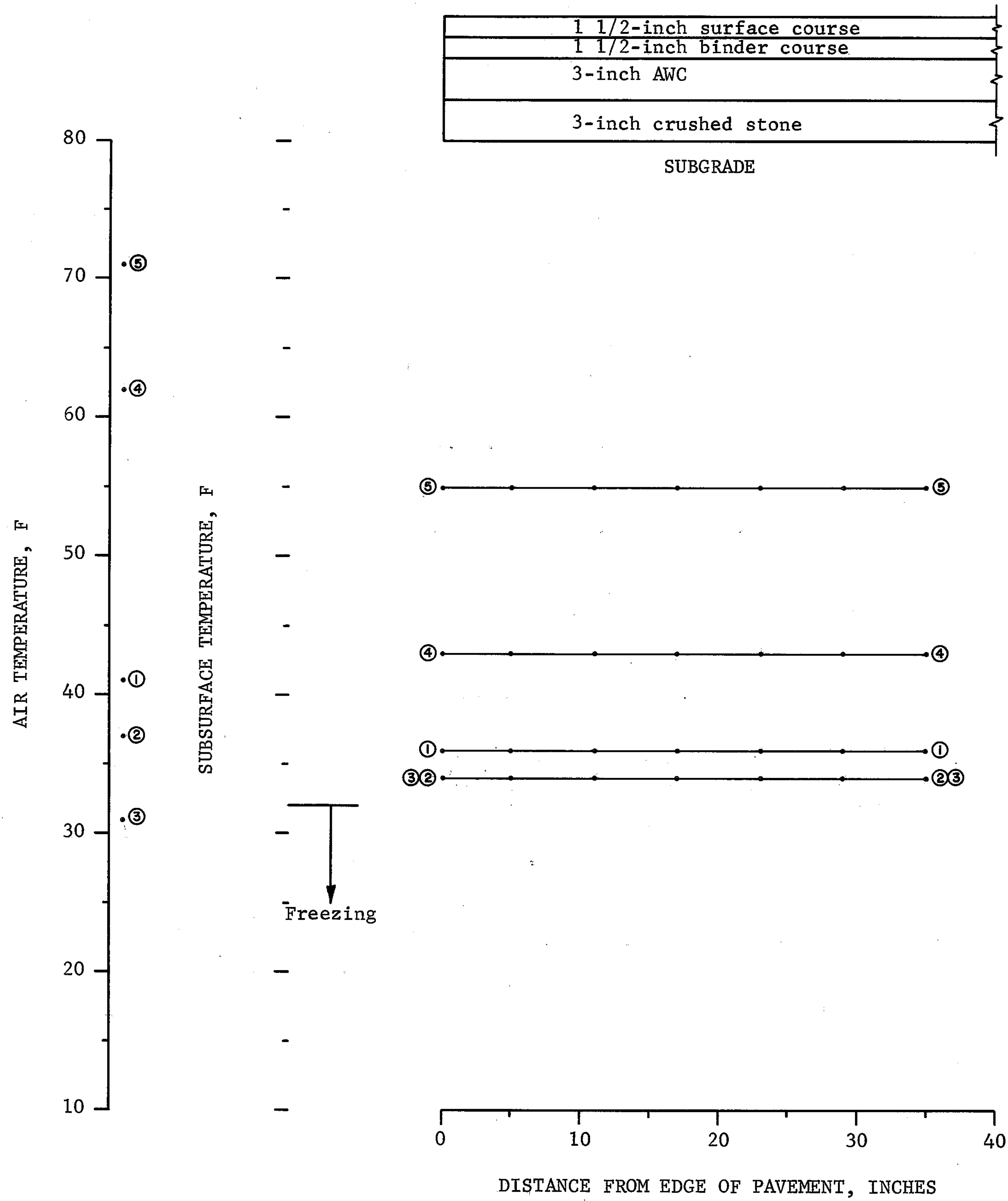


Figure A-8. Distance-temperature data in Test Section No. 3, near pavement edge (1971).

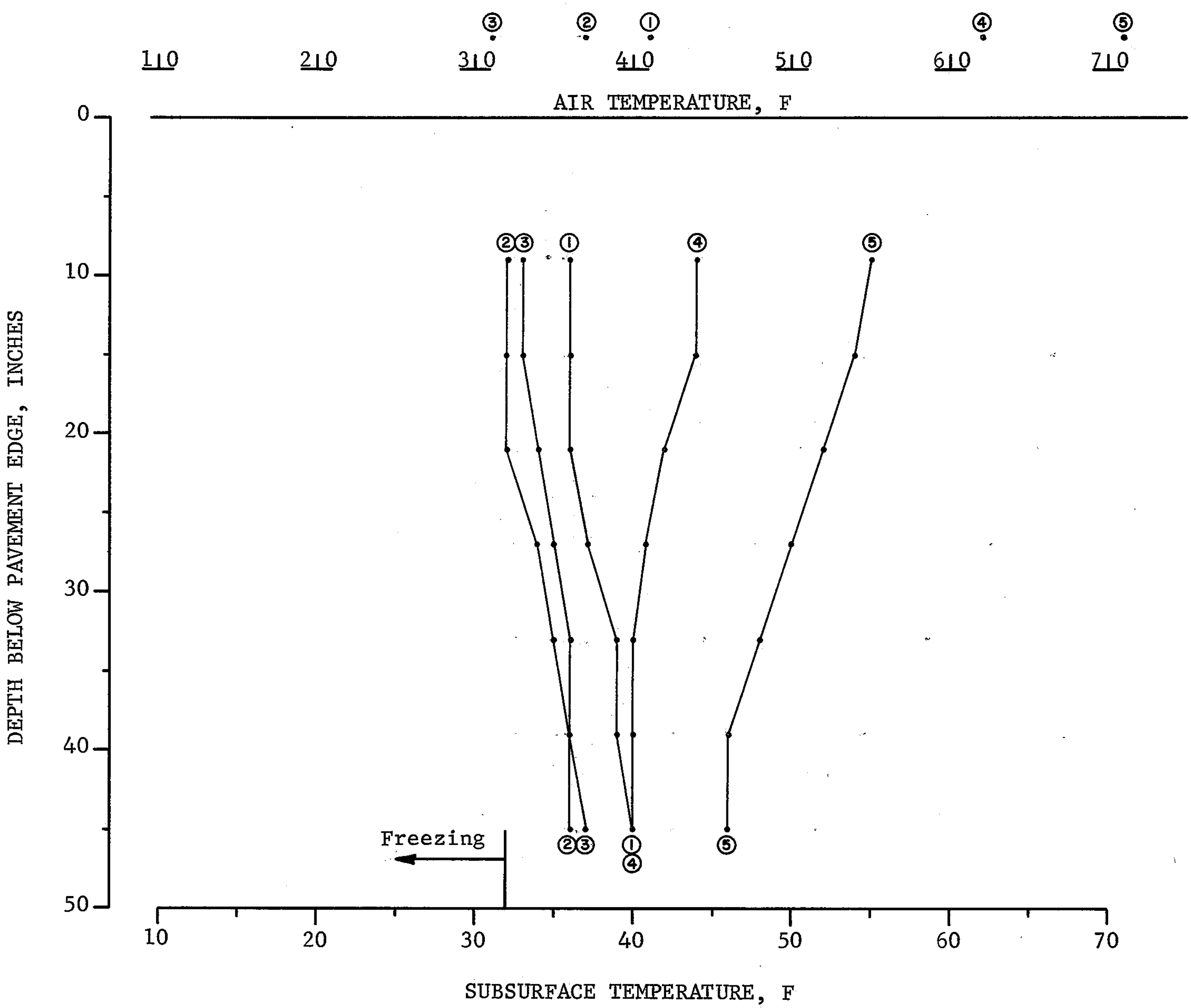


Figure A-9. Depth-temperature data in Test Section No. 3, pavement edge (1971).

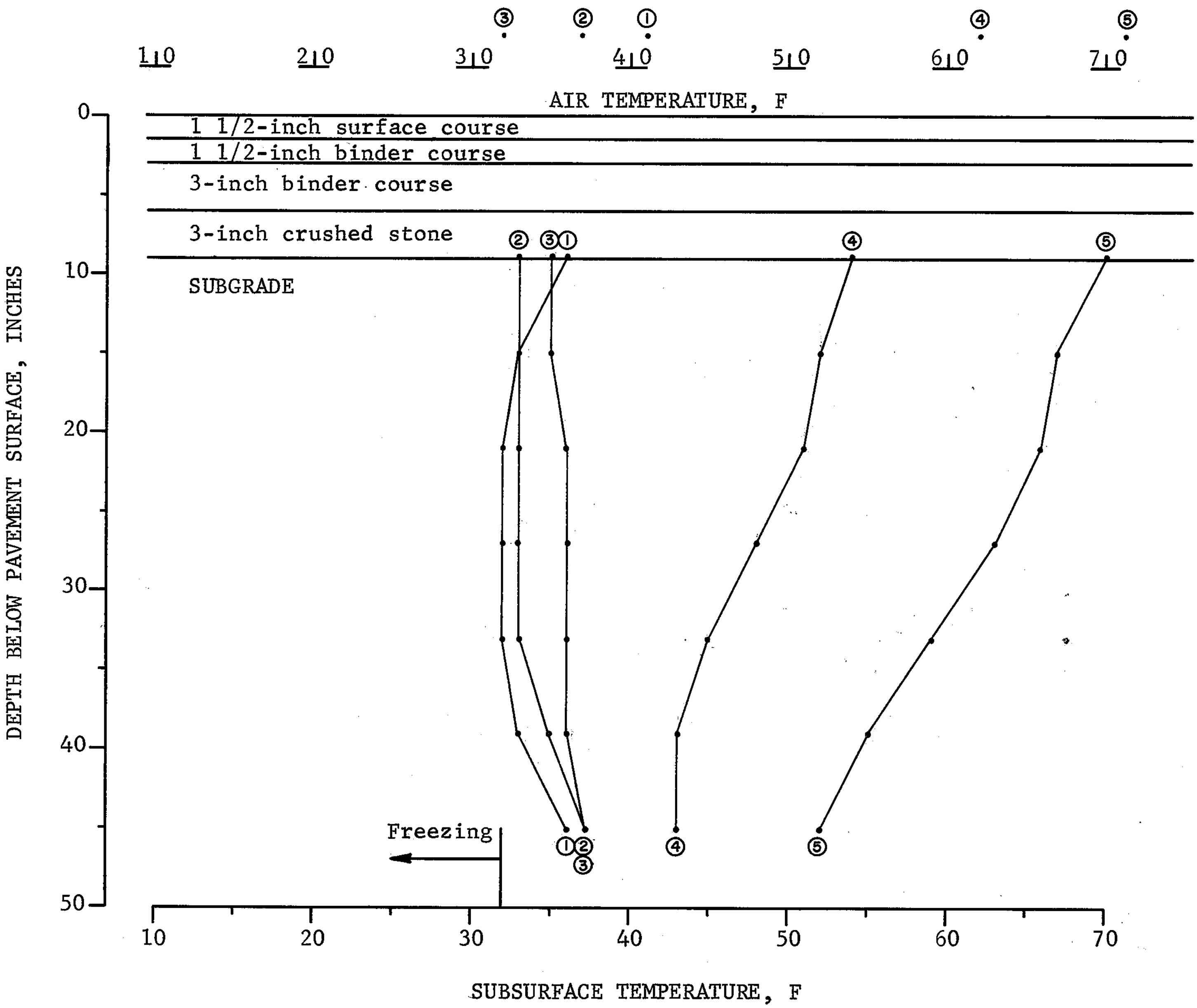


Figure A-10. Depth-temperature data in Control Section, center of lane (1971).

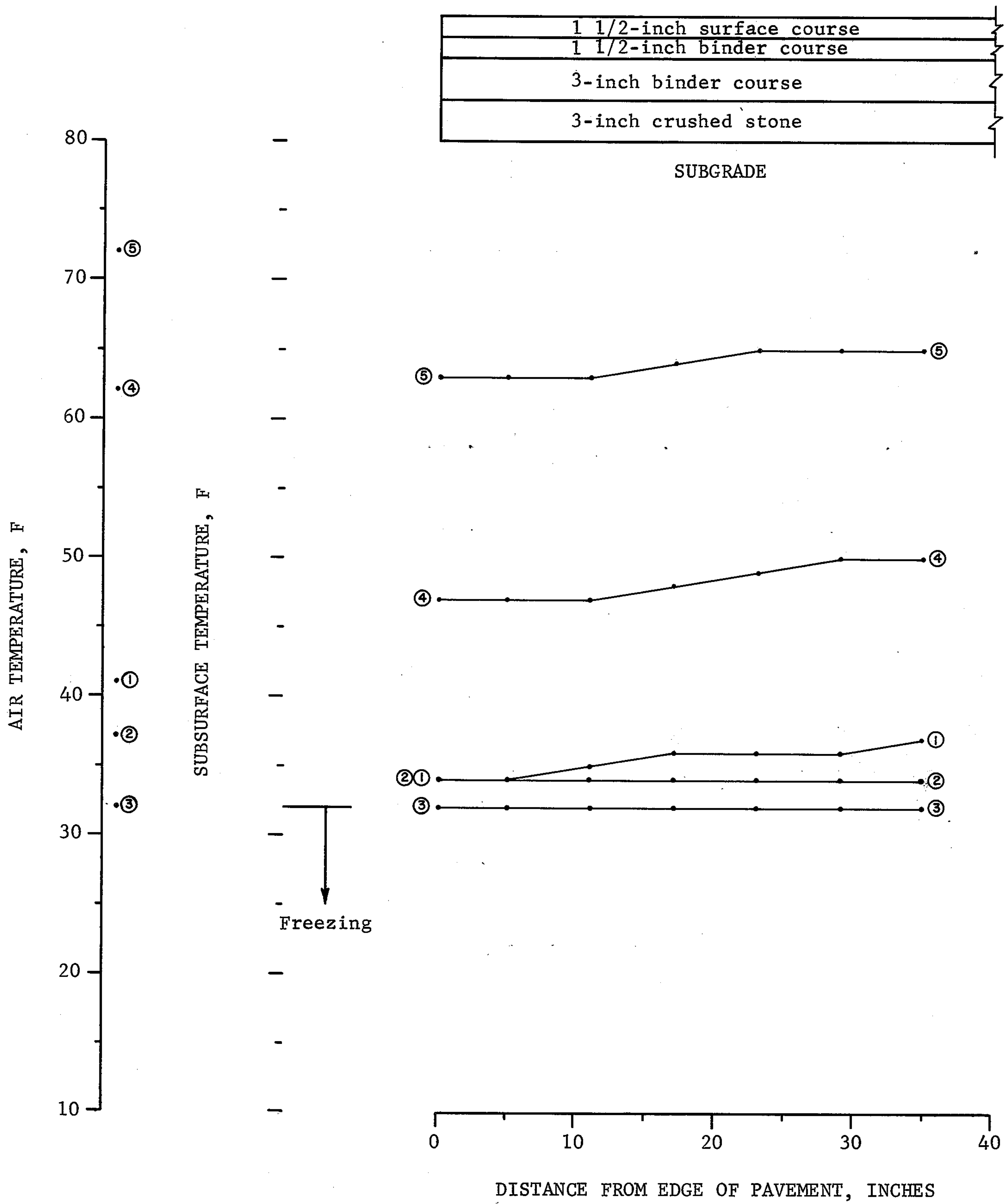


Figure A-11. Distance-temperature data in Control Section, near pavement edge (1971).

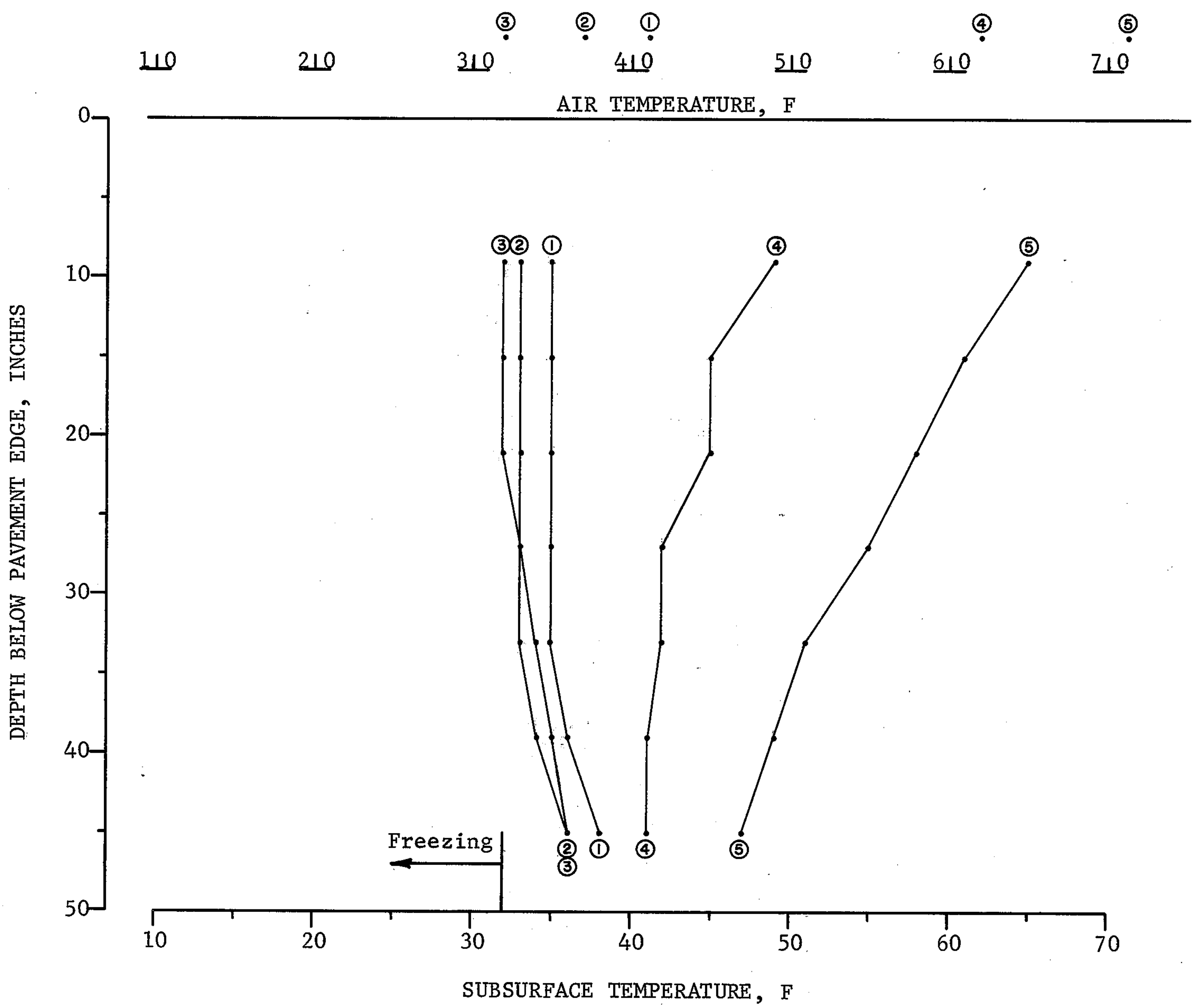


Figure A-12. Depth-temperature data in Control Section, pavement edge (1971).

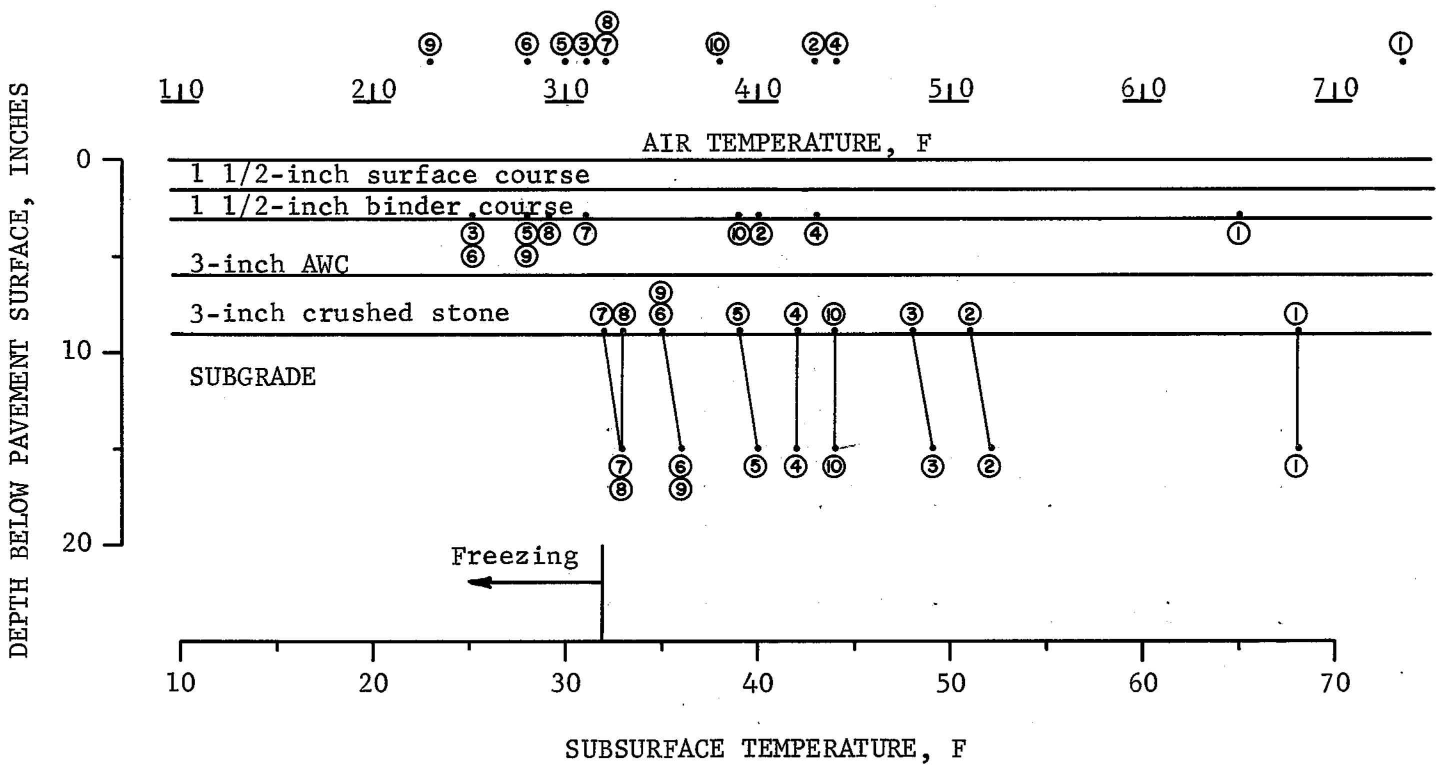


Figure A-13. Depth-temperature data in Test Section No. 1, center of lane (1971-1972).

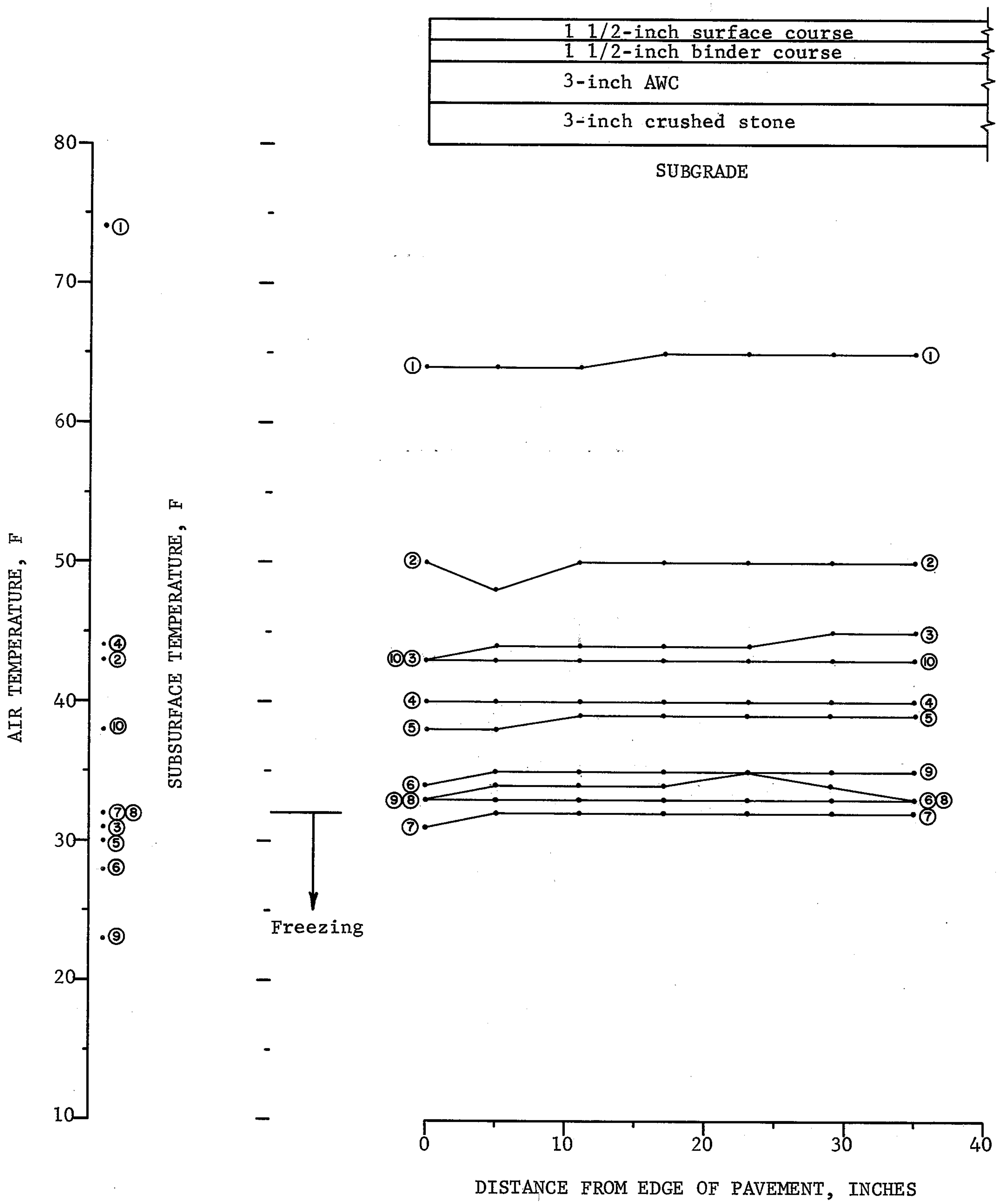


Figure A-14. Distance-temperature data in Test Section No. 1, near pavement edge (1971-1972).

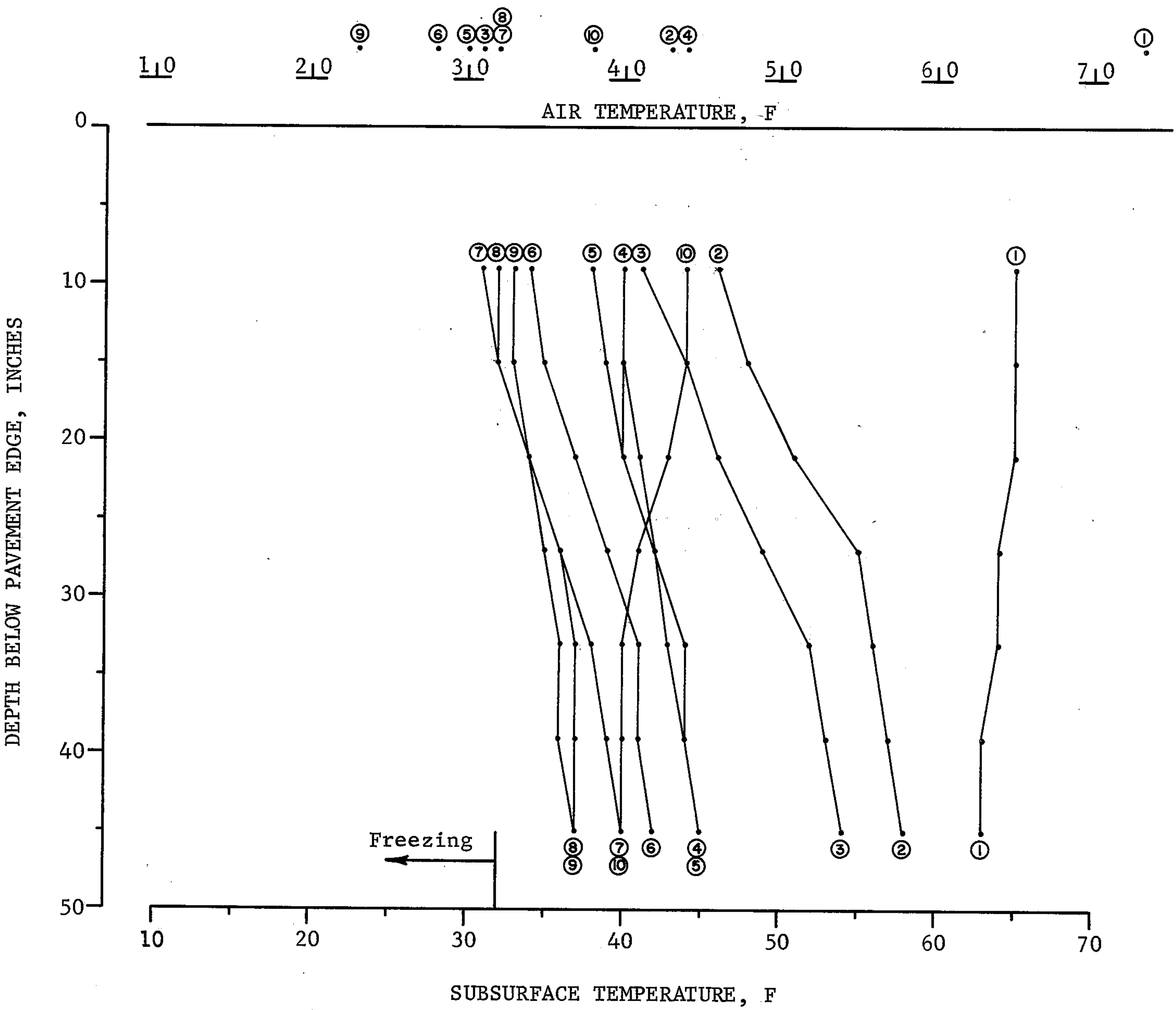


Figure A-15. Depth-temperature data in Test Section No. 1, pavement edge (1971-1972).

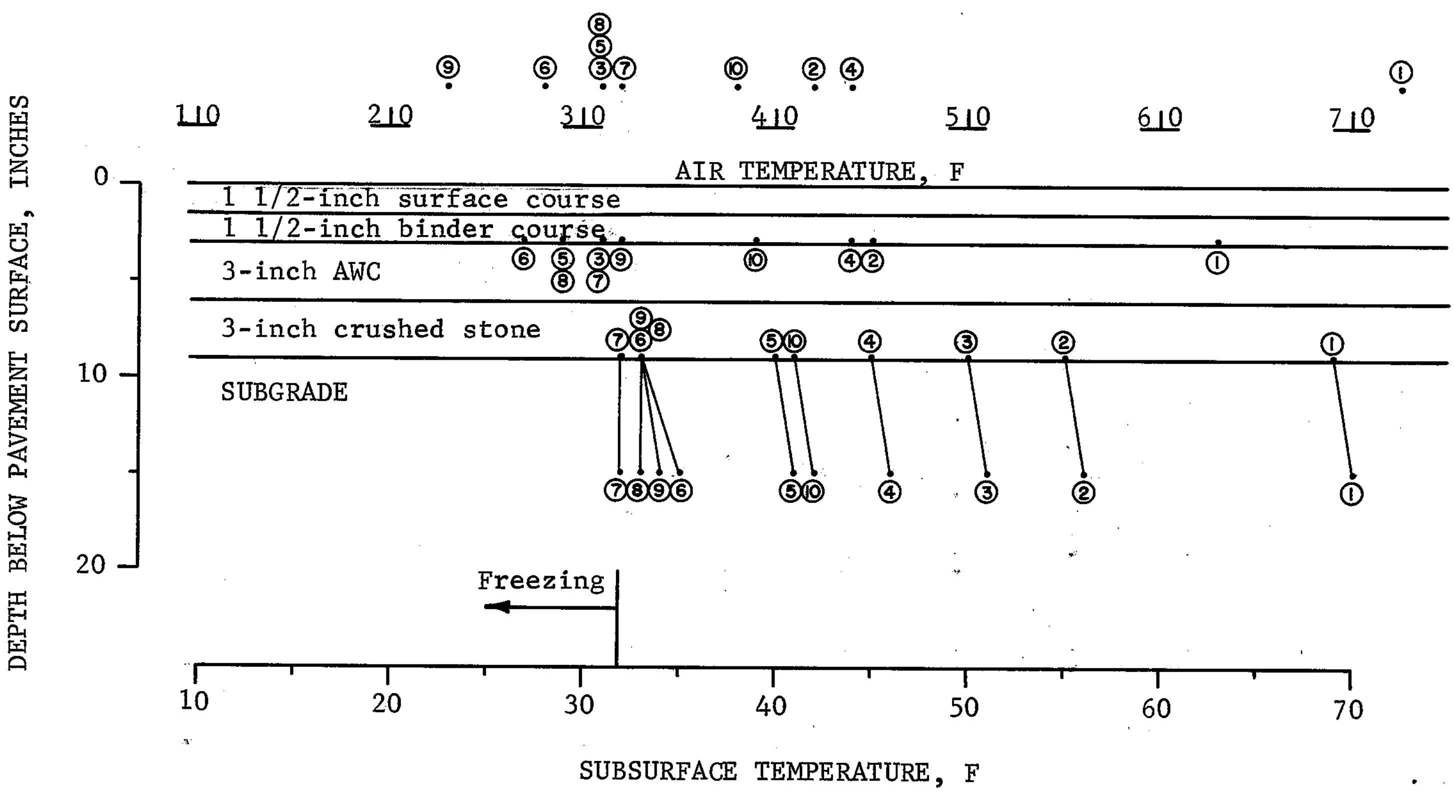


Figure A-16. Depth-temperature data in Test Section No. 2, center of lane (1971-1972).

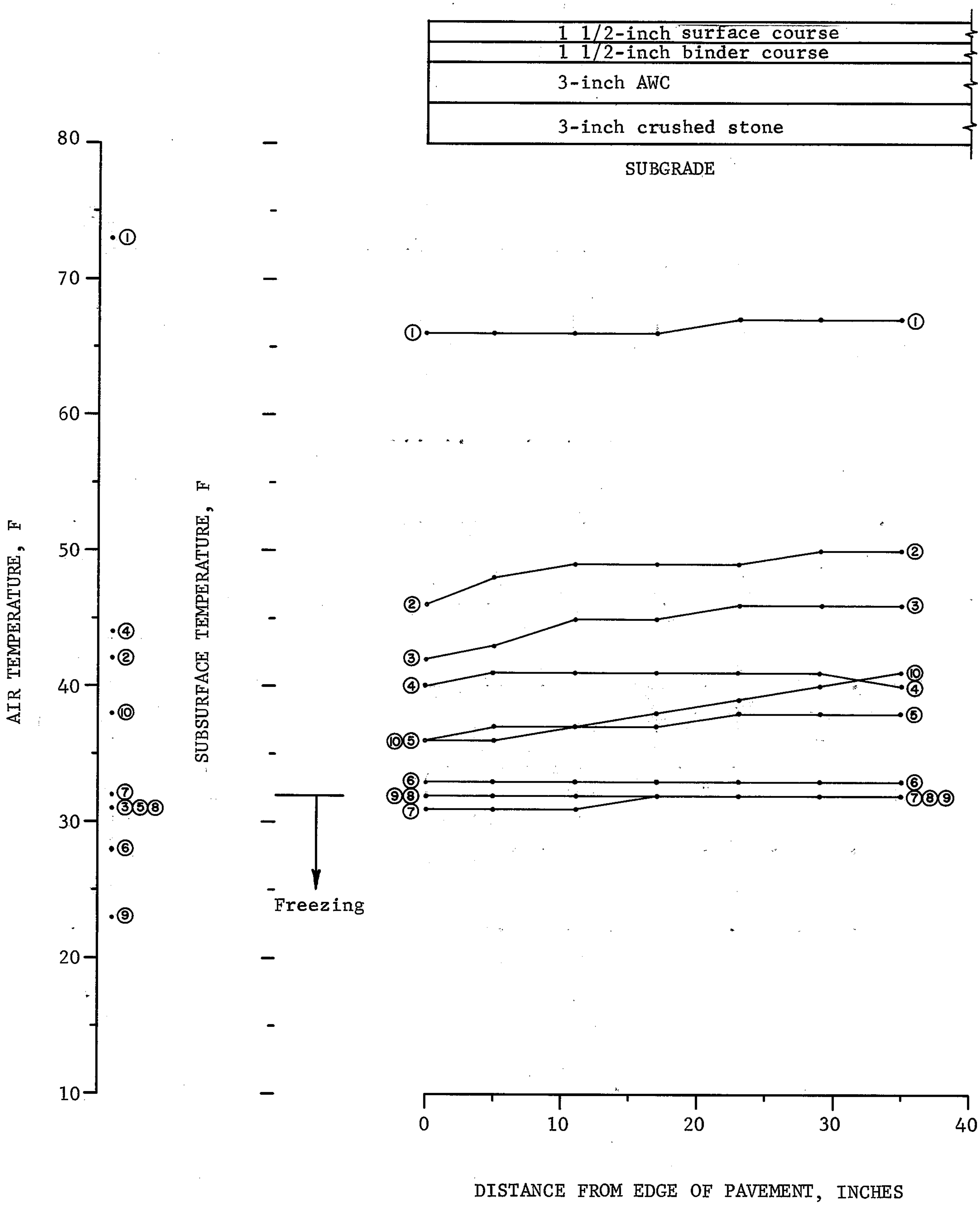


Figure A-17. Distance-temperature data in Test Section No. 2, near pavement edge (1971-1972).

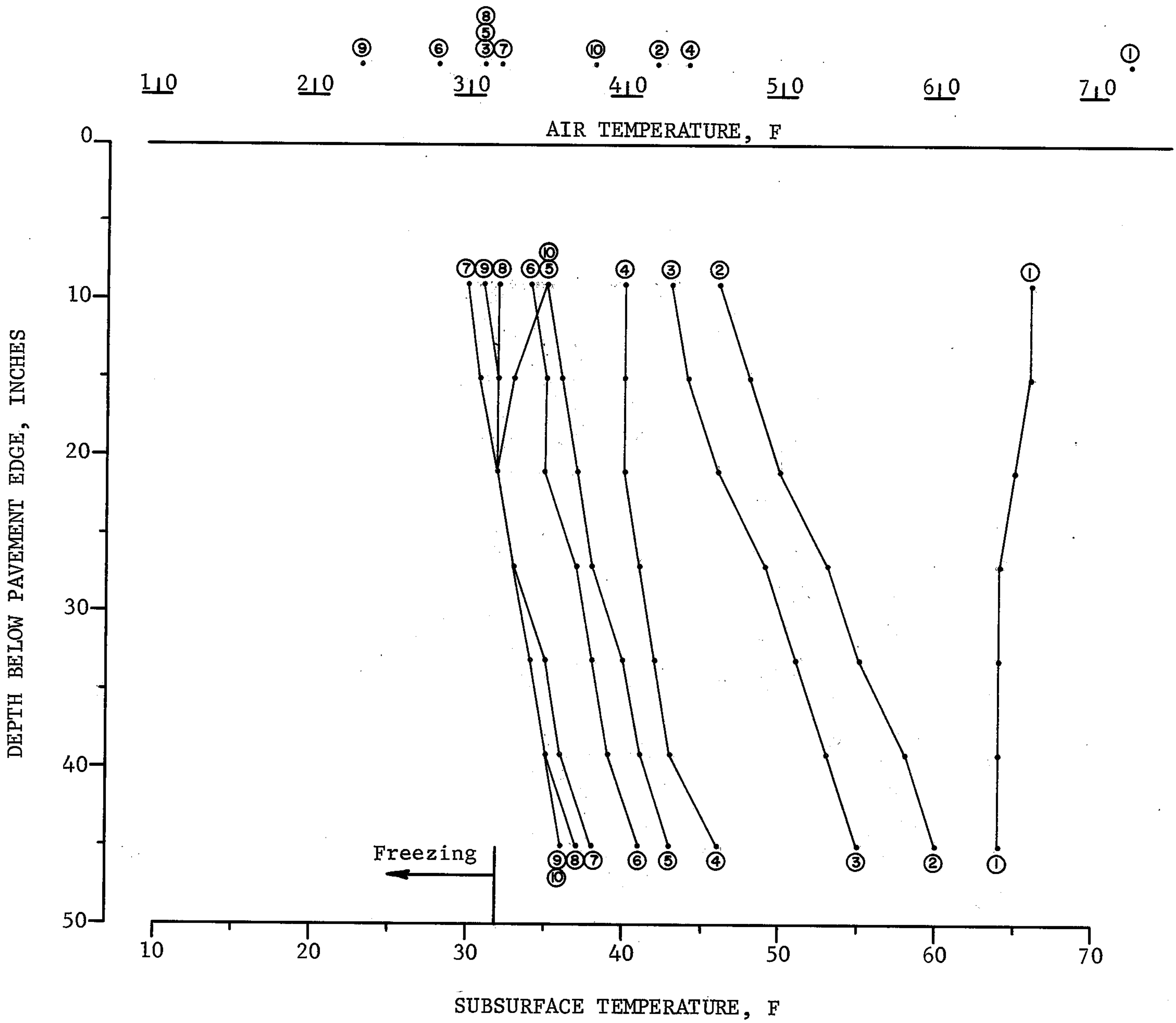


Figure A-18. Depth-temperature data in Test Section No. 2, pavement edge (1971-1972).

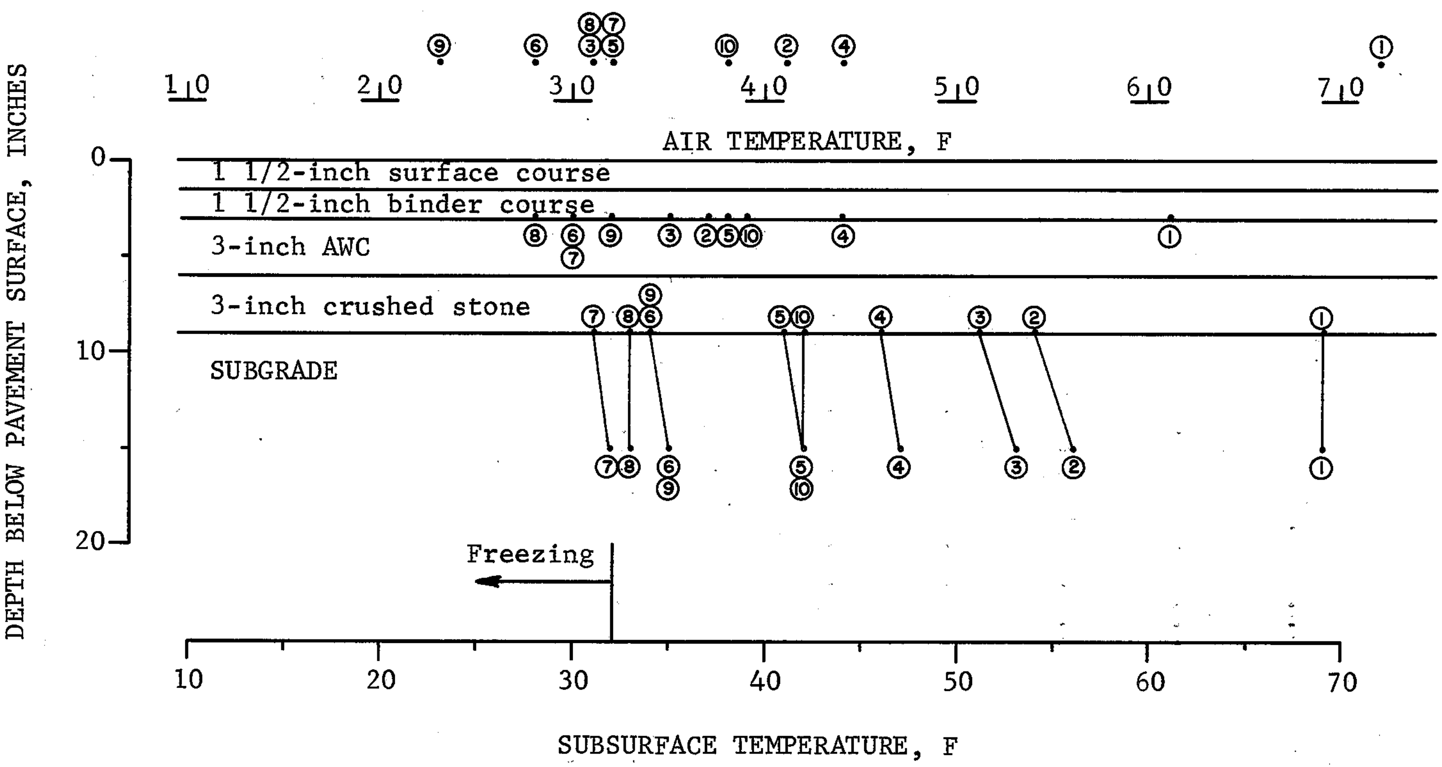


Figure A-19. Depth-temperature data in Test Section No. 3, center of lane (1971-1972).

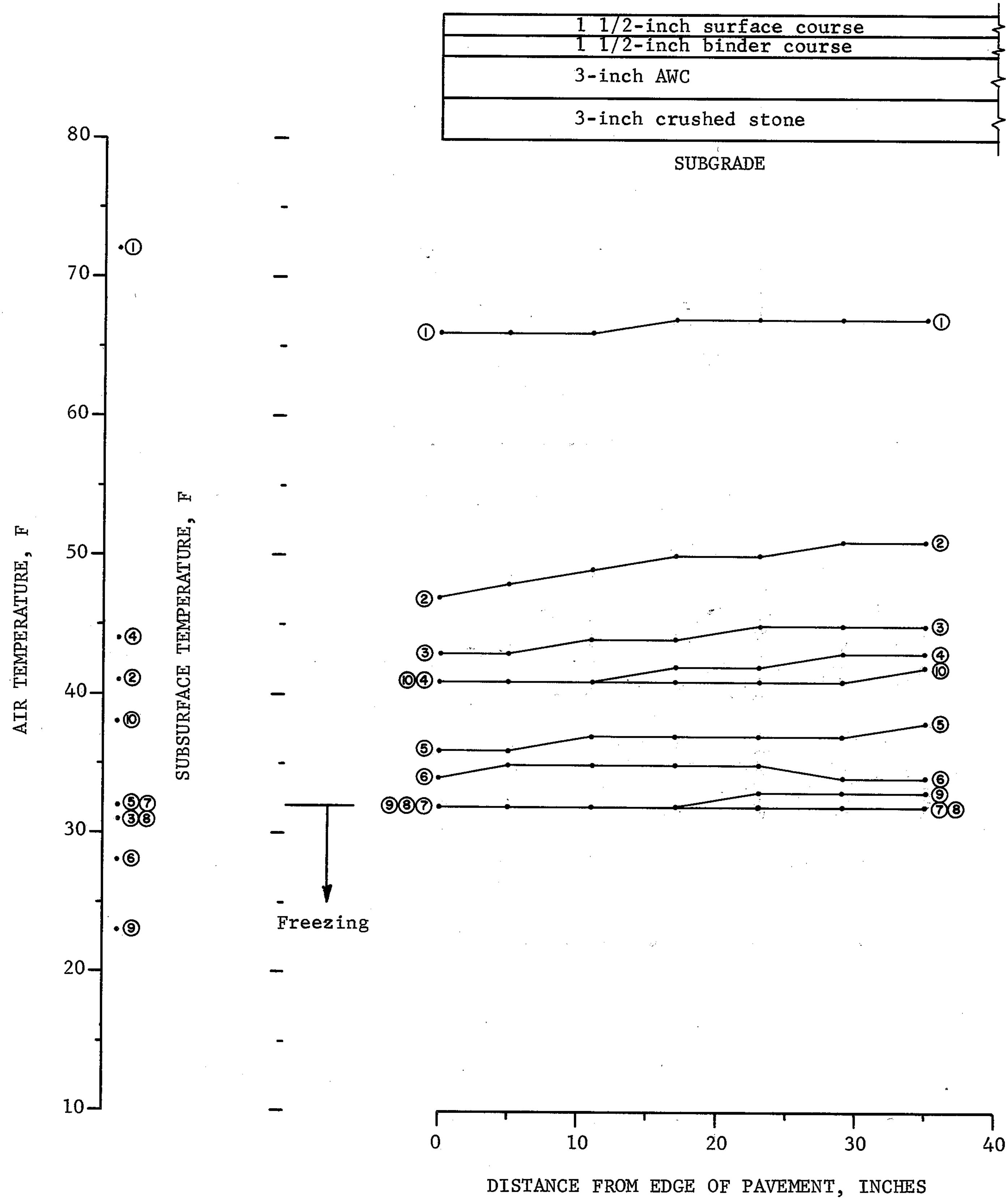


Figure A-20. Distance-temperature data in Test Section No. 3, near pavement edge (1971-1972).

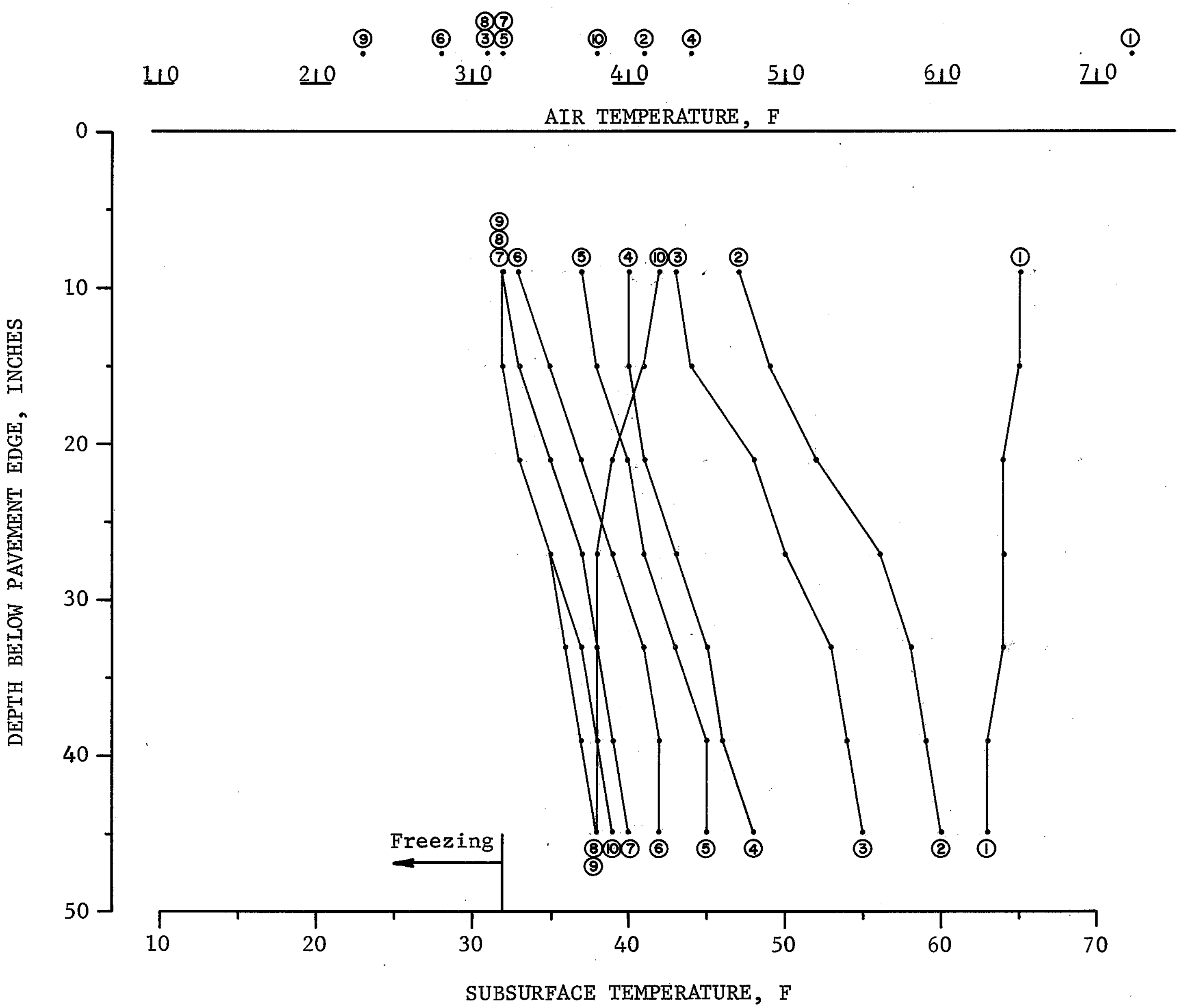


Figure A-21. Depth-temperature data in Test Section No. 3., pavement edge (1971-1972).

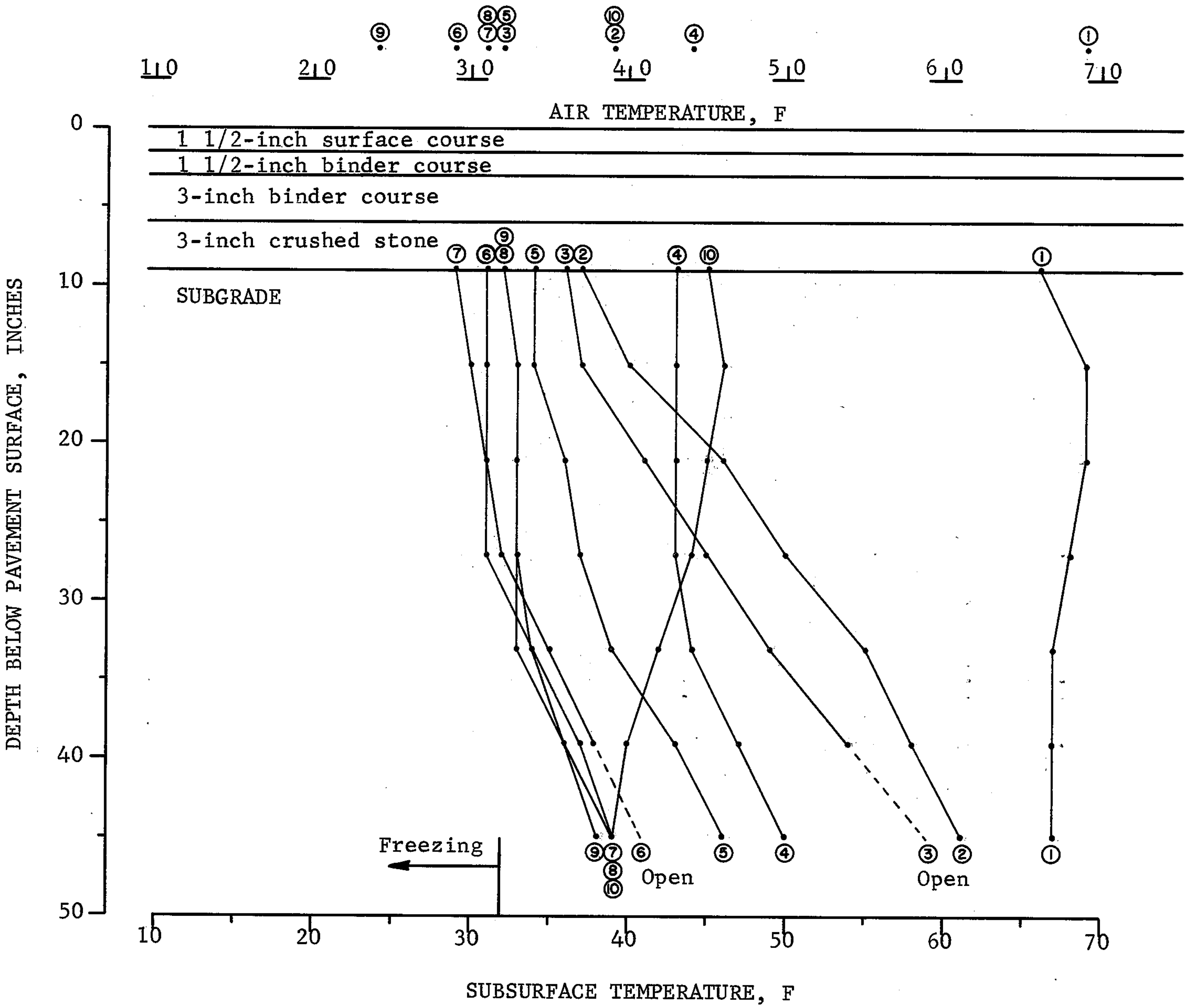


Figure A-22. Depth-temperature data in Control Section, center of lane (1971-1972).

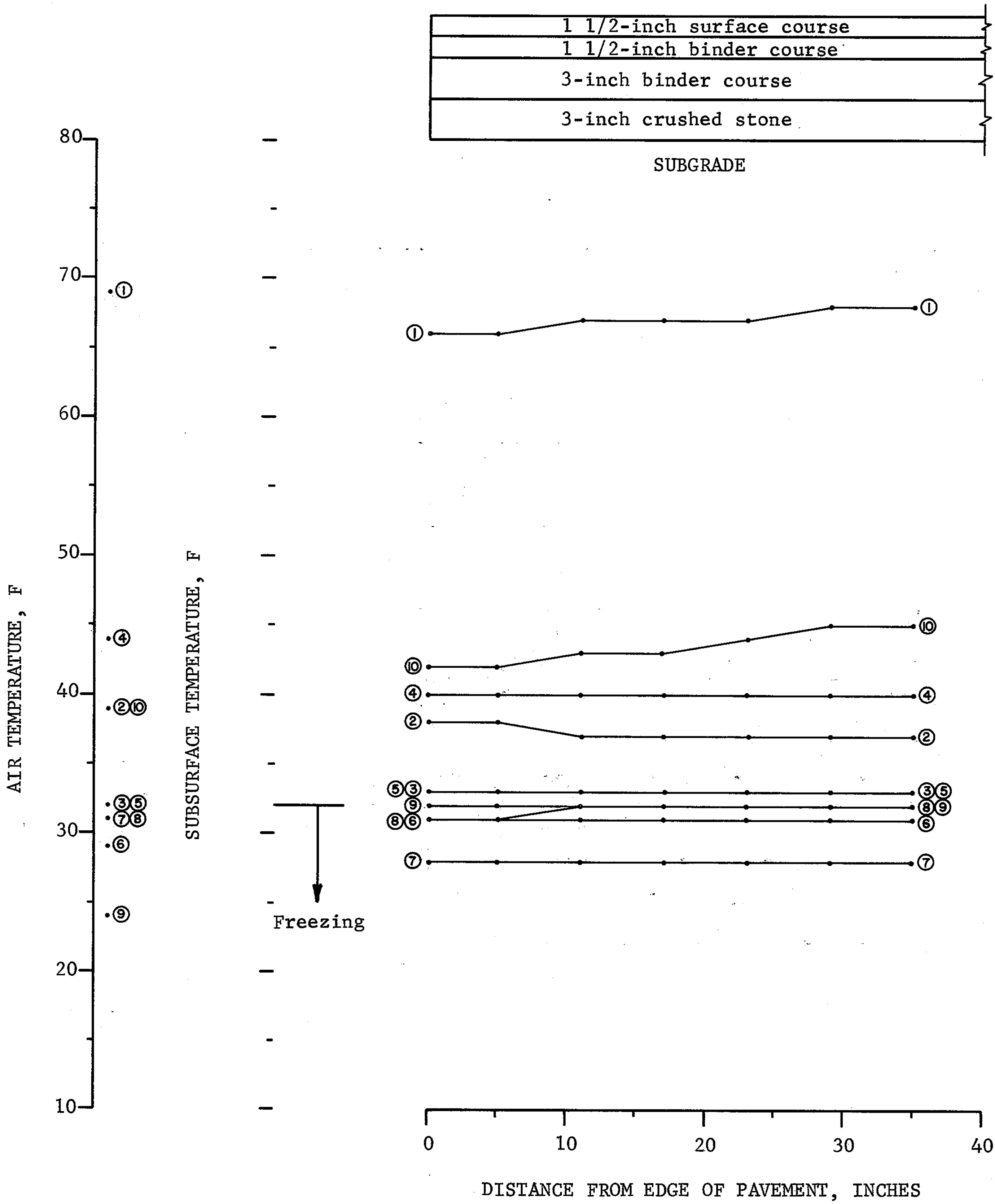


Figure A-23. Distance-temperature data in Control Section, near pavement edge (1971-1972).

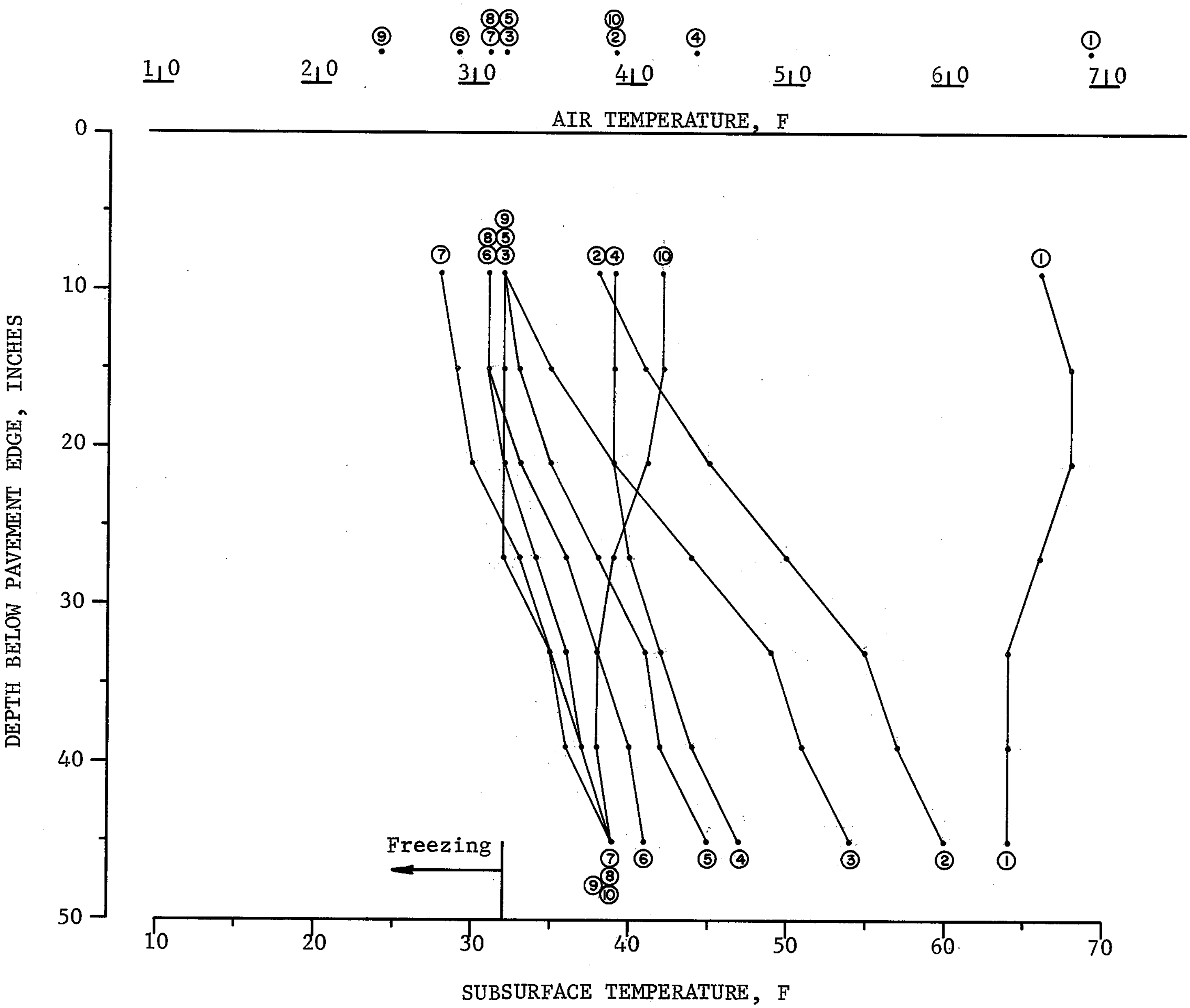


Figure A-24. Depth-temperature data in Control Section, pavement edge (1971-1972).

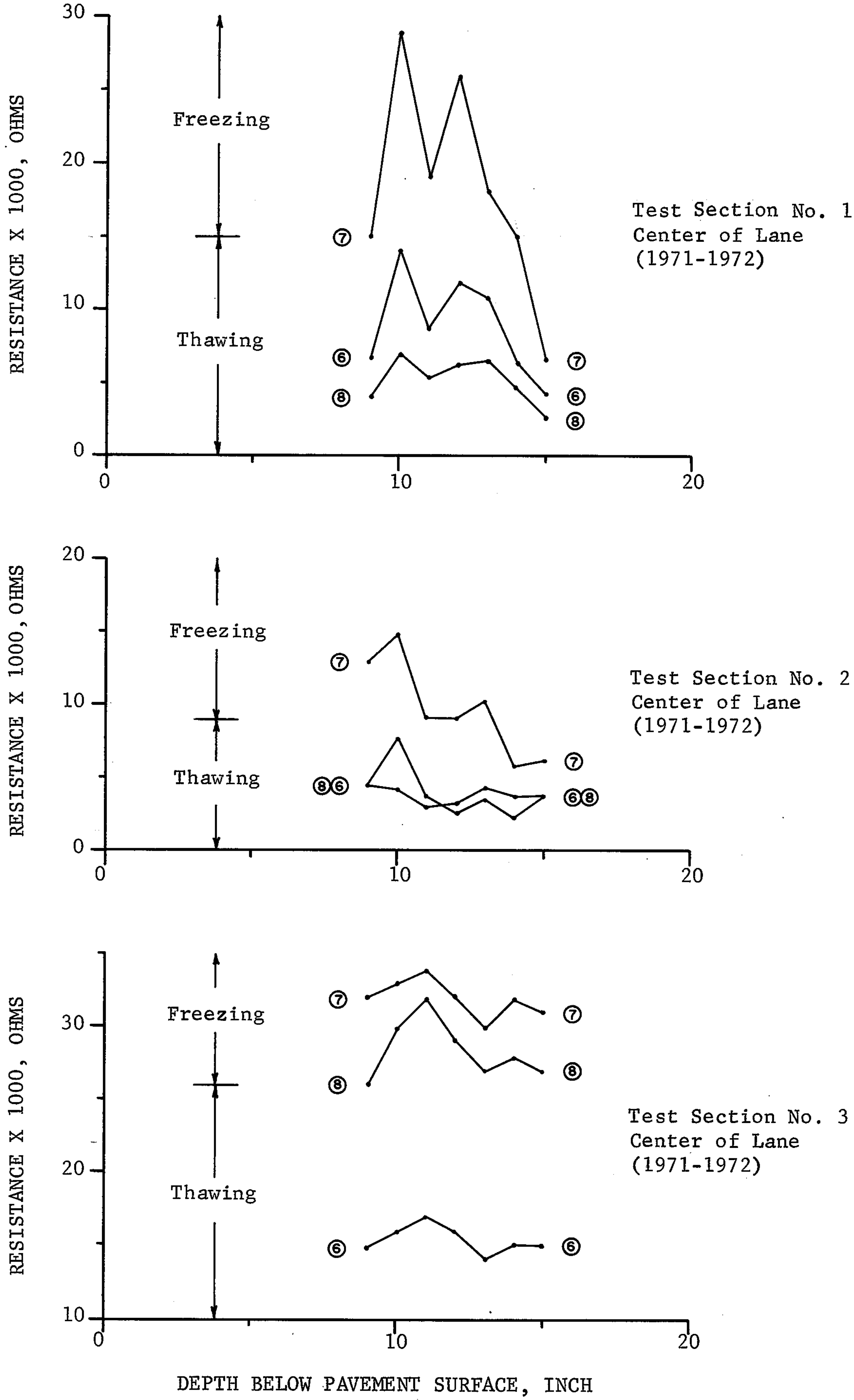


Figure A-25. Typical soil depth versus resistance relationship.

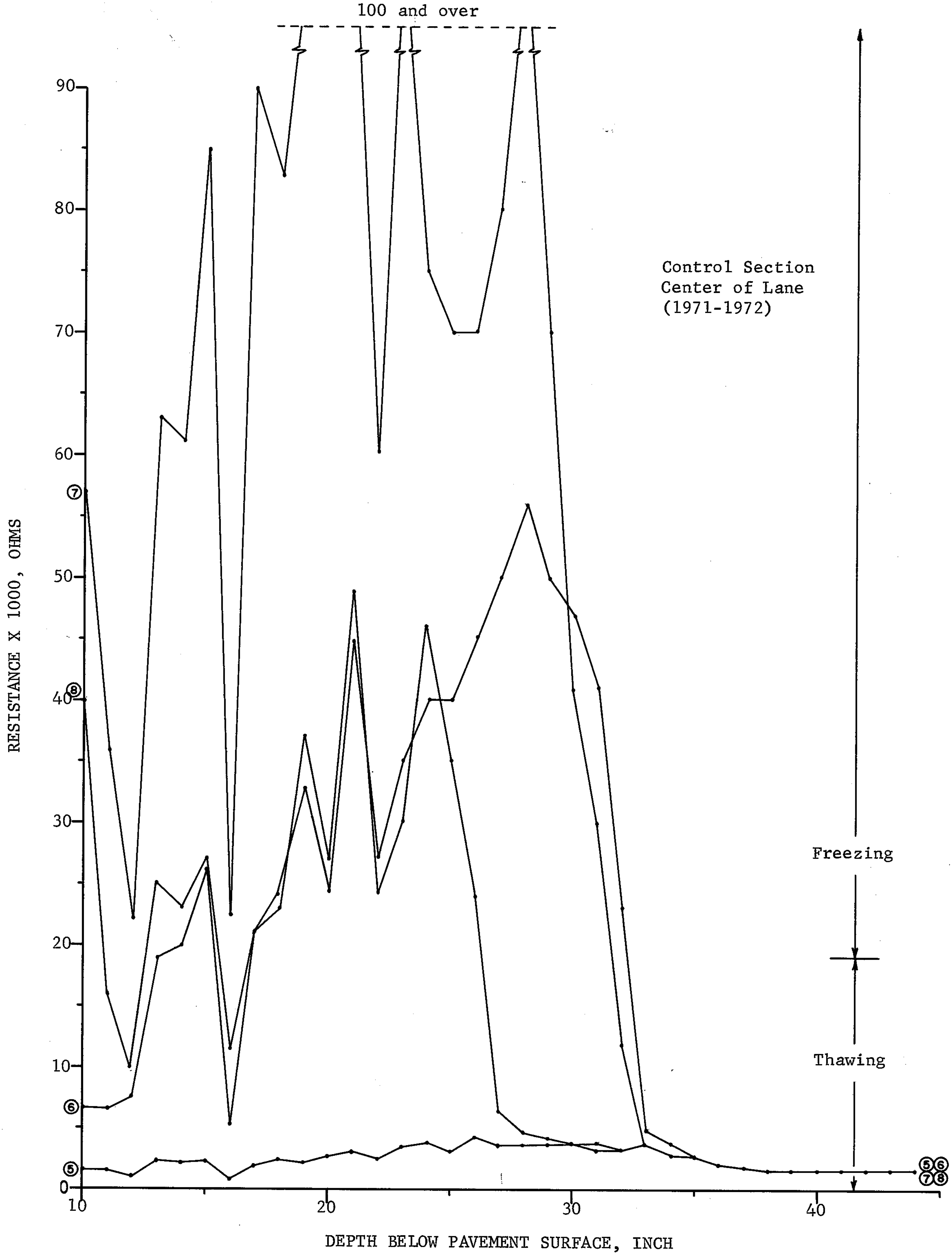


Figure A-26. Typical soil depth versus resistance relationships.

APPENDIX B

DEPTH-TEMPERATURE AND DEPTH-RESISTANCE RELATIONSHIPS IN THE AWC EXPERIMENTAL PROJECT

Figures B-1 to B-36 show the depth-temperature data in Test Sections No. 1 to No. 5 and in Control Sections No. 1 and No. 2. These data were taken from the thermocouple readings in the outer lane center, inner lane center, outer lane curb, and outer lane shoulder. Figures B-37 to B-40 show the typical soil depth-resistance relationships in the outer lane center of the test and control sections. The encircled numbers in the figure correspond to the dates the thermocouple and frost gage readings were recorded. The corresponding numbers and dates are as follow:

Number	1970-1971 Cold Season
1	November 29, 1970
2	December 21, 1970
3	December 31, 1970
4	January 10, 1971
5	January 28, 1971
6	February 11, 1971
7	February 24, 1971
8	March 9, 1971
9	March 23, 1971
10	April 7, 1971
11	April 20, 1971

Number	1971-1972 Cold Season
1	October 5, 1971
2	October 19, 1971
3	November 9, 1971
4	November 23, 1971
5	December 7, 1971
6	December 21, 1971
7	January 4, 1972
8	January 18, 1972
9	February 1, 1972
10	February 24, 1972
11	March 7, 1972
12	March 21, 1972

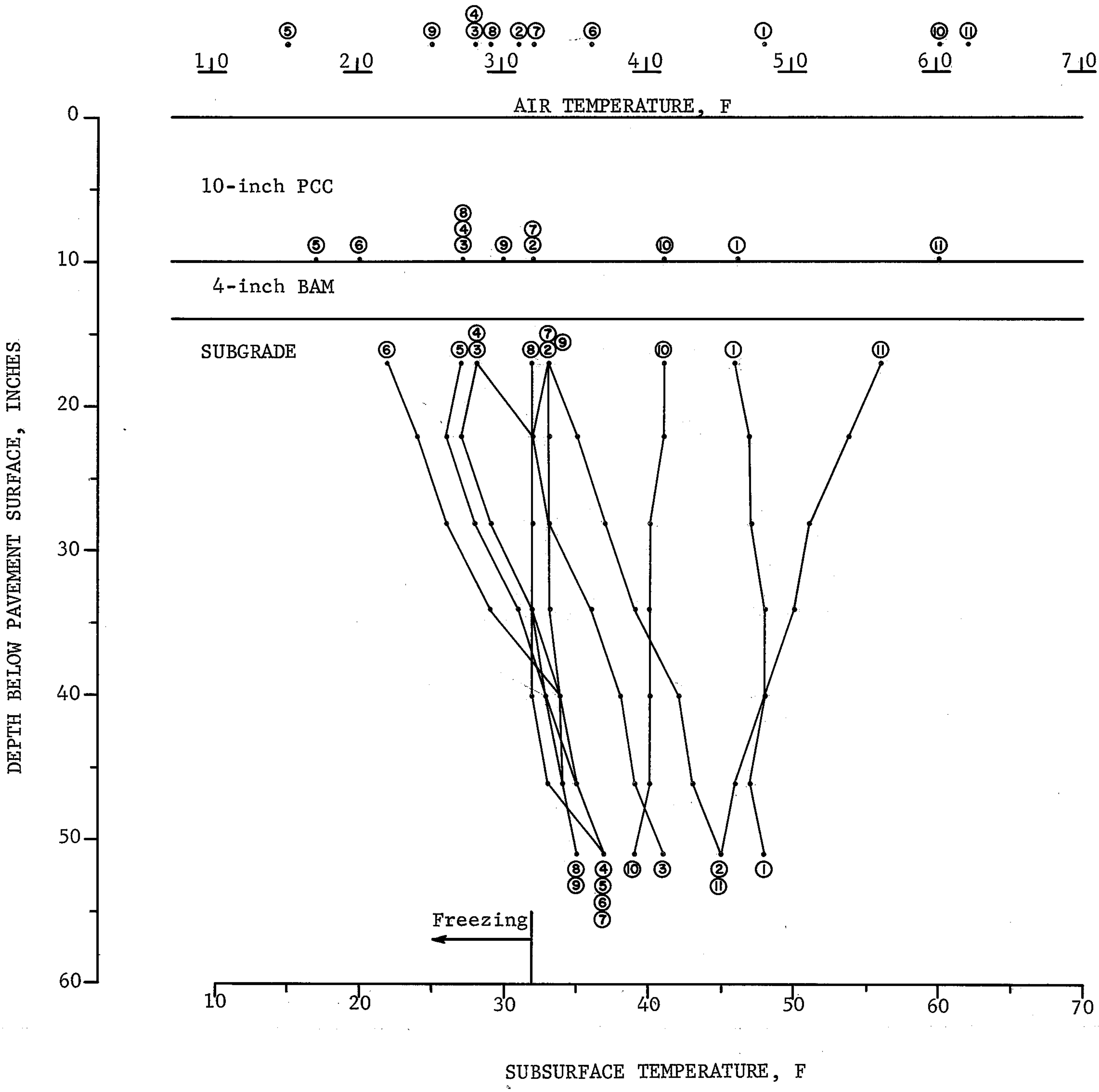


Figure B-1. Depth-temperature data in Control Section No. 1, outer lane center (1970-1971).

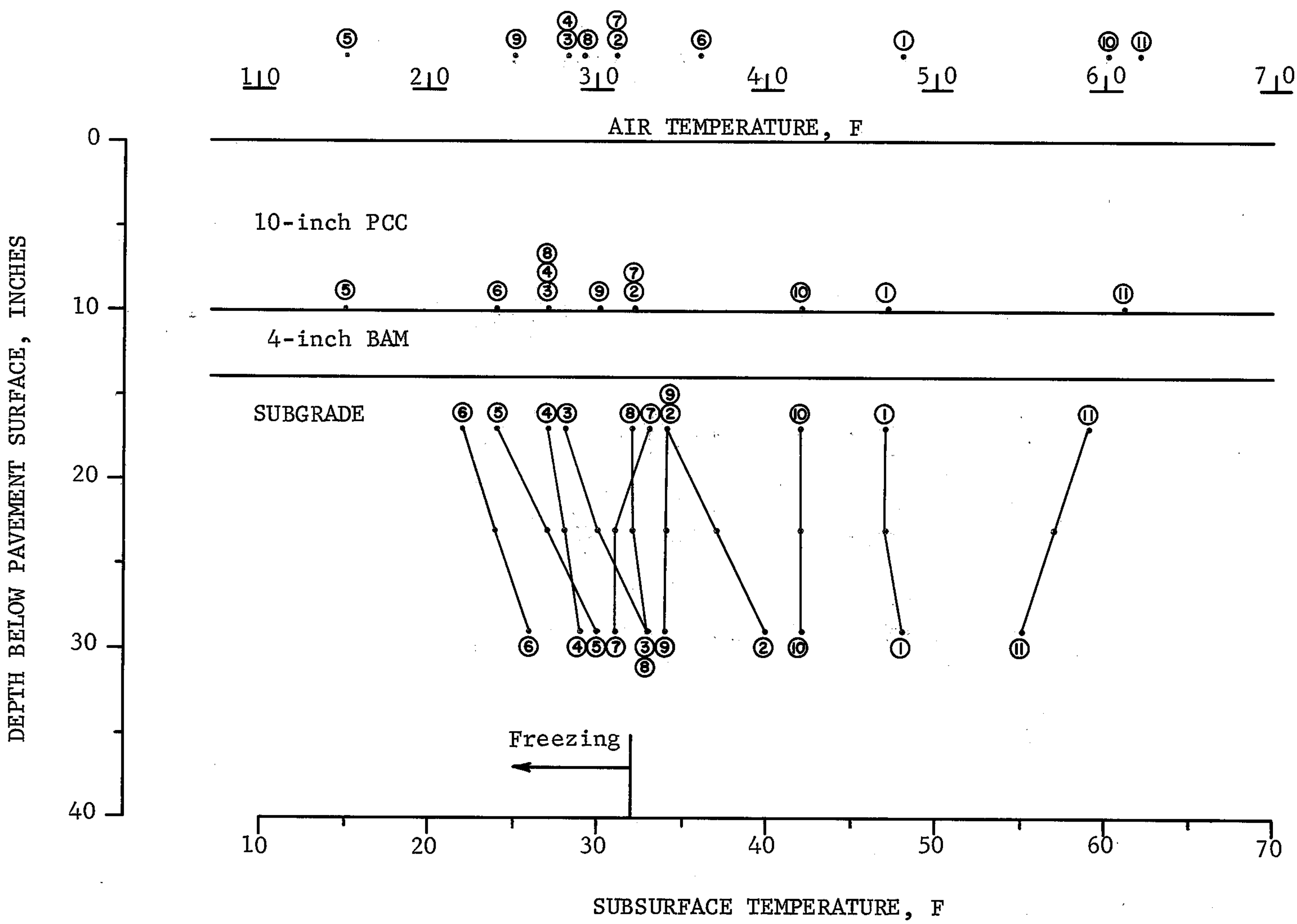


Figure B-2. Depth-temperature data in Control Section No. 1, inner lane center (1970-1971).

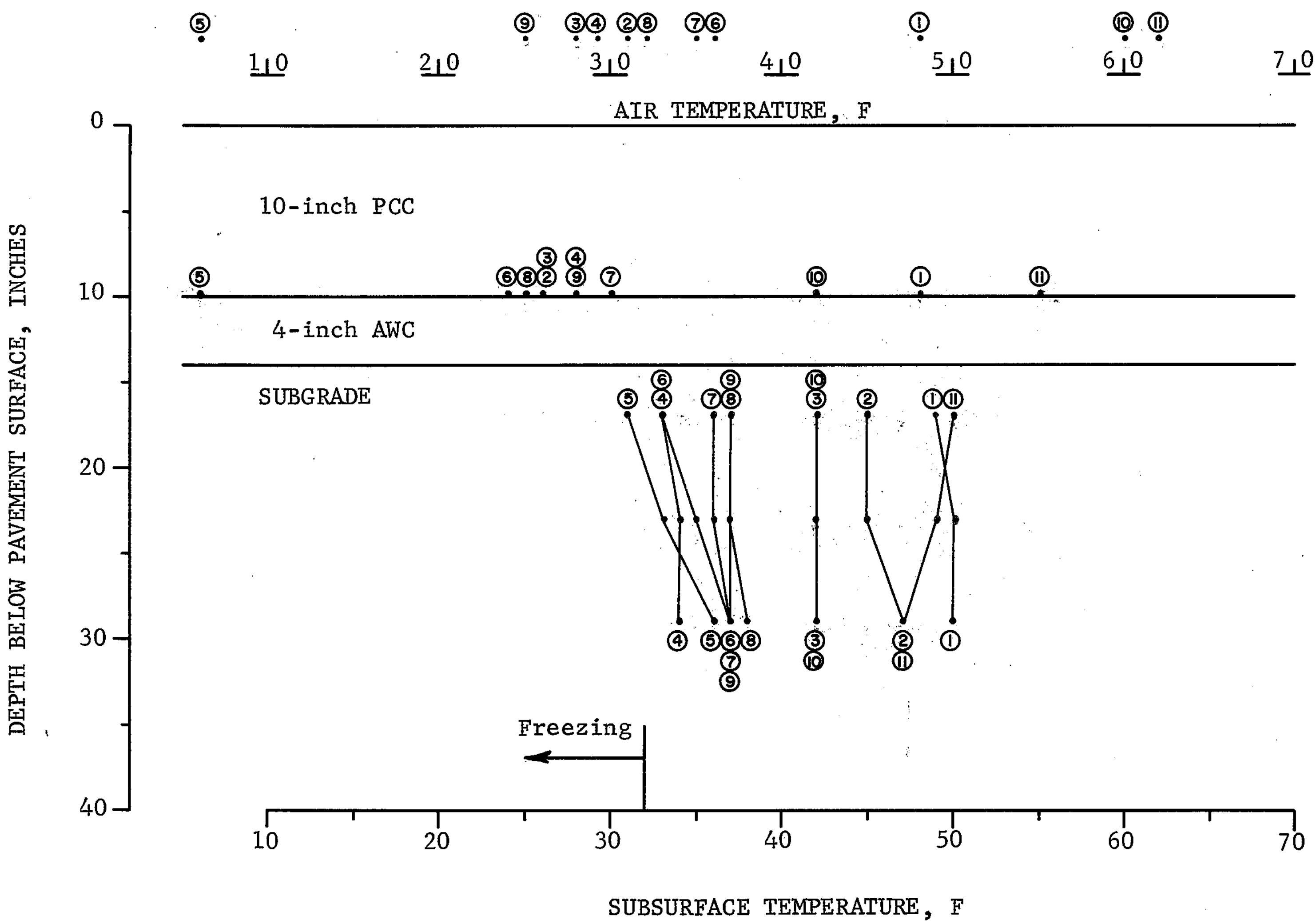


Figure B-3. Depth-temperature data in Test Section No. 1, outer lane center (1970-1971).

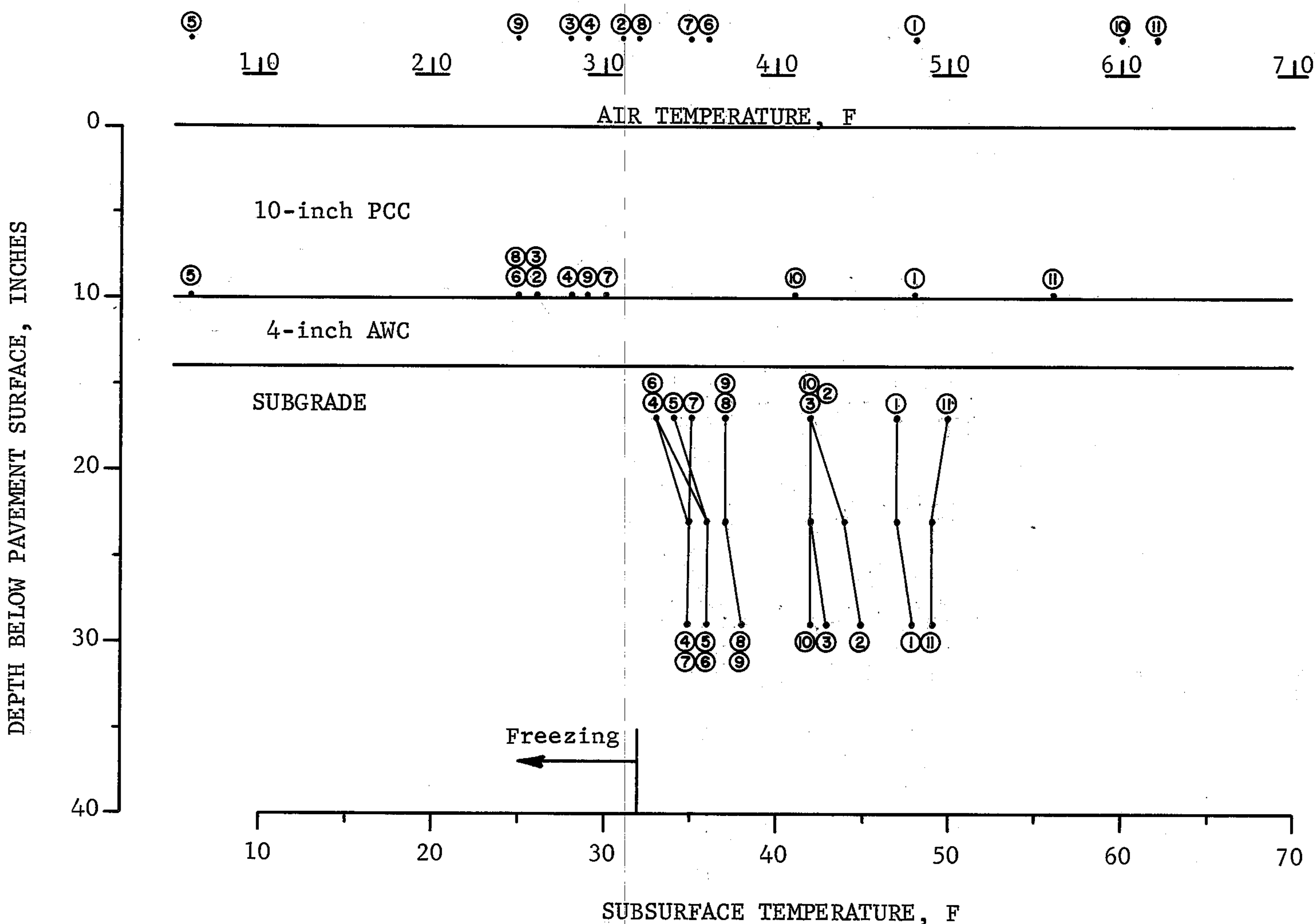


Figure B-4. Depth-temperature data in Test Section No. 1, inner lane center (1970-1971).

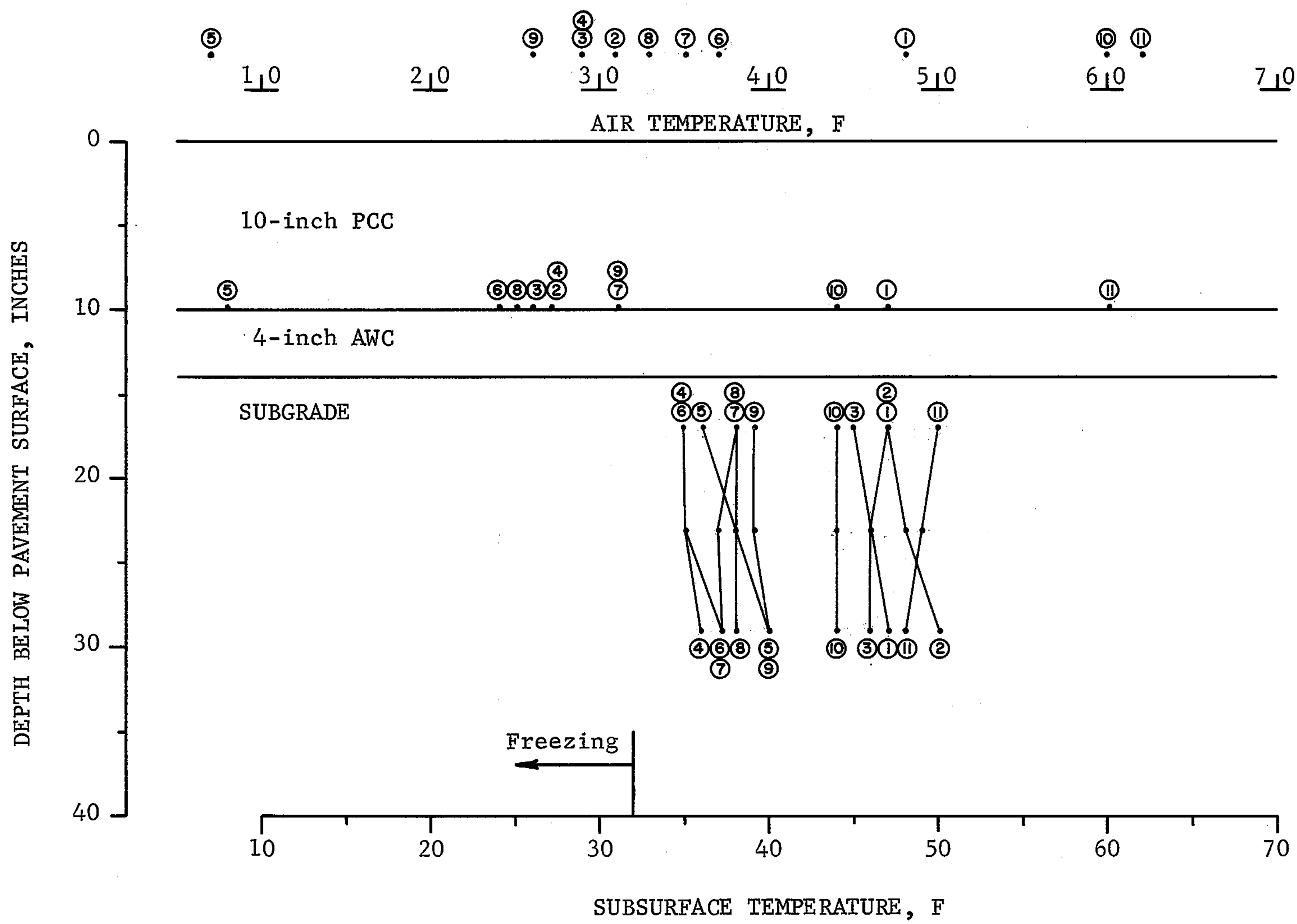


Figure B-5. Depth-temperature data in Test Section No. 2, outer lane center (1970-1971).

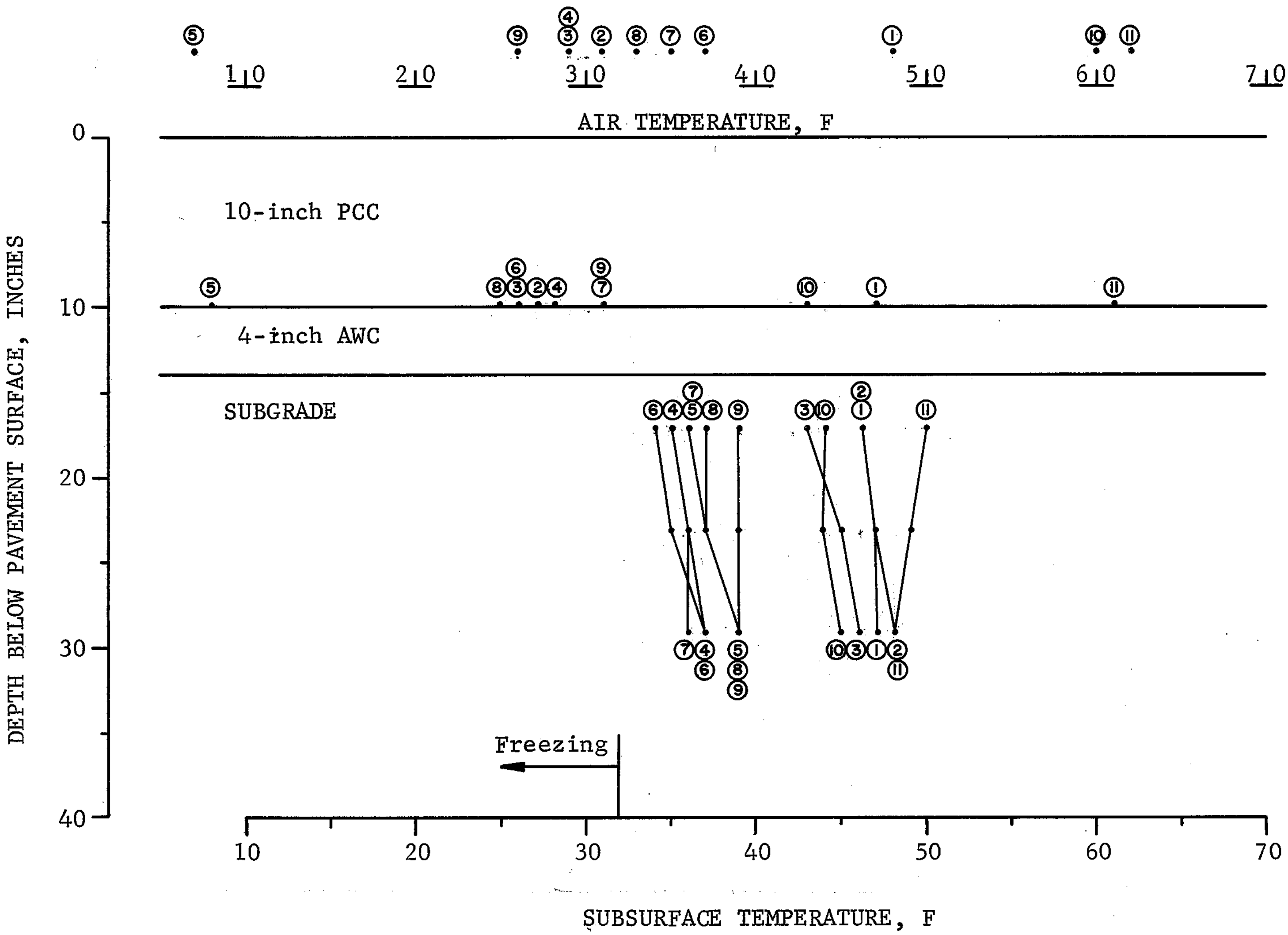


Figure B-6. Depth-temperature data in Test Section No. 2, inner lane center (1970-1971).

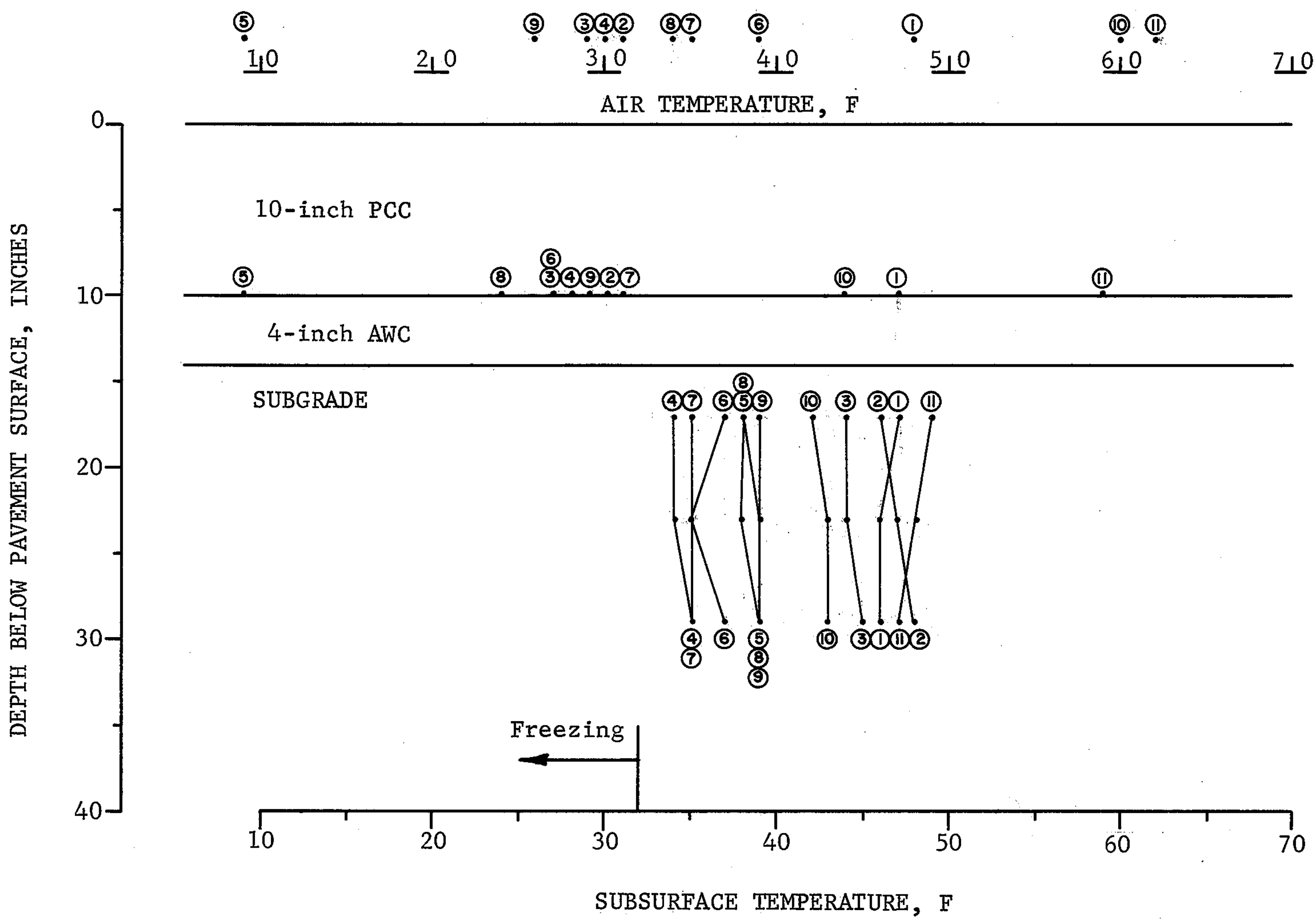


Figure B-7. Depth-temperature data in Test Section No. 3, outer lane center (1970-1971).

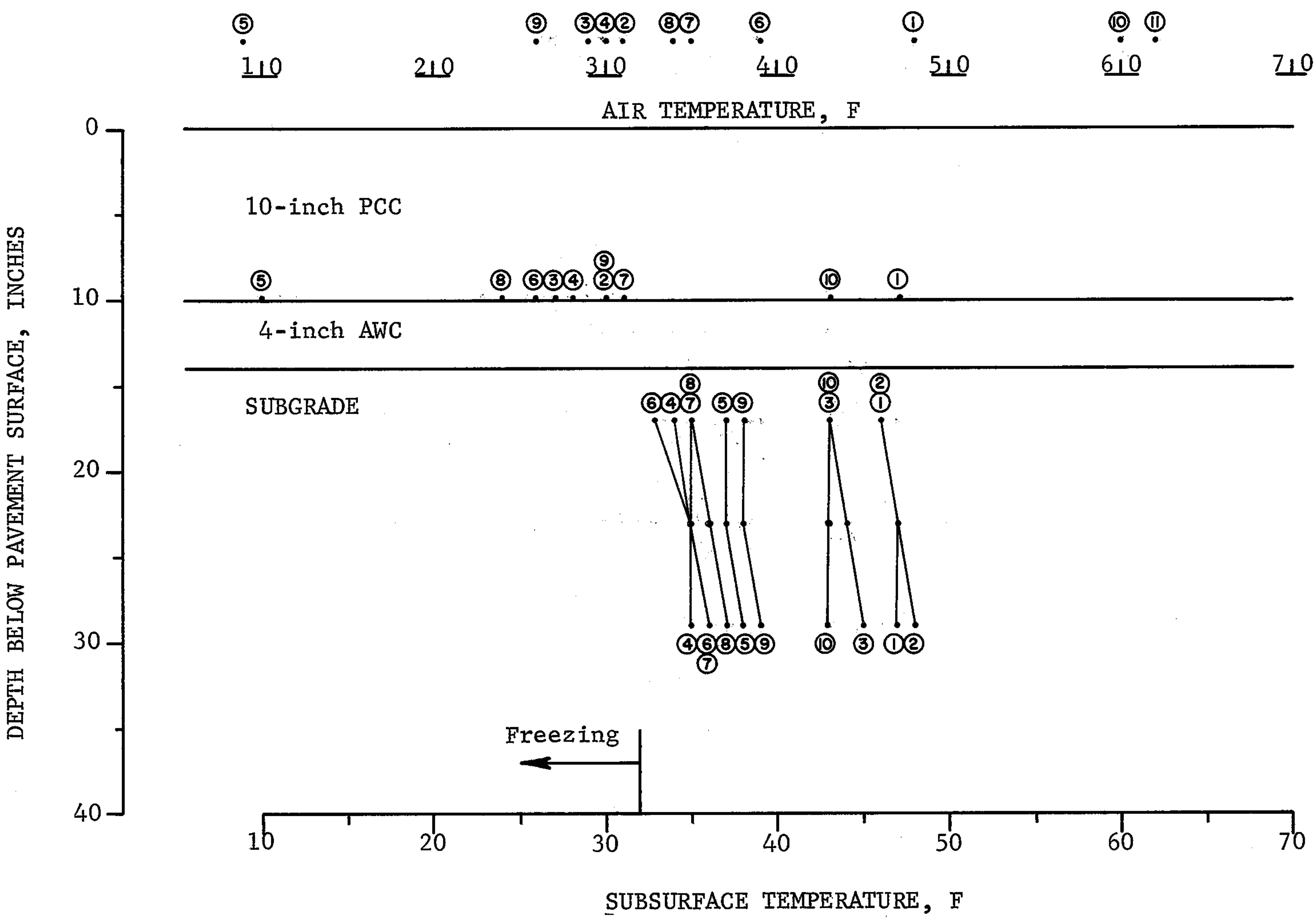


Figure B-8. Depth-temperature data in Test Section No. 3, inner lane center (1970-1971).

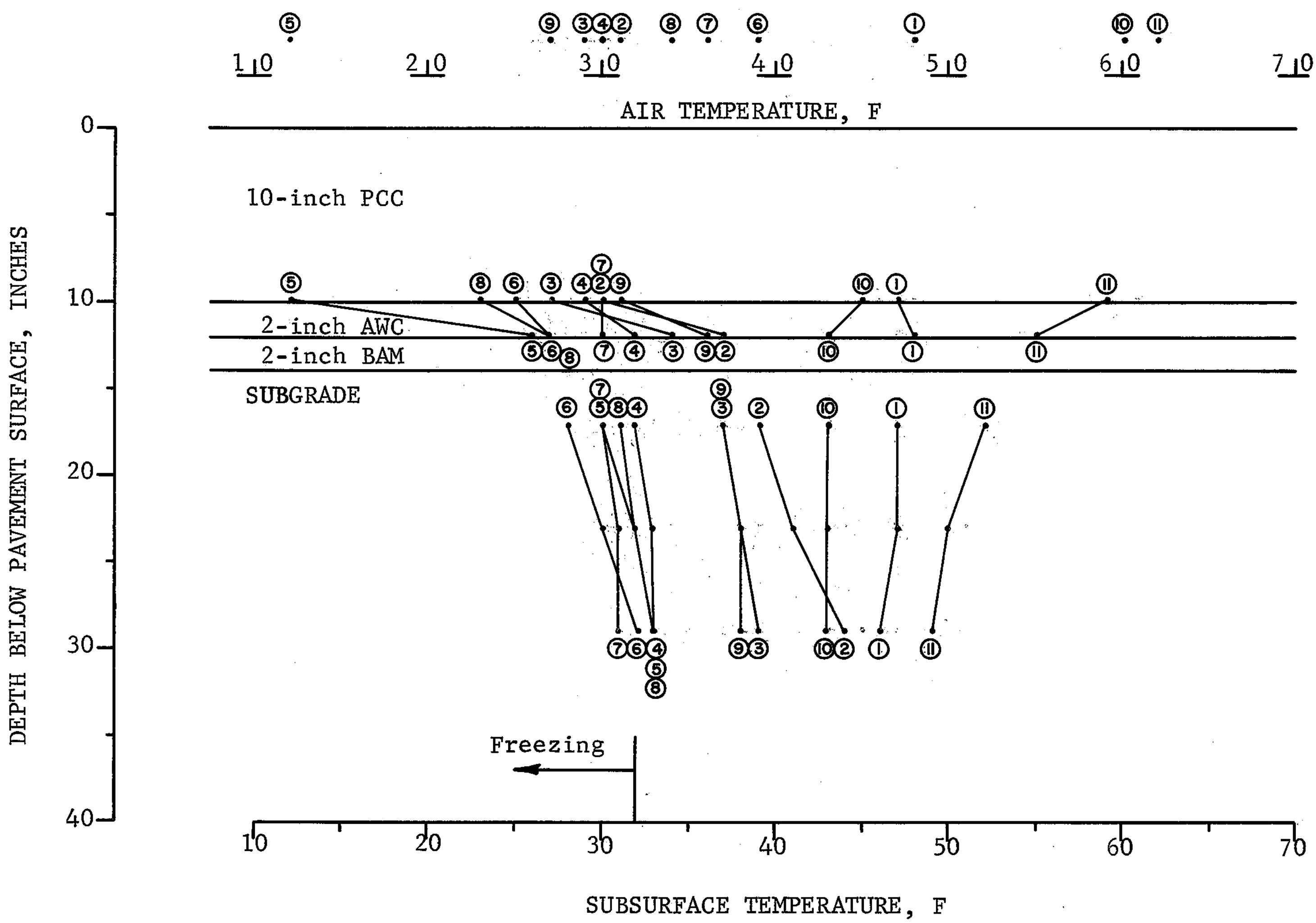


Figure B-9. Depth-temperature data in Test Section No. 4, outer lane center (1970-1971).

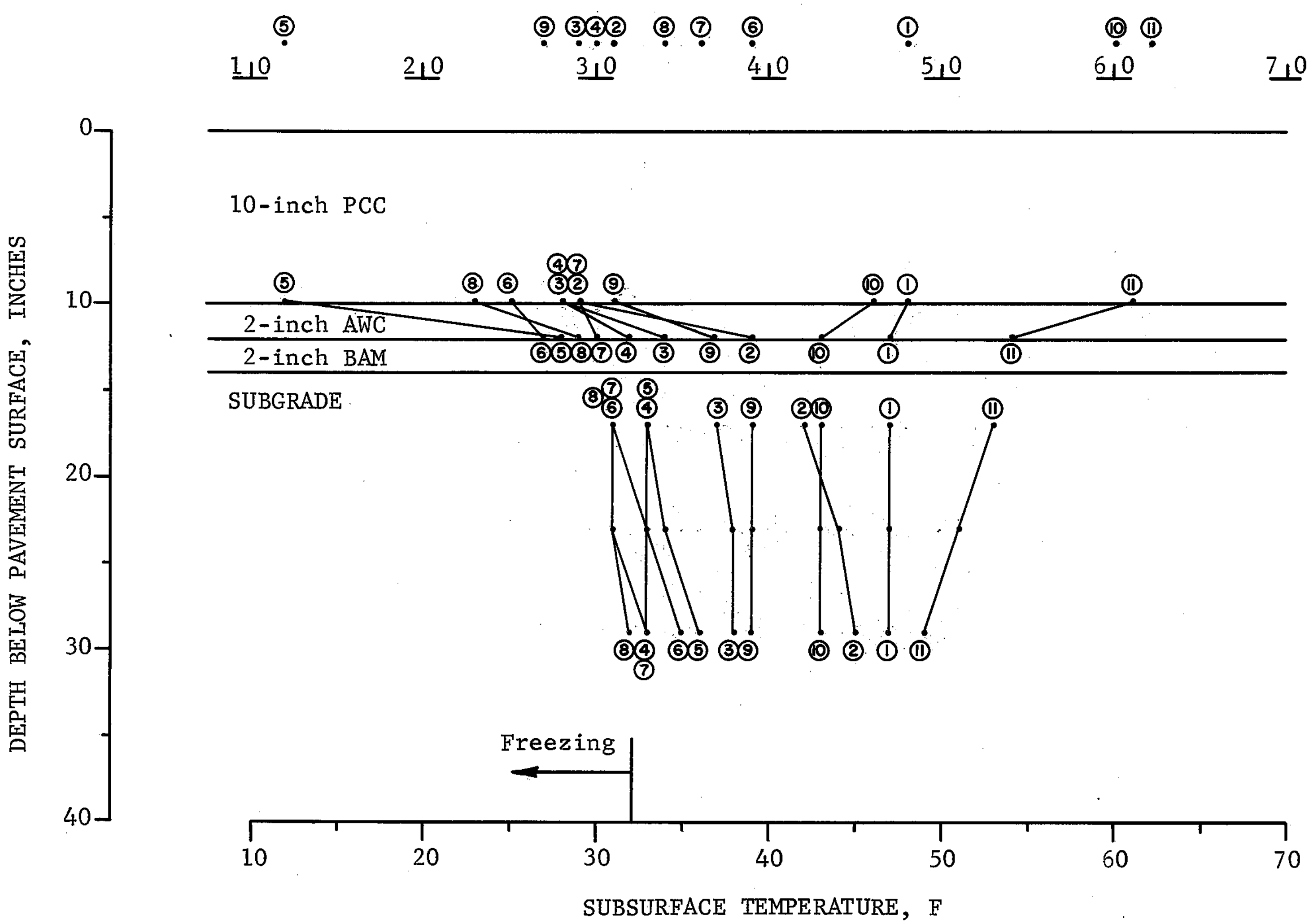


Figure B-10. Depth-temperature data in Test Section No. 4, inner lane center (1970-1971).

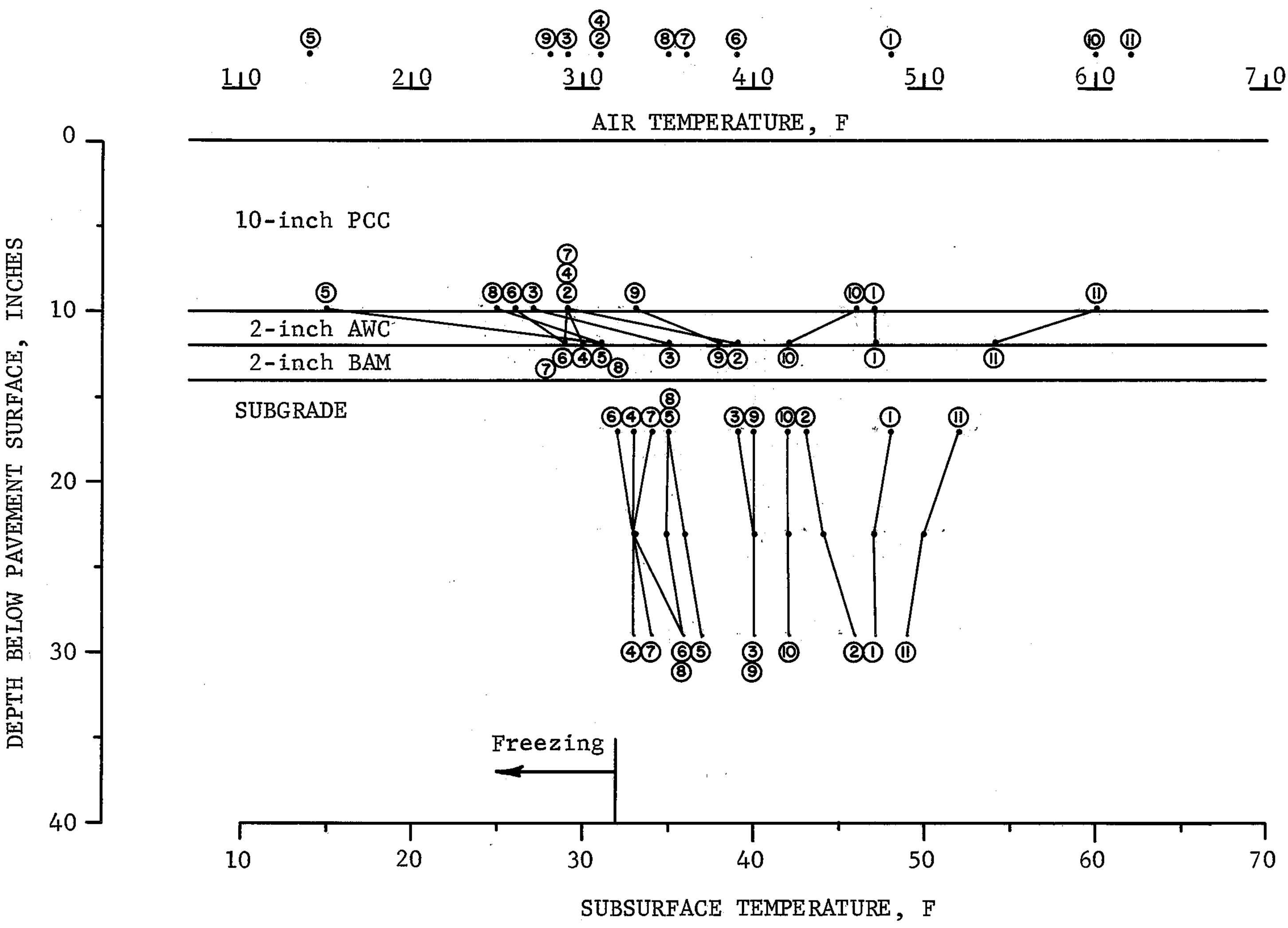


Figure B-11. Depth-temperature data in Test Section No. 5, outer lane center (1970-1971).

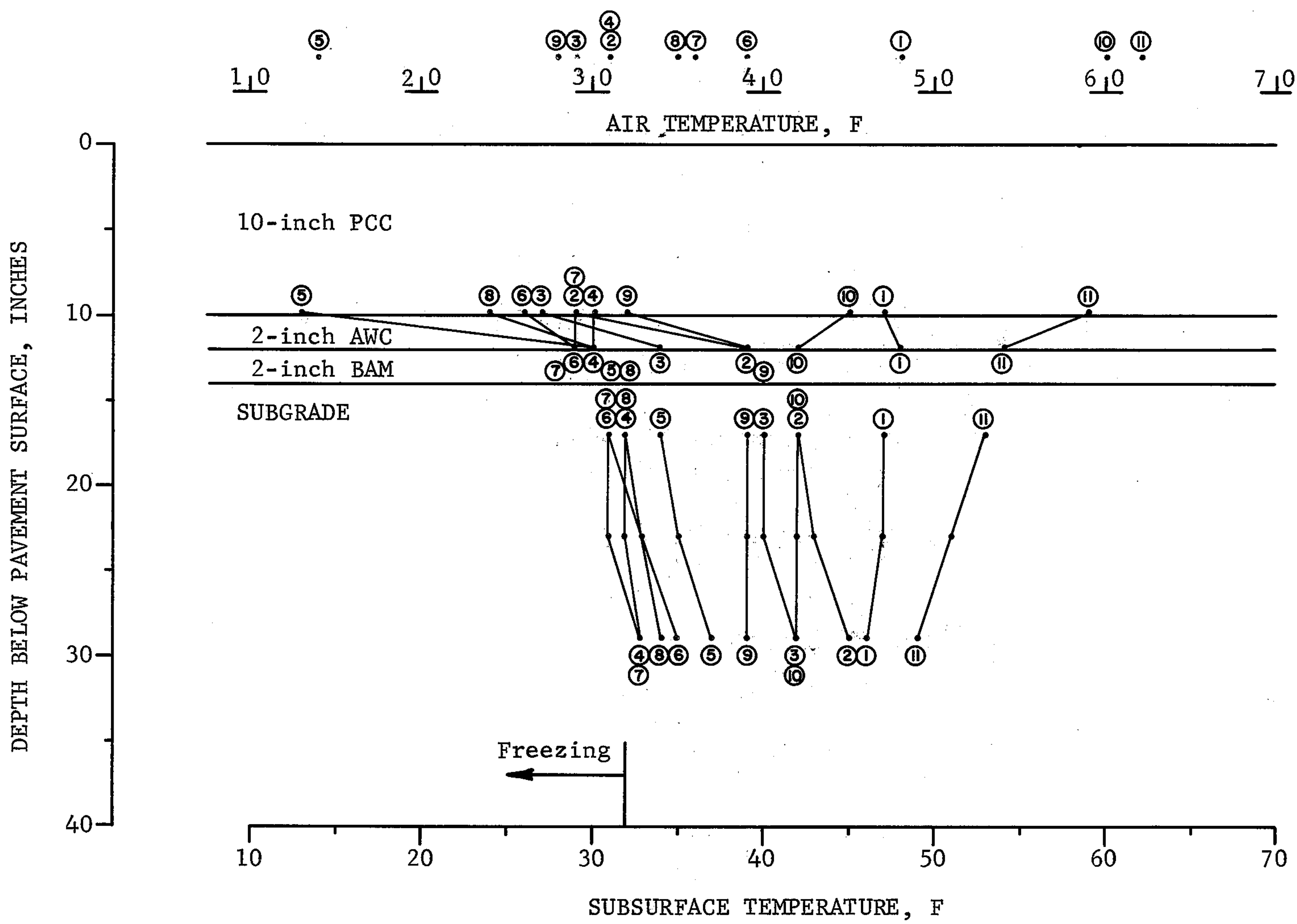


Figure B-12. Depth-temperature data in Test Section No. 5, inner lane center (1970-1971).

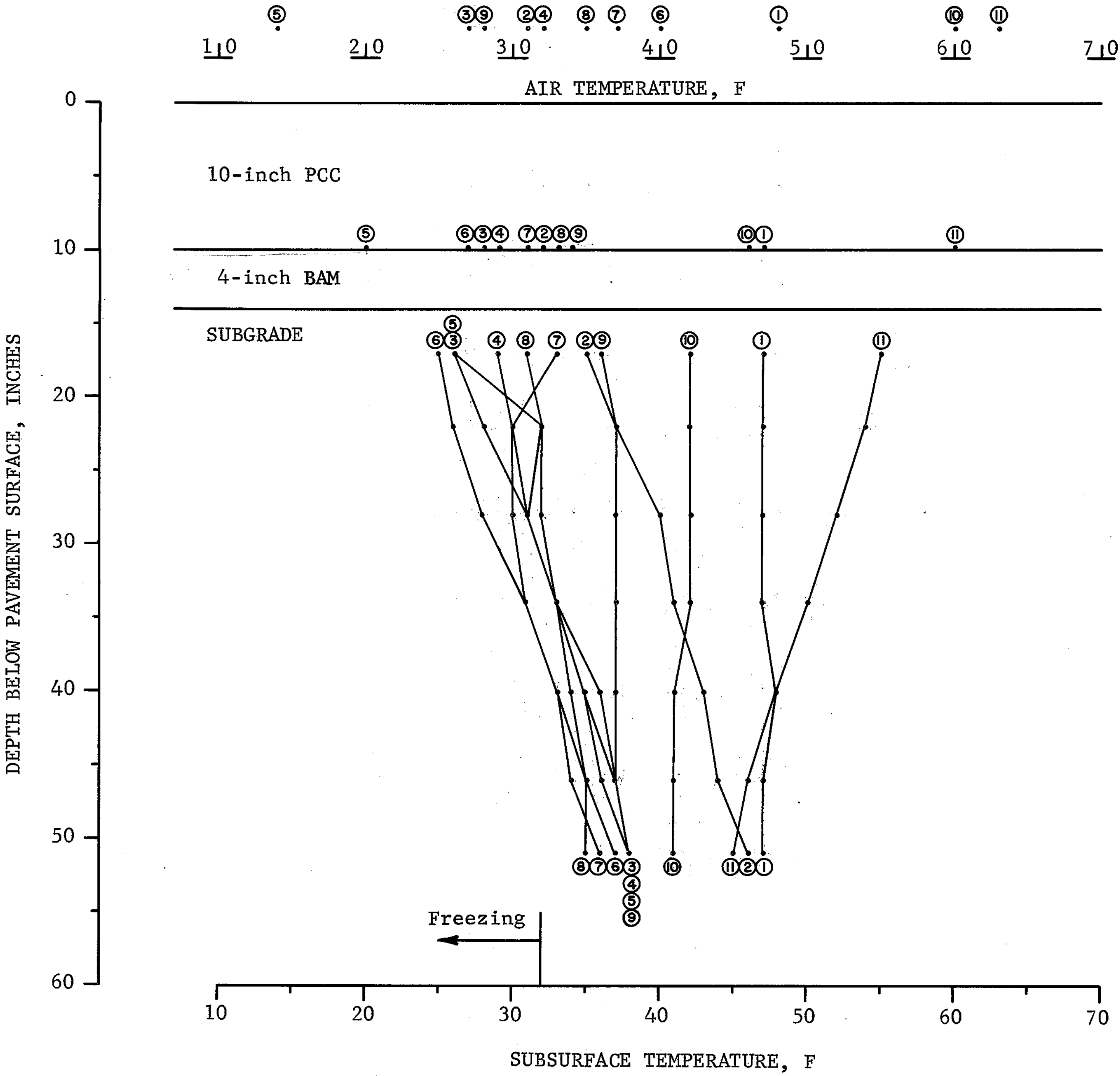


Figure B-13. Depth-temperature data in Control Section No. 2, outer lane center (1970-1971).

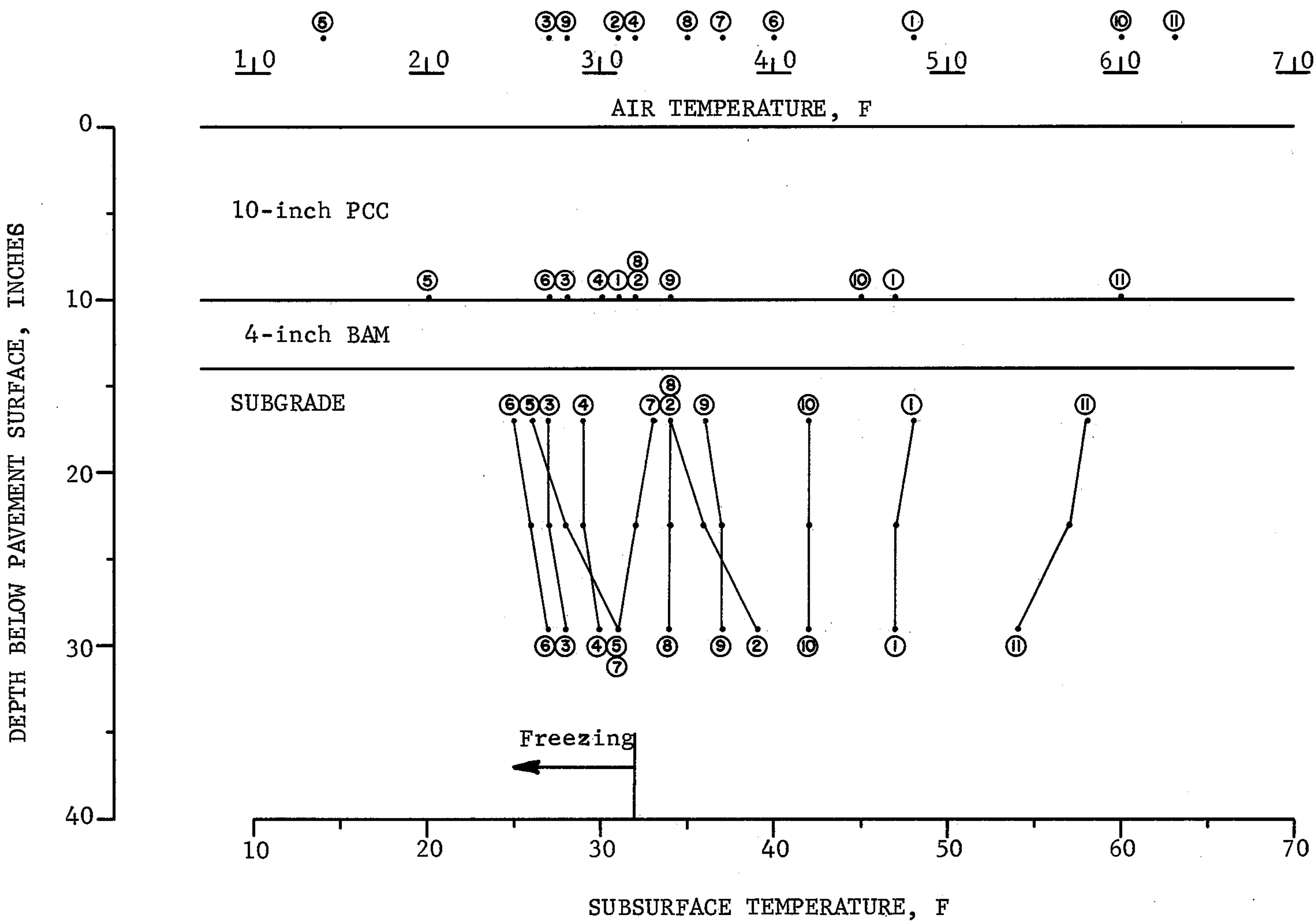


Figure B-14. Depth-temperature data in Control Section No. 2, inner lane center (1970-1971).

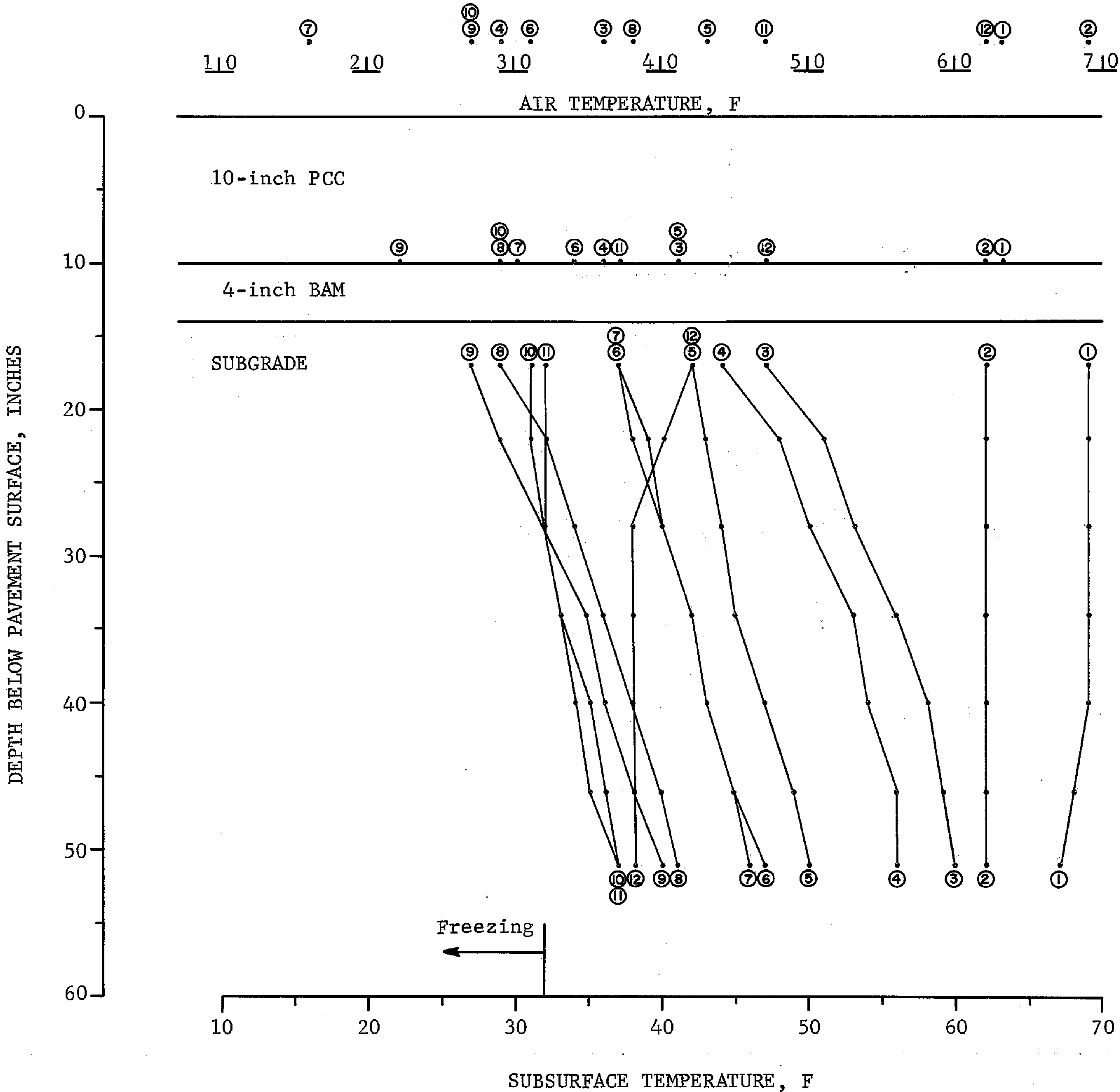


Figure B-15. Depth-temperature data in Control Section No. 1, outer lane center (1971-1972).

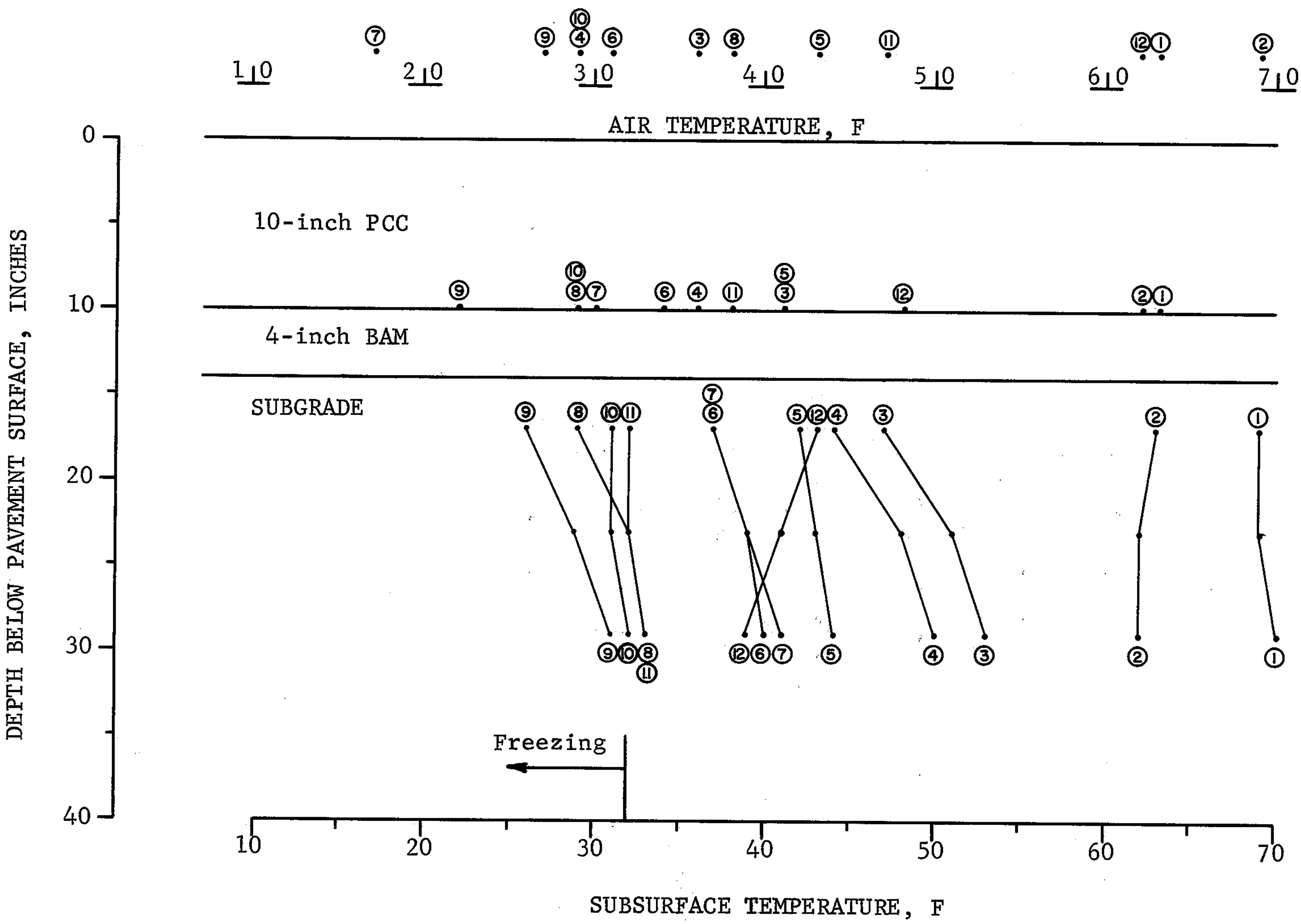


Figure B-16. Depth-temperature data in Control Section No. 1, inner lane center (1971-1972).

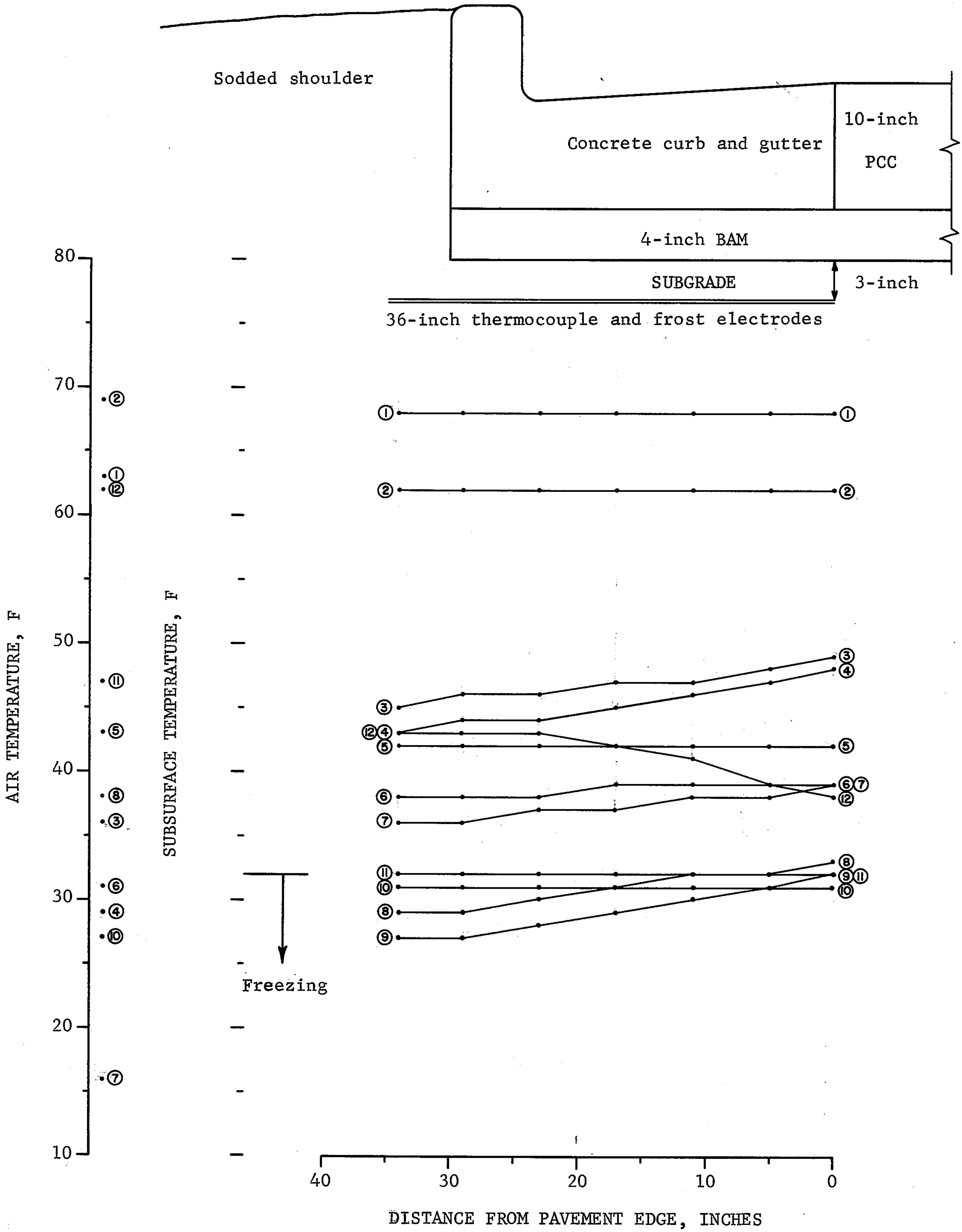


Figure B-17. Distance-temperature data in Control Section No. 1, outer lane curb (1971-1972).

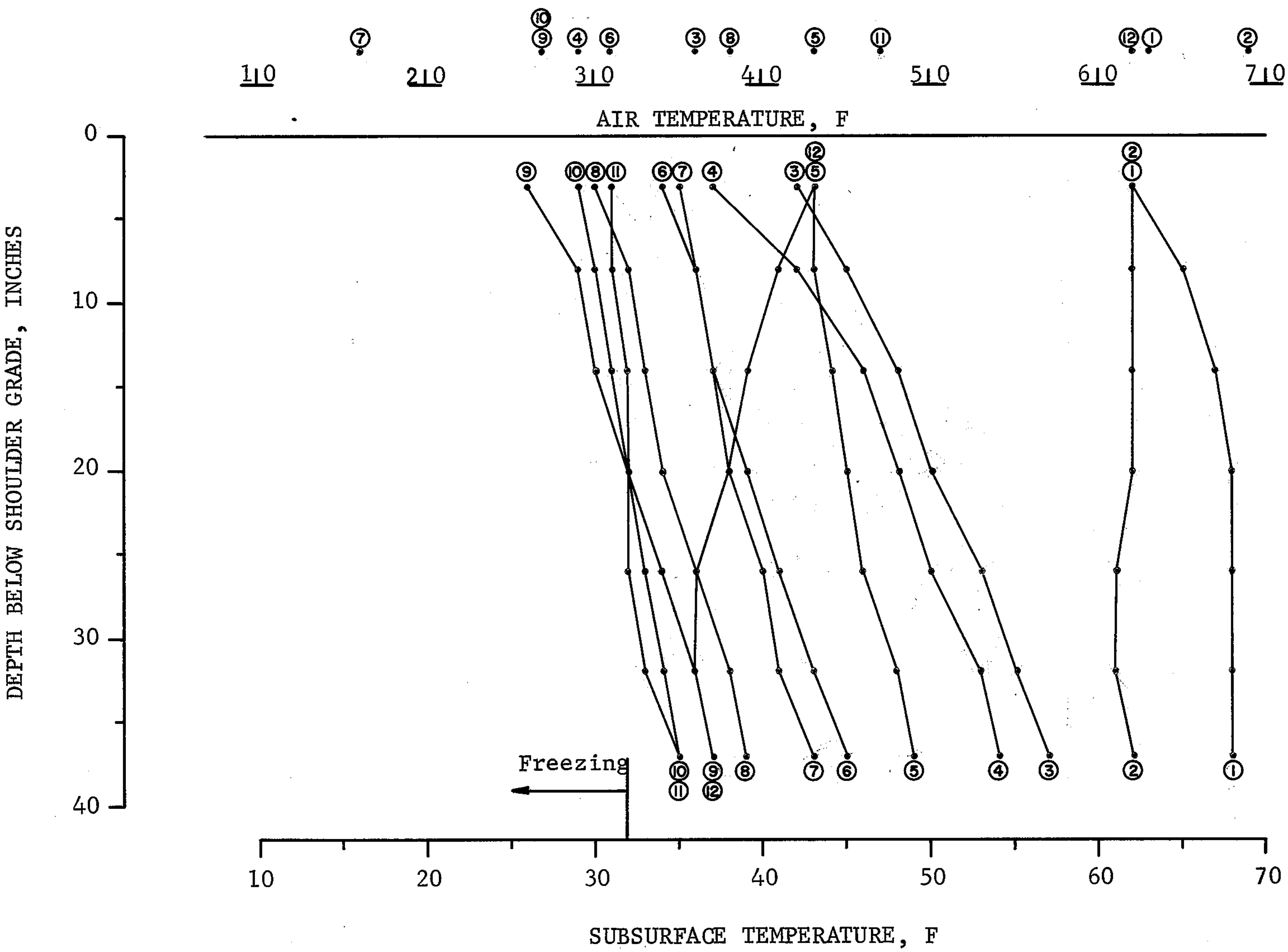


Figure B-18. Depth-temperature data in Control Section No. 1, outer lane shoulder (1971-1972).

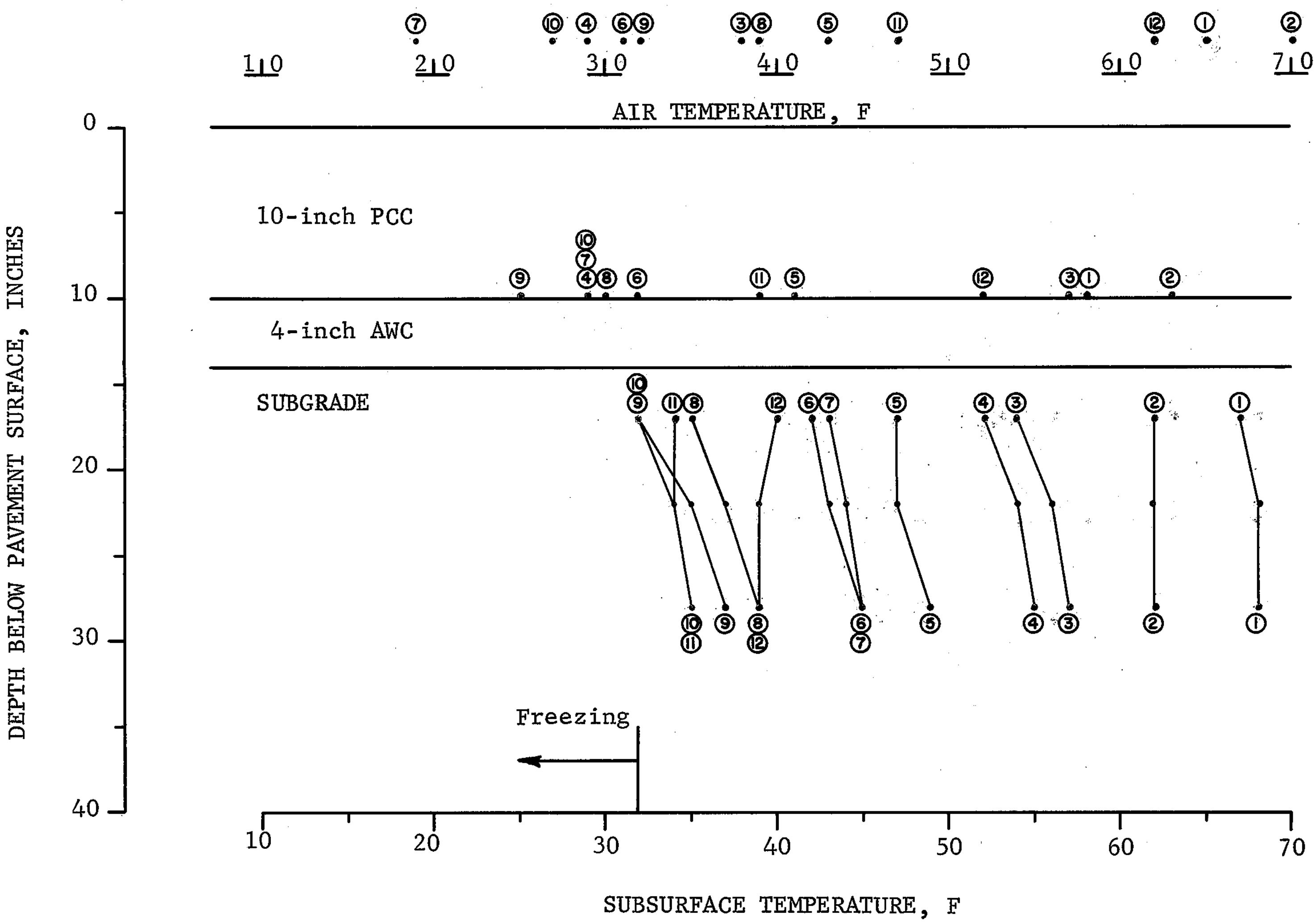


Figure B-19. Depth-temperature data in Test Section No. 1, outer lane center (1971-1972).

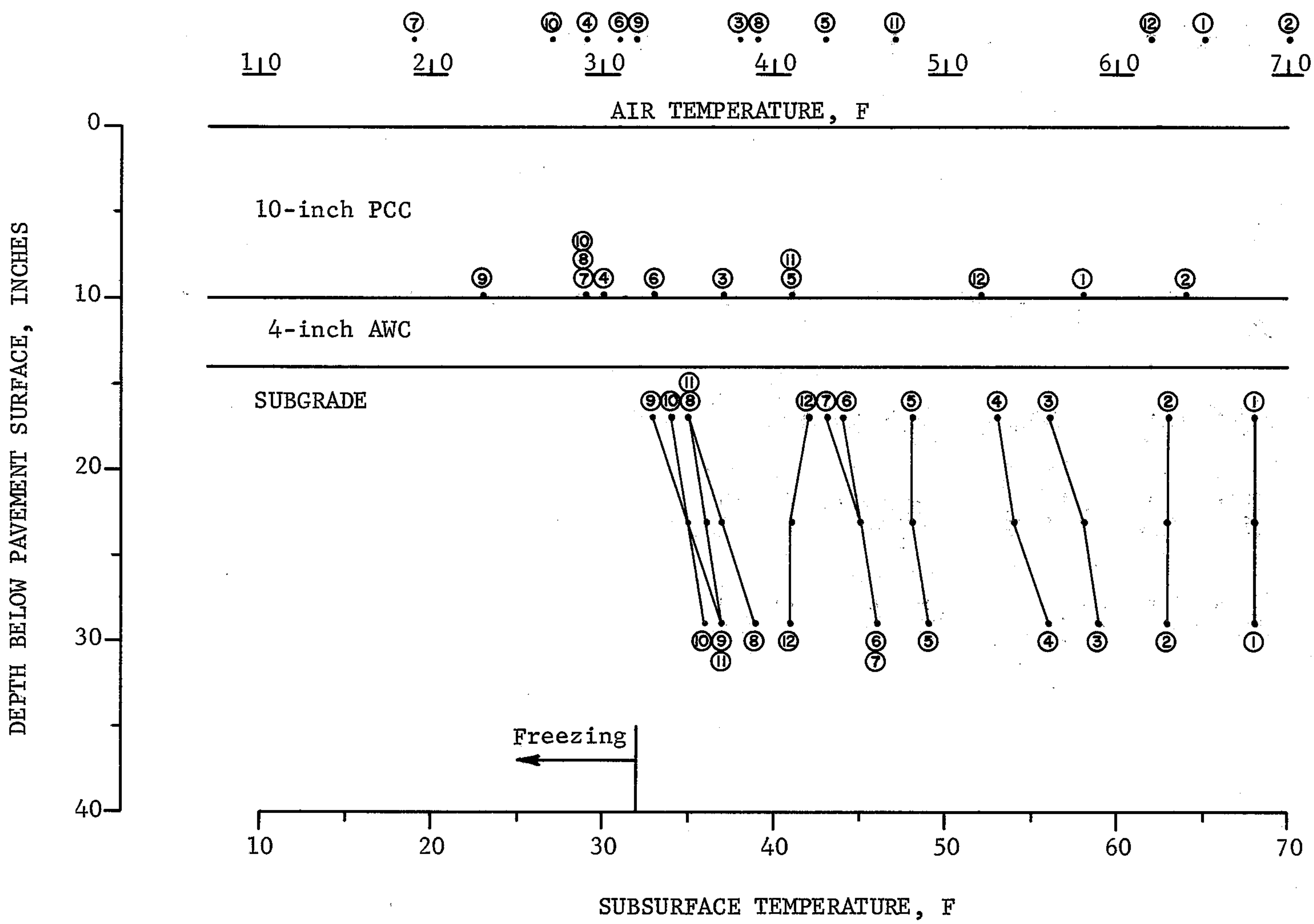


Figure B-20. Depth-temperature data in Test Section No. 1, inner lane center (1971-1972).

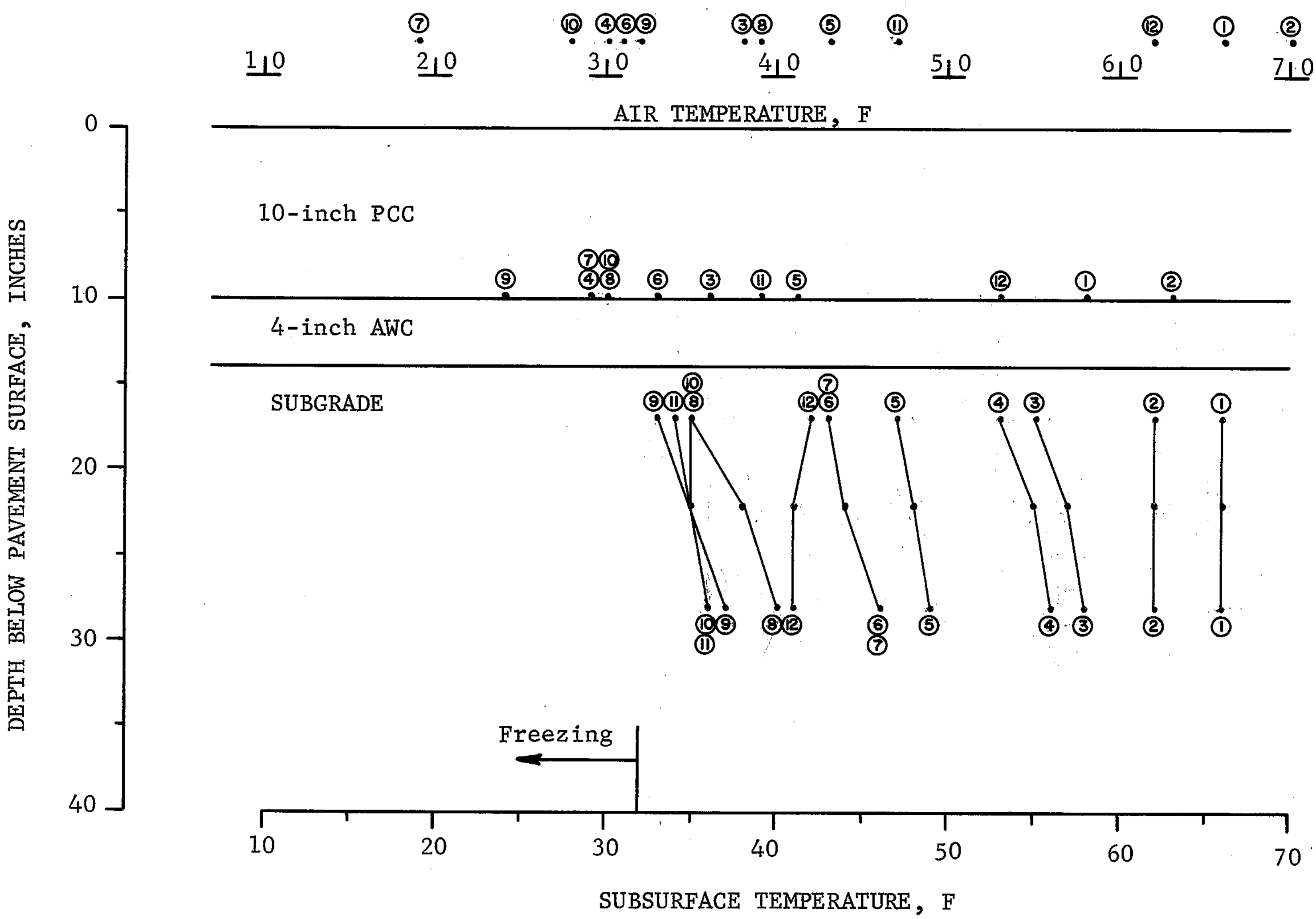


Figure B-21. Depth-temperature data in Test Section No. 2, outer lane center (1971-1972).

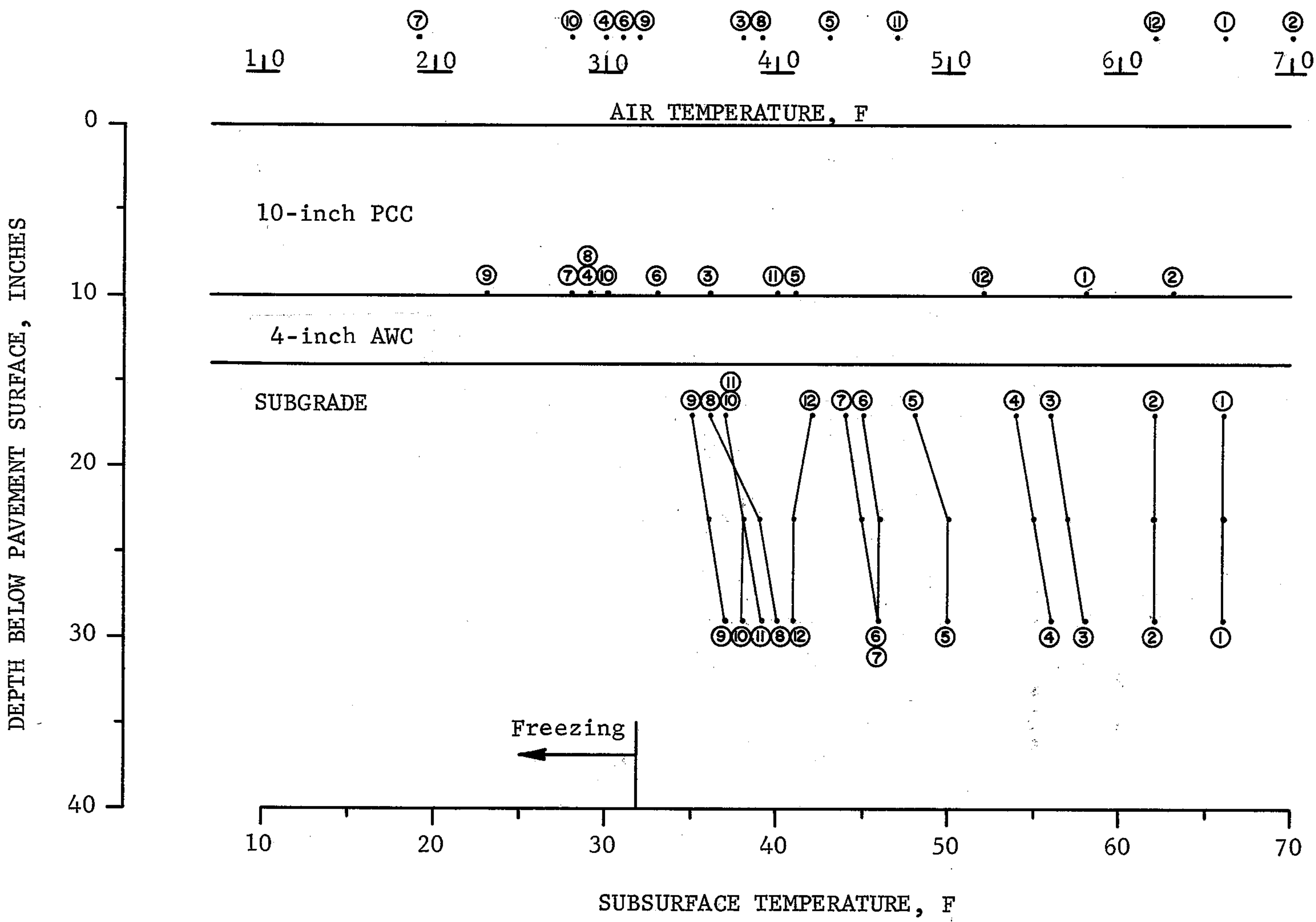


Figure B-22. Depth-temperature data in Test Section No. 2, inner lane center (1971-1972).

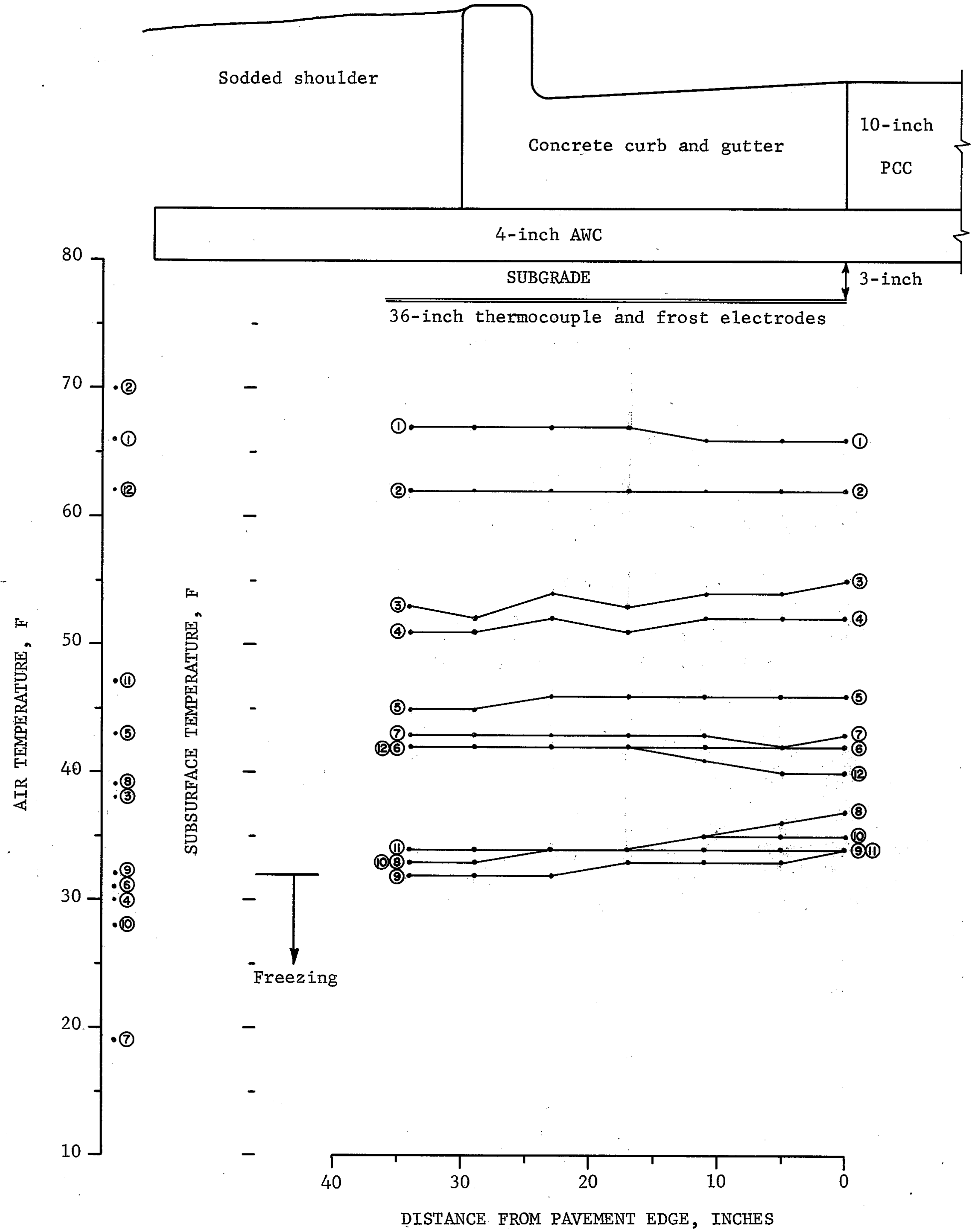


Figure B-23. Distance-temperature data in Test Section No. 2, outer lane curb (1971-1972).

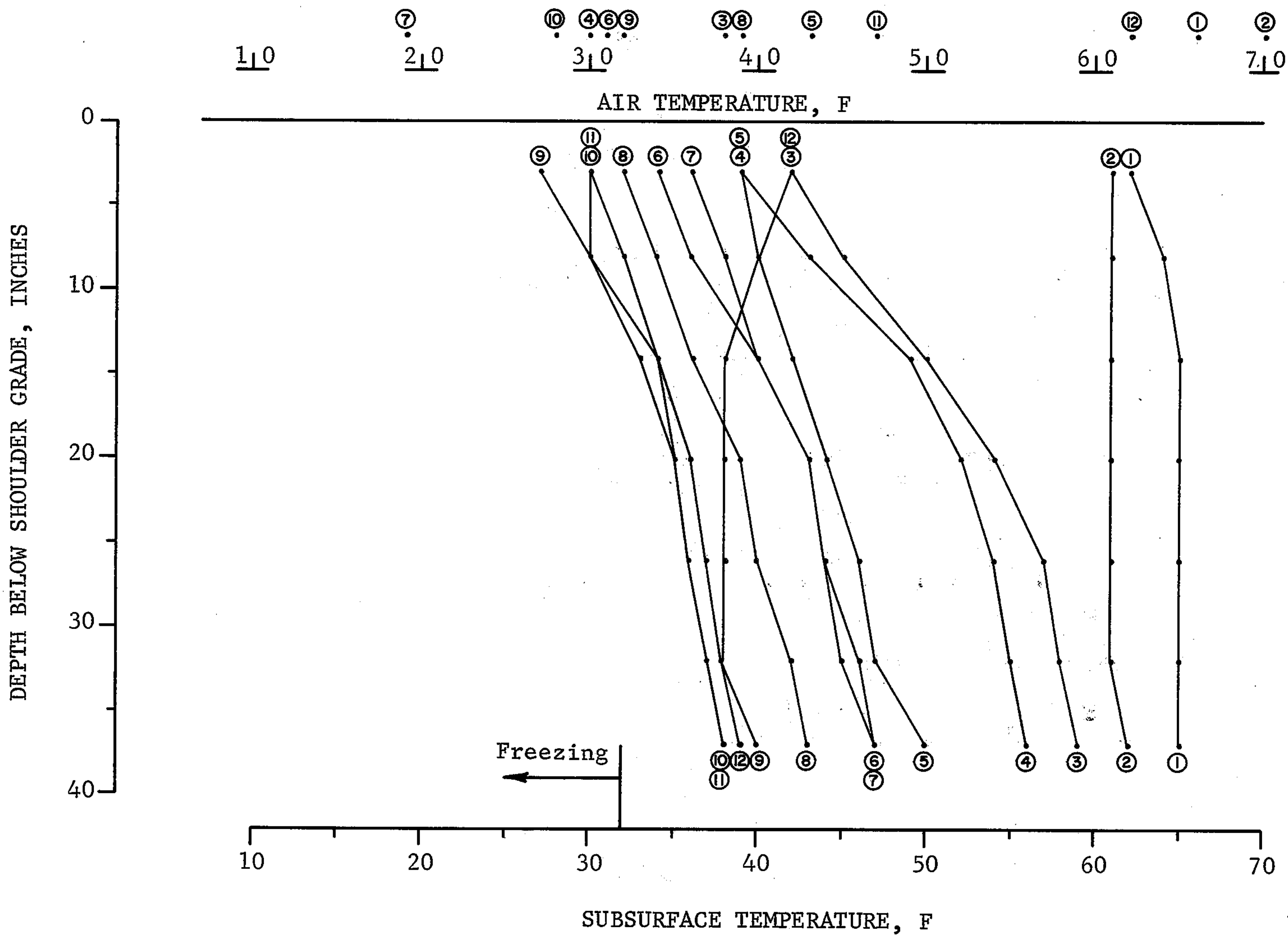


Figure B-24. Depth-temperature data in Test Section No. 2, outer lane shoulder (1971-1972).

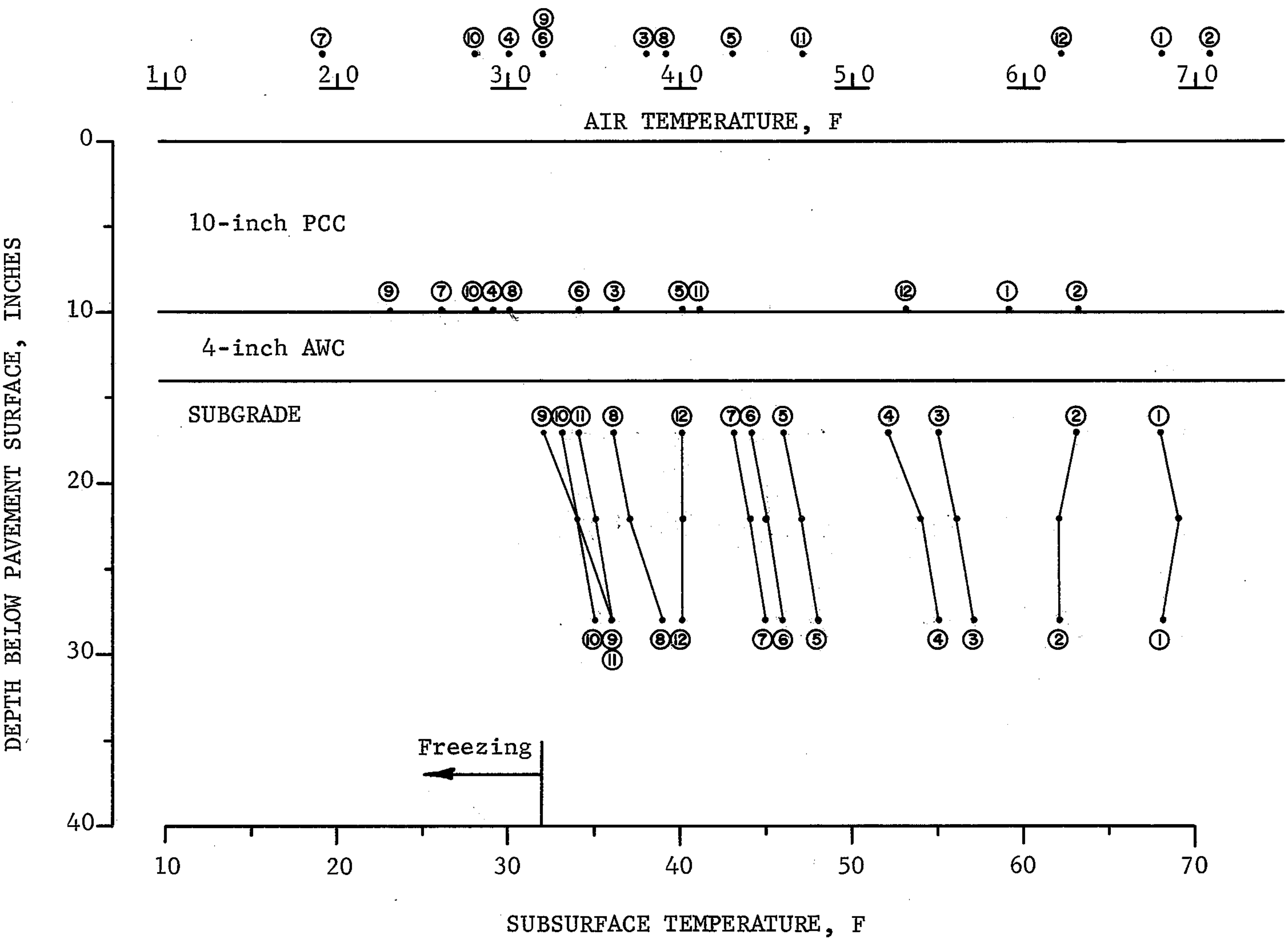


Figure B-25. Depth-temperature data in Test Section No. 3, outer lane center (1971-1972).

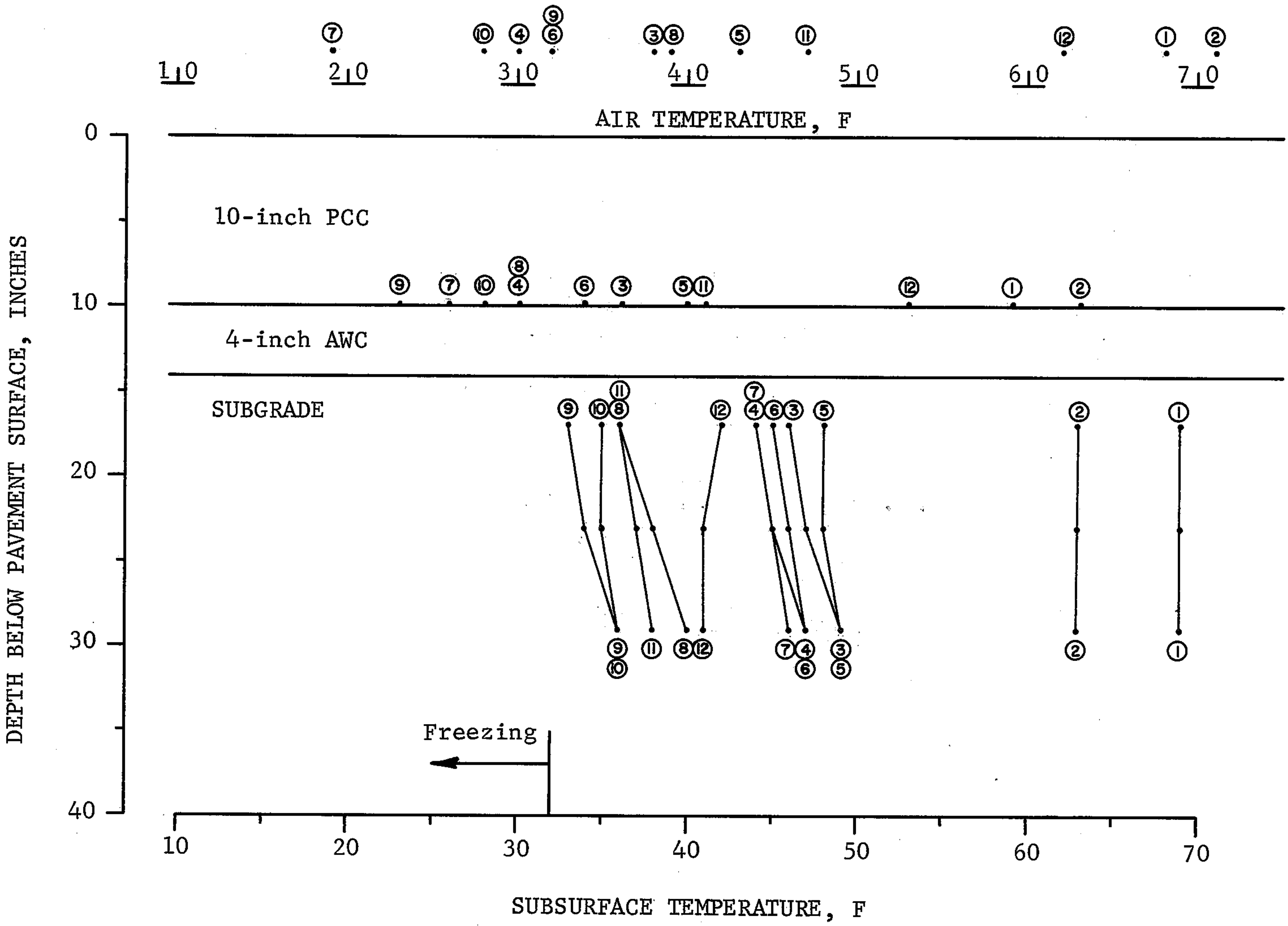


Figure B-26. Depth-temperature data in Test Section No. 3, inner lane center (1971-1972).

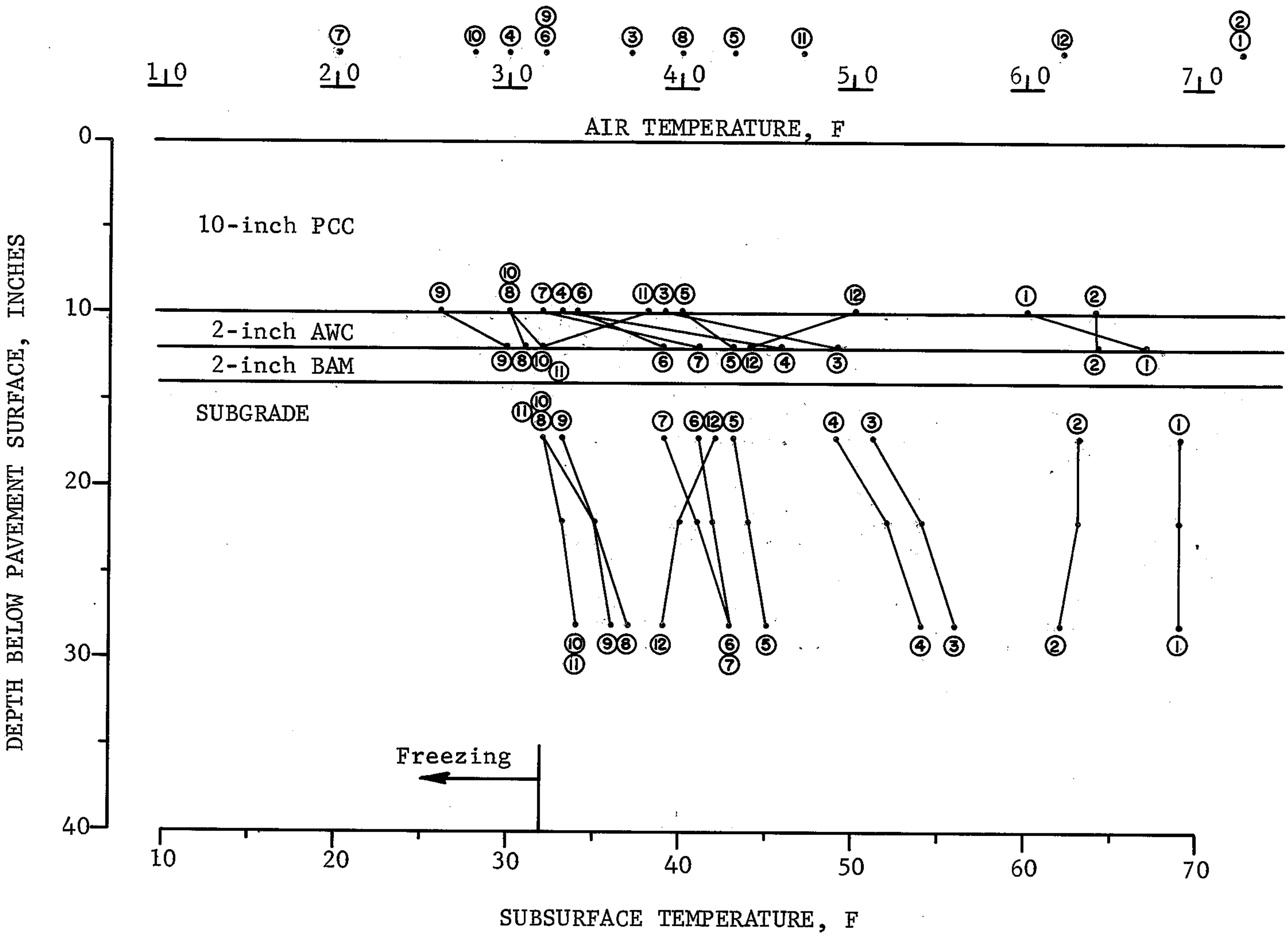


Figure B-27. Depth-temperature data in Test Section No. 4, outer lane center (1971-1972).

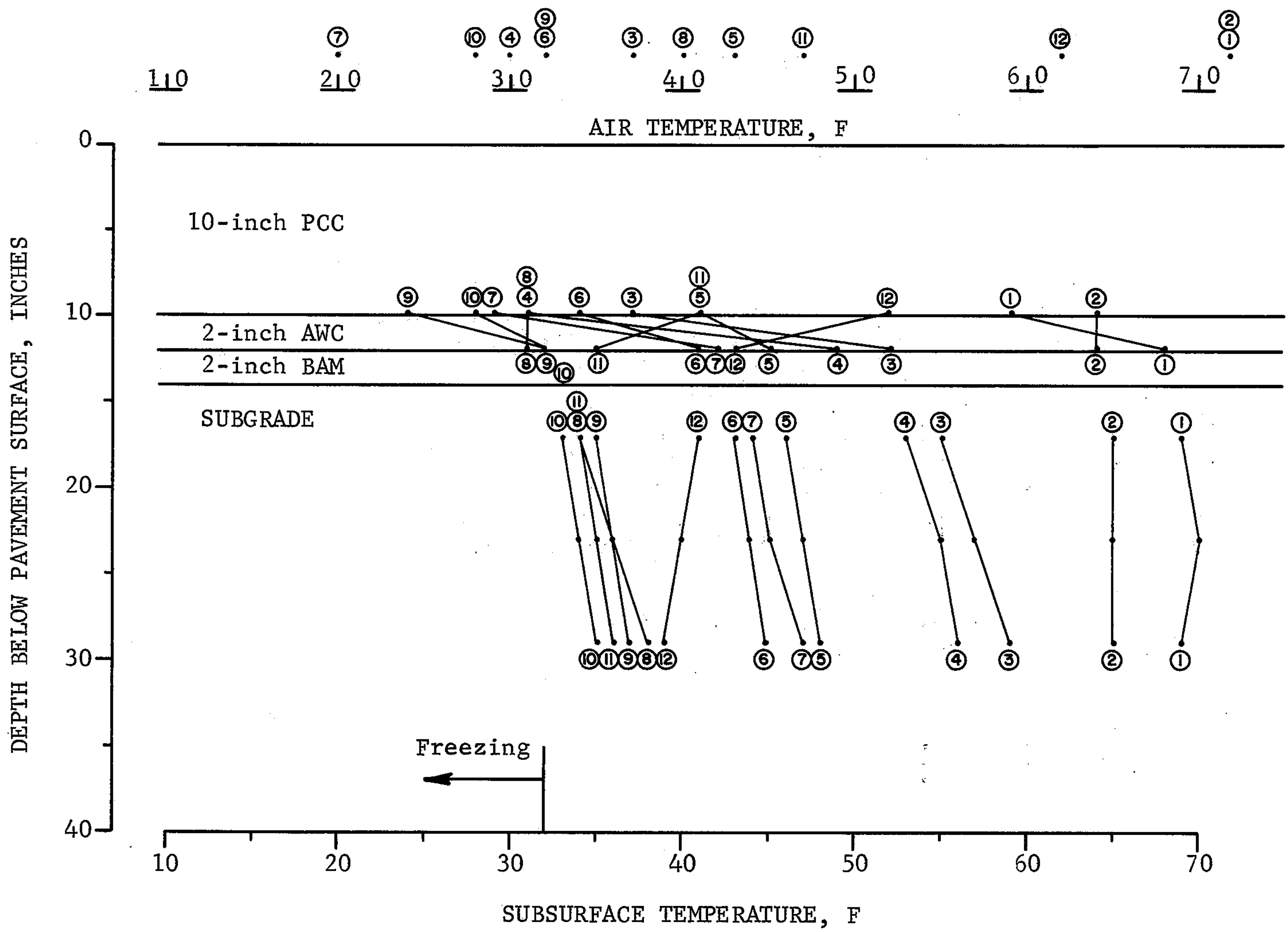


Figure B-28. Depth-temperature data in Test Section No. 4, inner lane center (1971-1972).

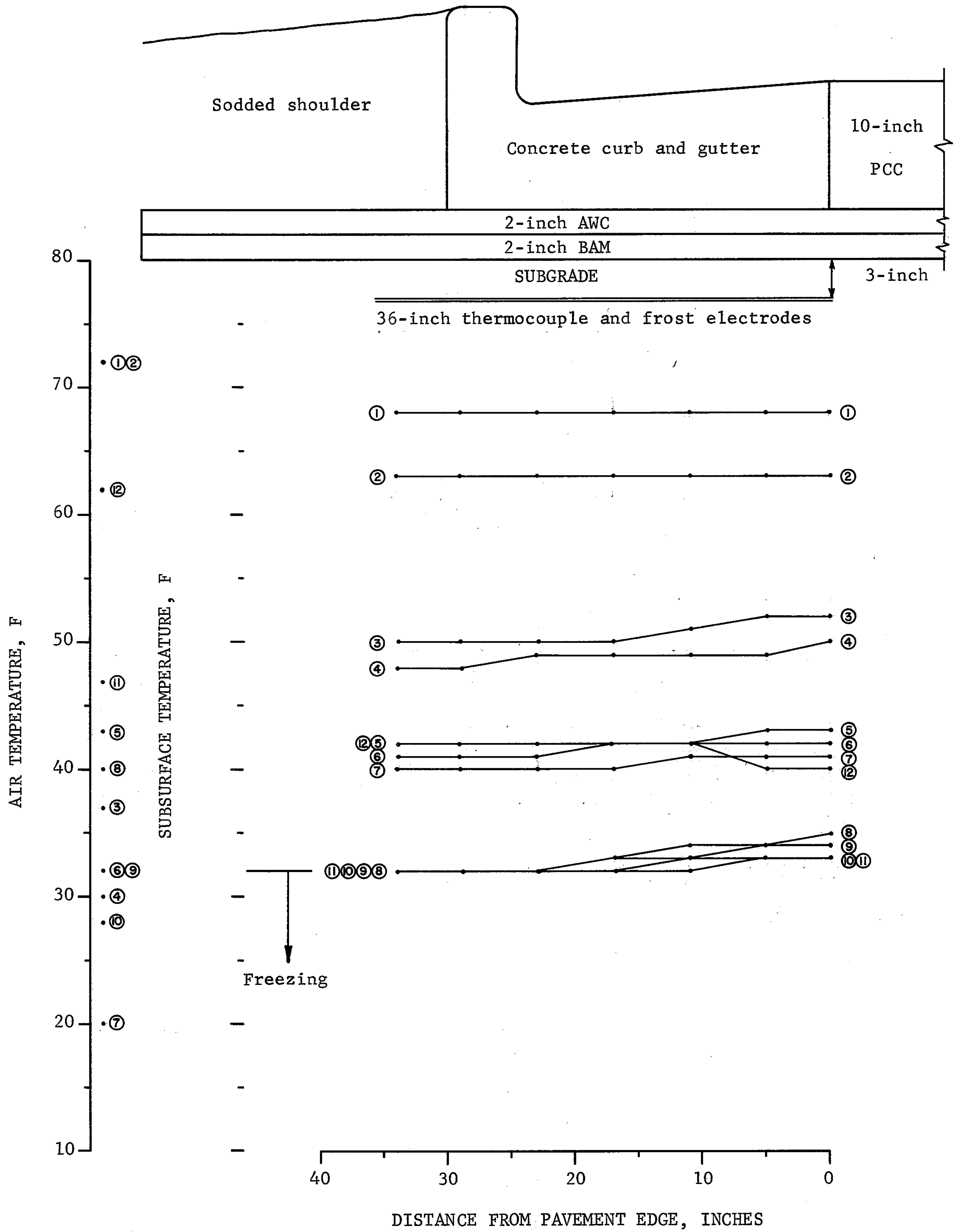


Figure B-29. Distance-temperature data in Test Section No. 4, outer lane curb (1971-1972).

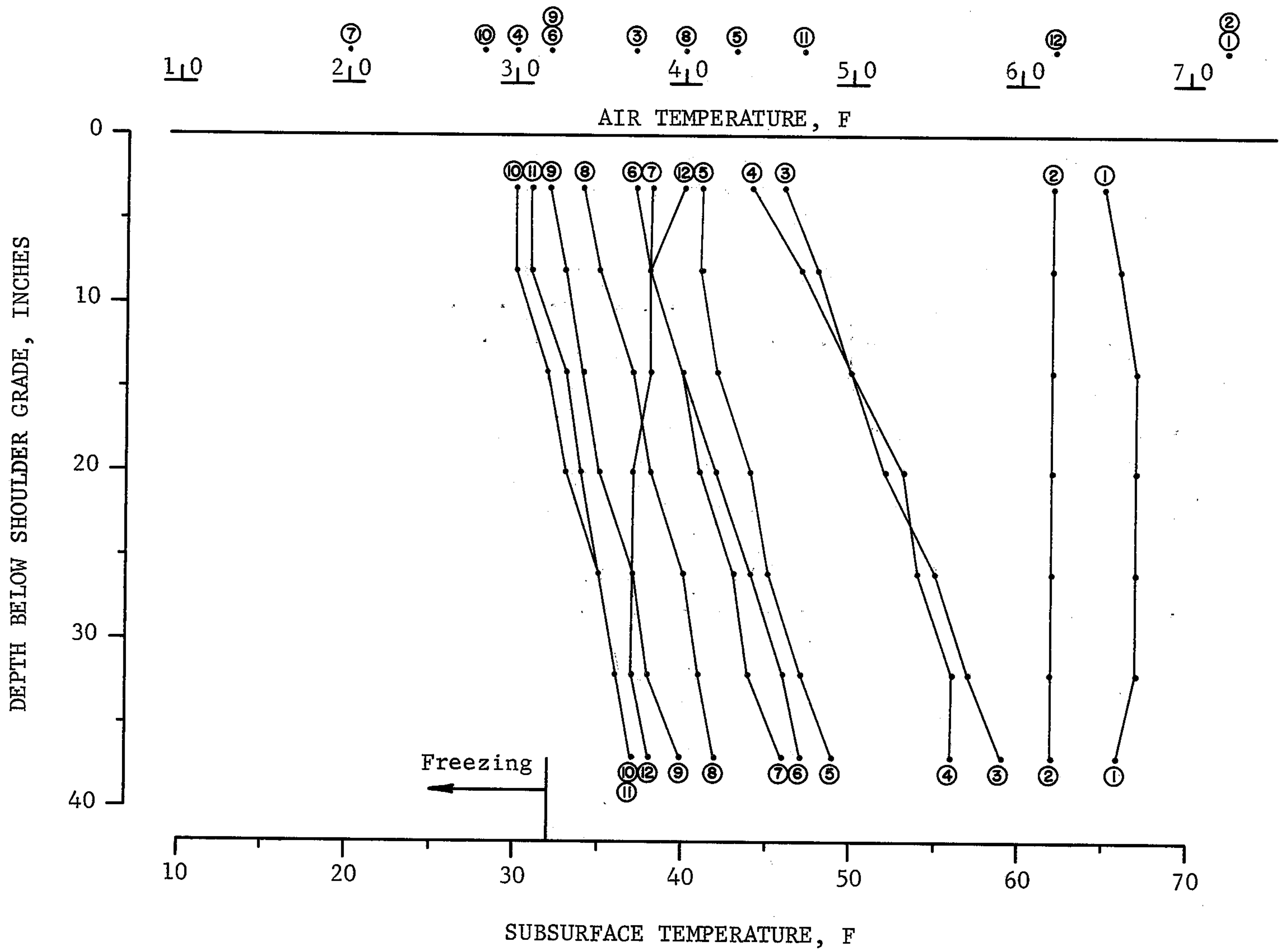


Figure B-30. Depth-temperature data in Test Section No. 4, outer lane shoulder (1971-1972).

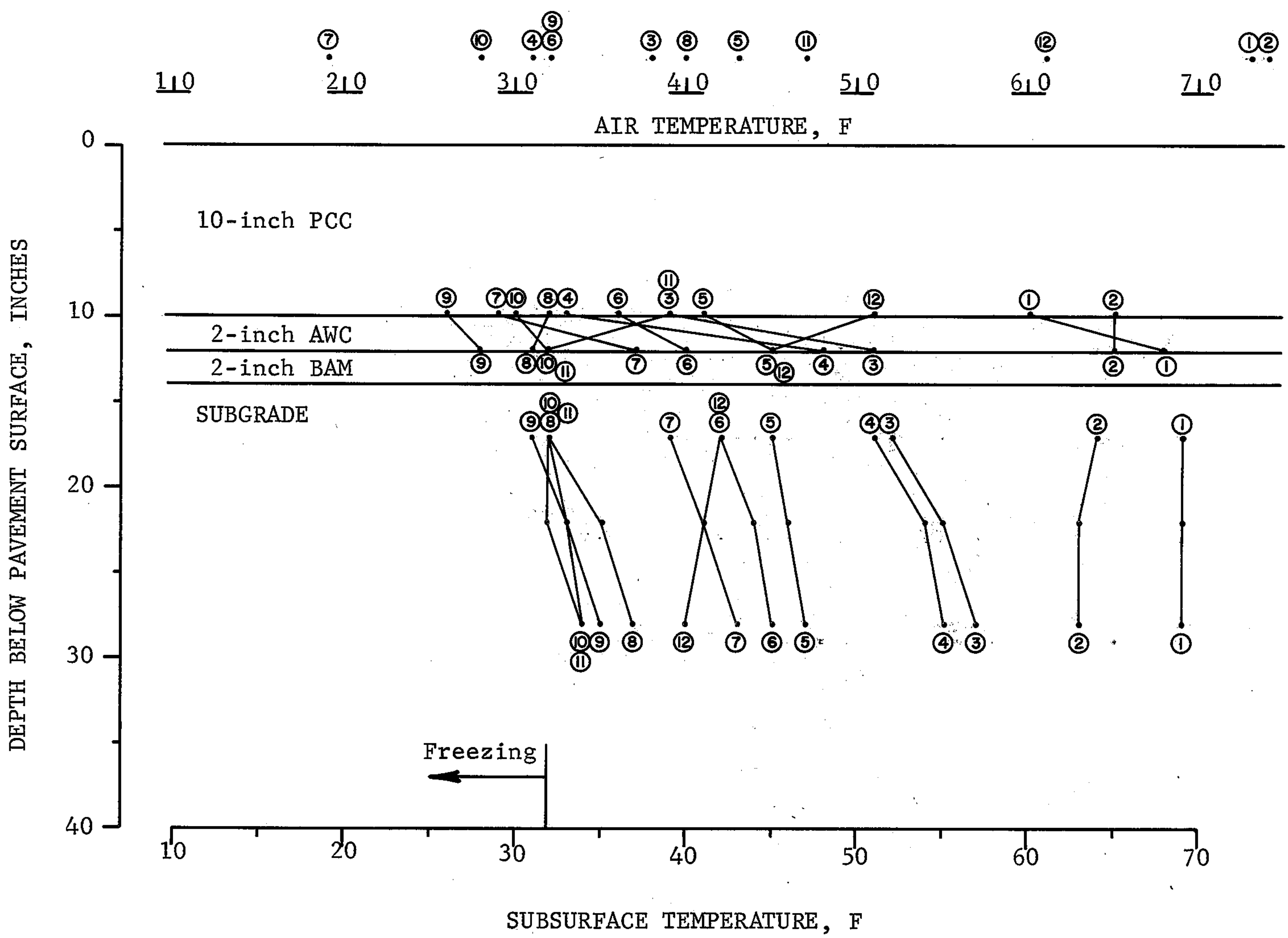


Figure B-31. Depth-temperature data in Test Section No. 5, outer lane center (1971-1972).

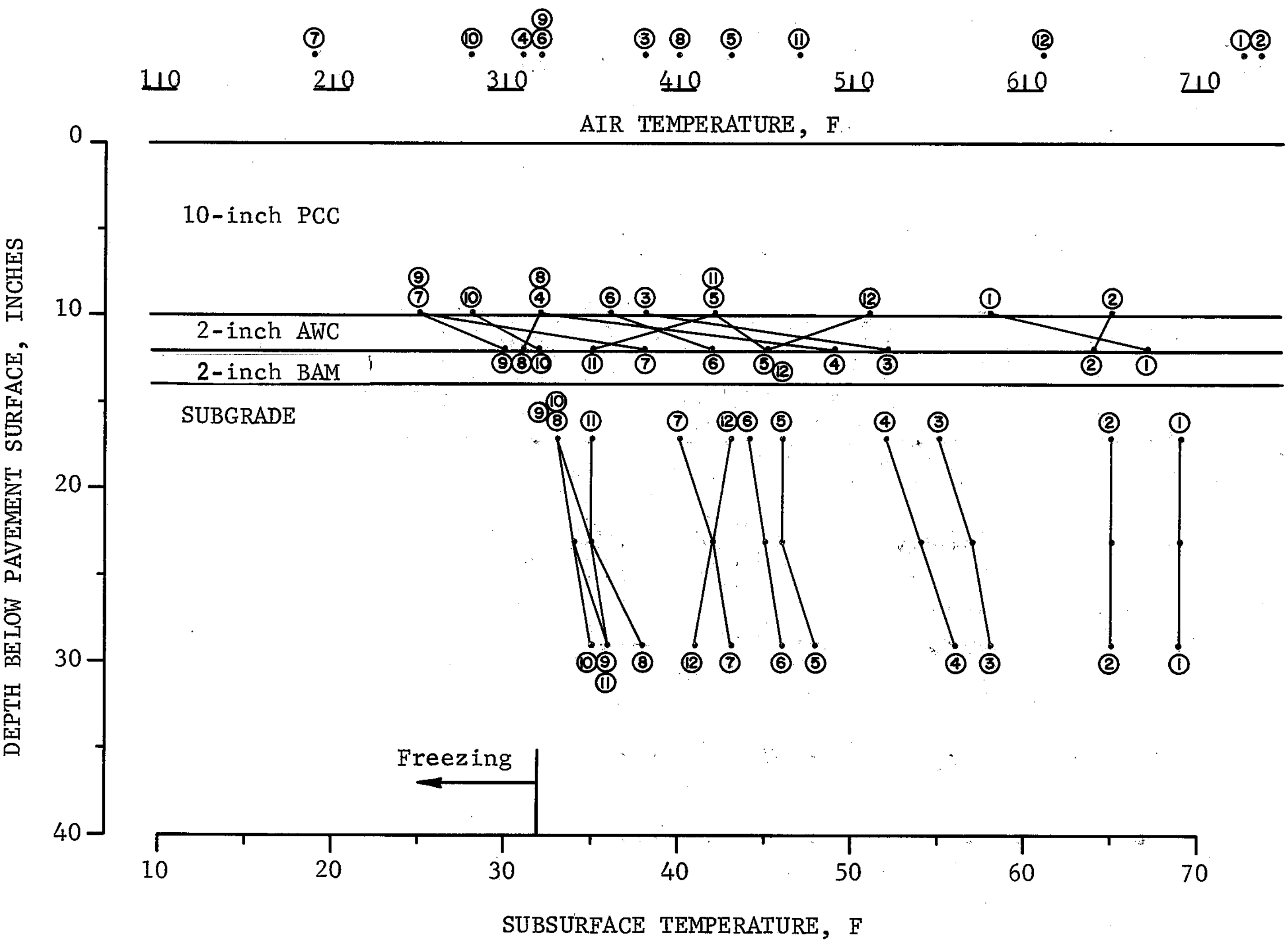


Figure B-32. Depth-temperature data in Test Section No. 5, inner lane center (1971-1972).

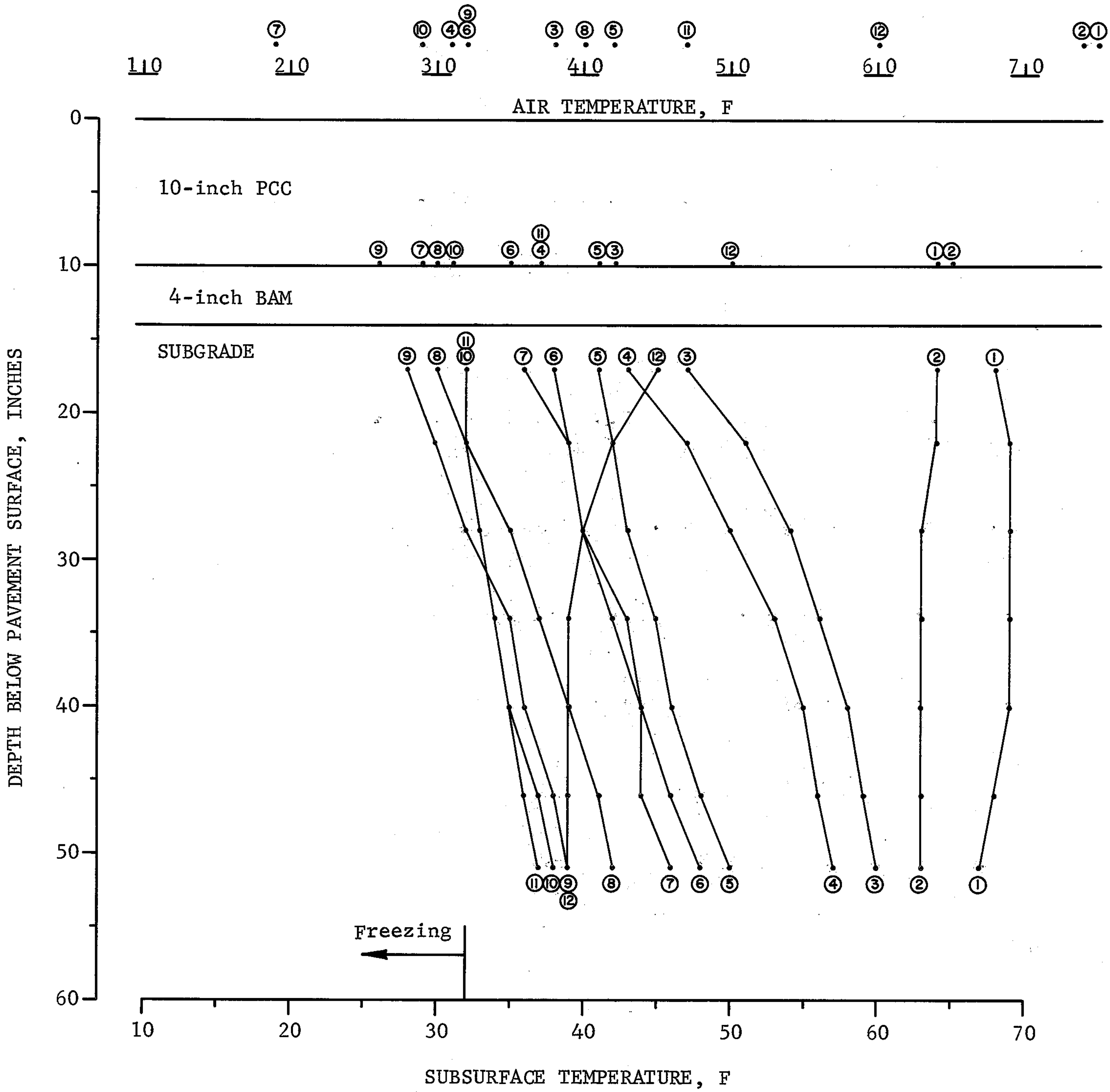


Figure B-33. Depth-temperature data in Control Section No. 2, outer lane center (1971-1972).

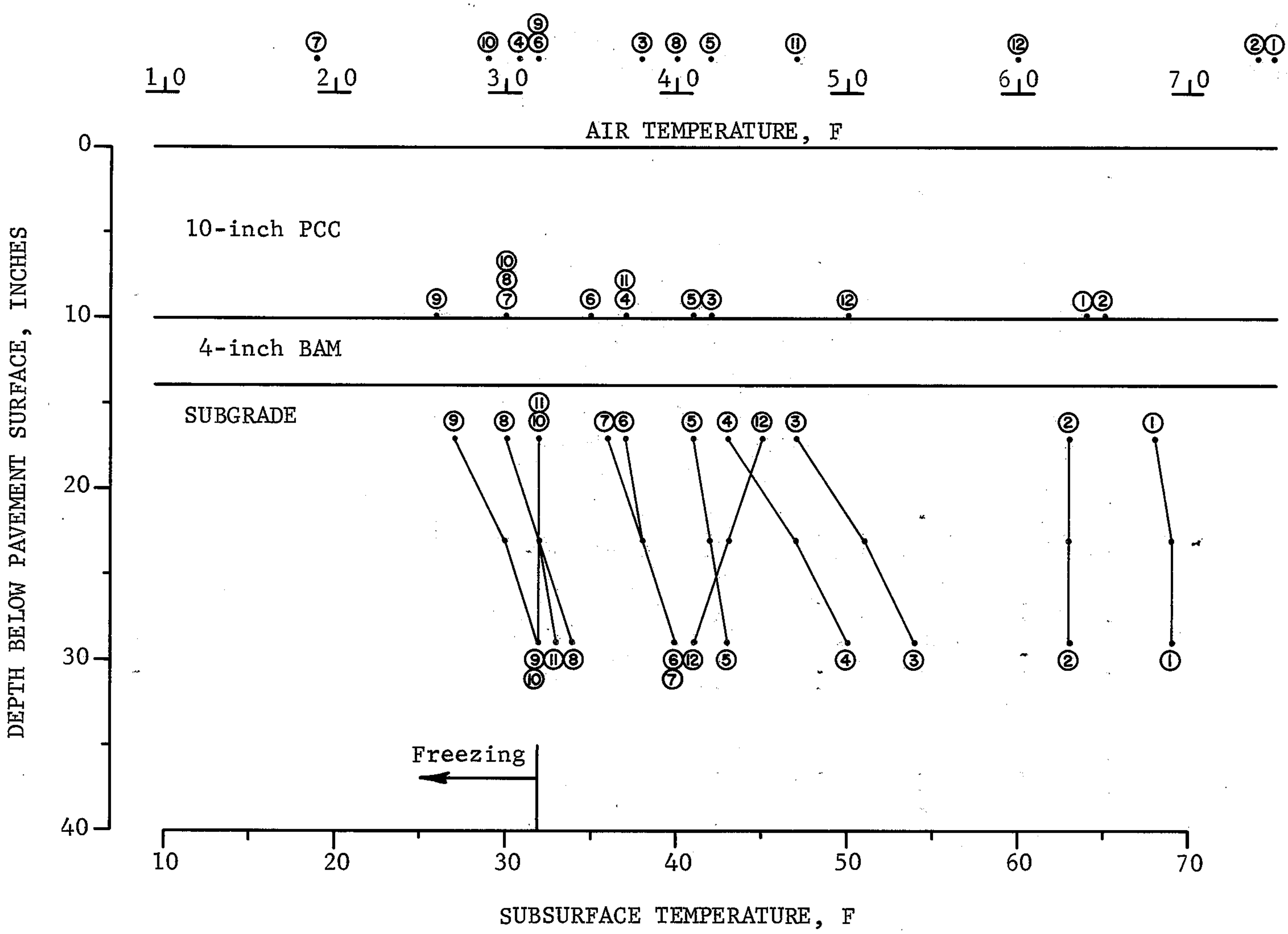


Figure B-34. Depth-temperature data in Control Section No. 2, inner lane center (1971-1972).

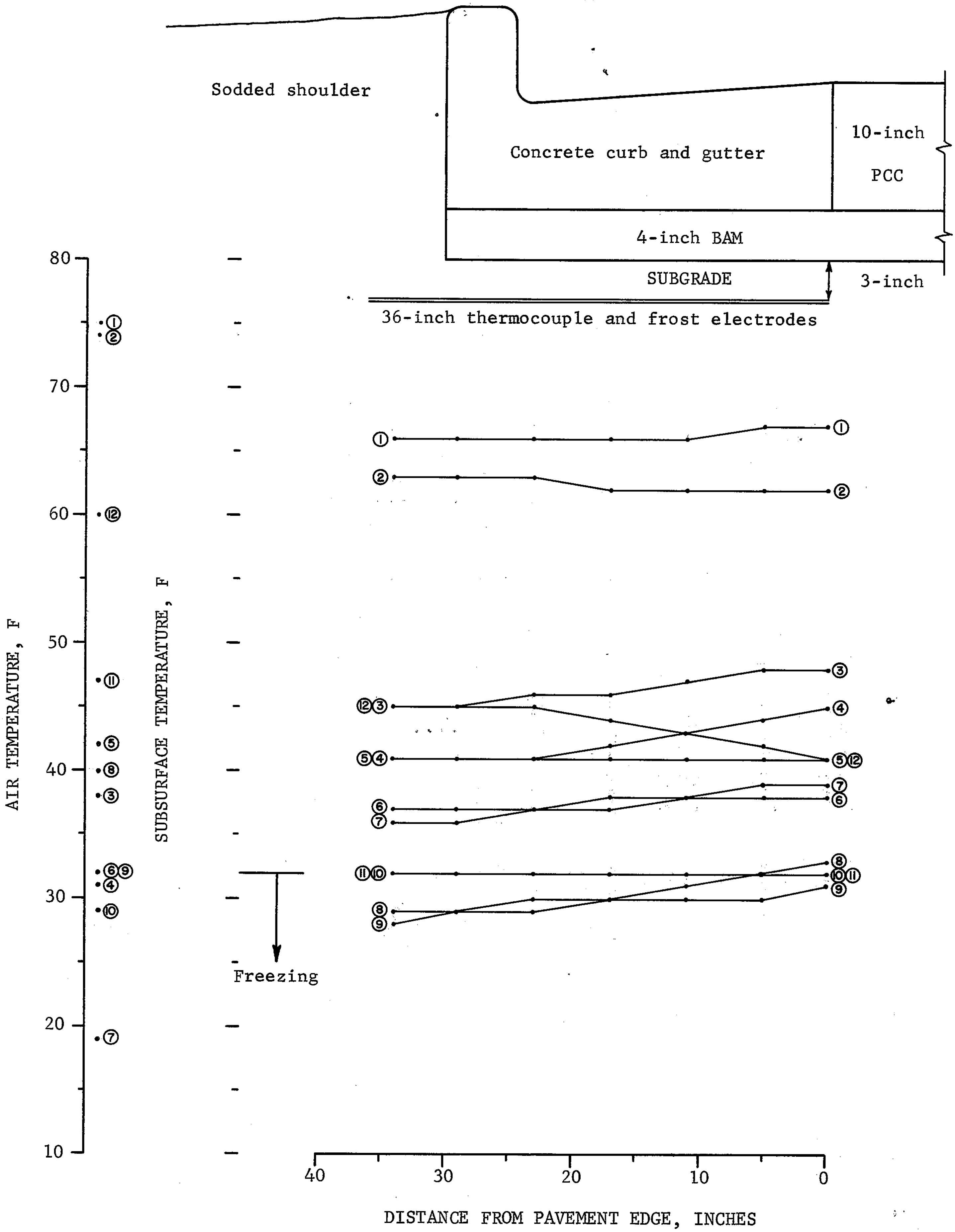


Figure B-35. Distance-temperature data in Control Section No. 2, outer lane curb (1971-1972).

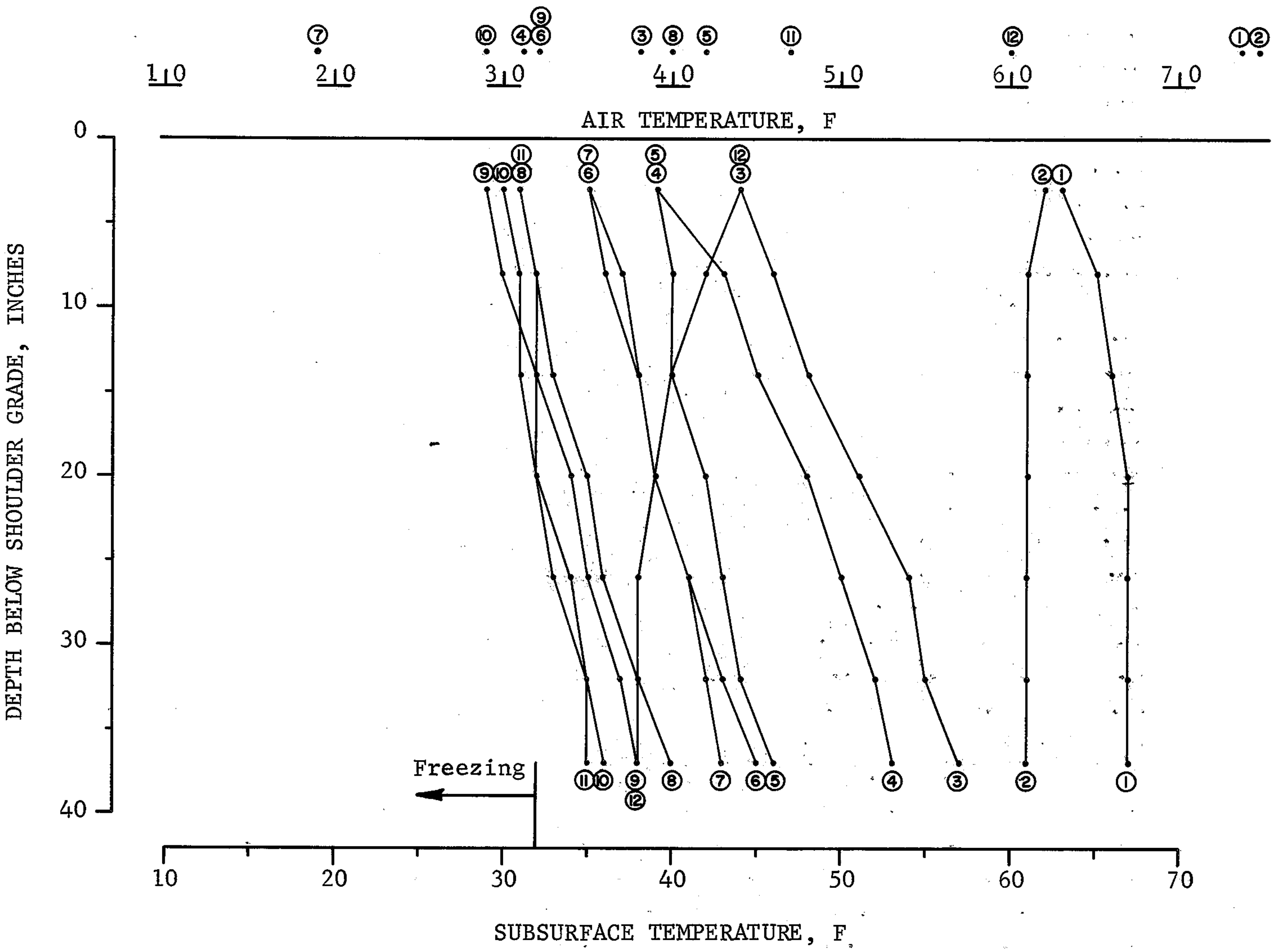


Figure B-36. Depth-temperature data in Control Section No. 2, outer lane shoulder (1971-1972).

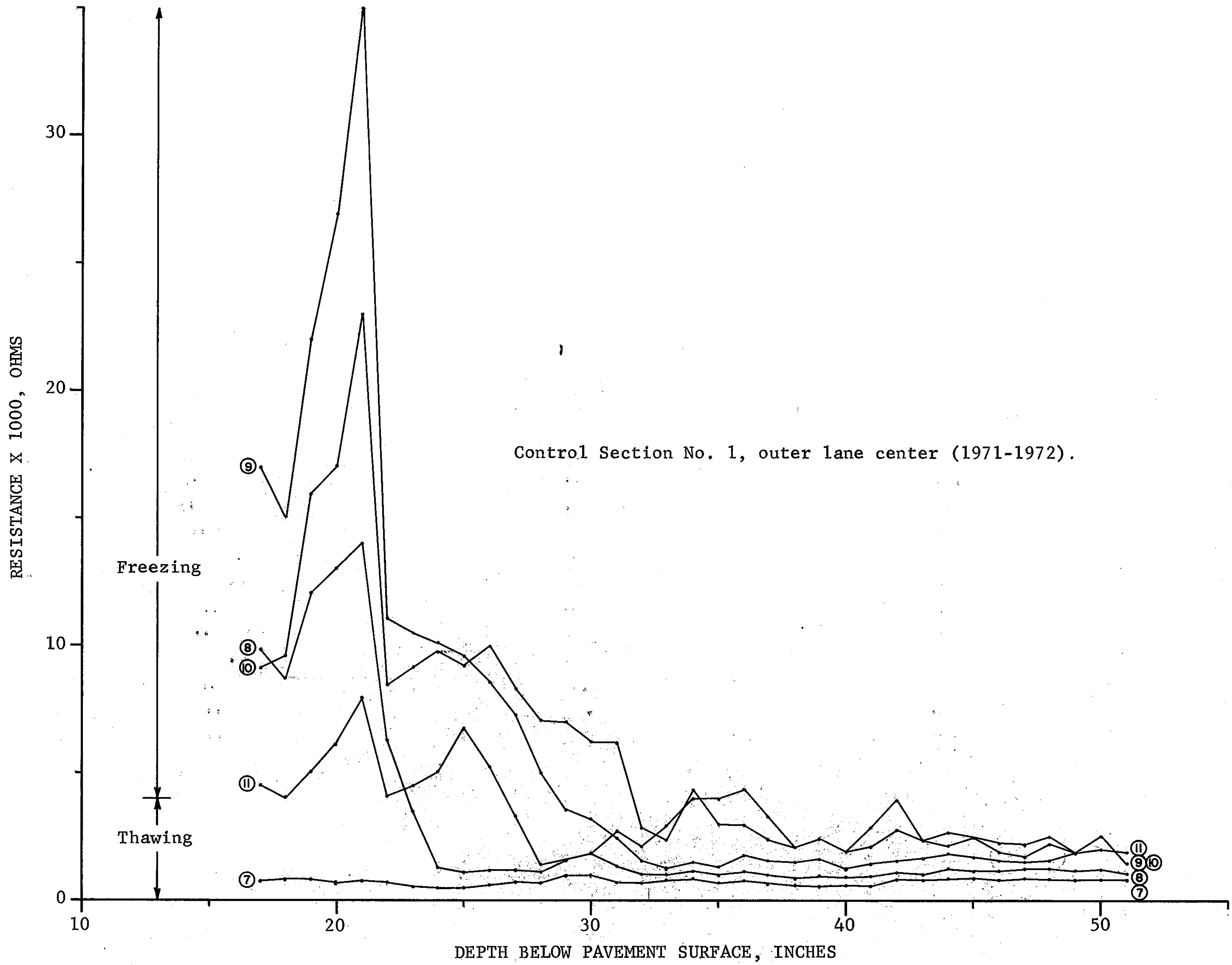


Figure B-37. Typical soil depth versus resistance relationships.

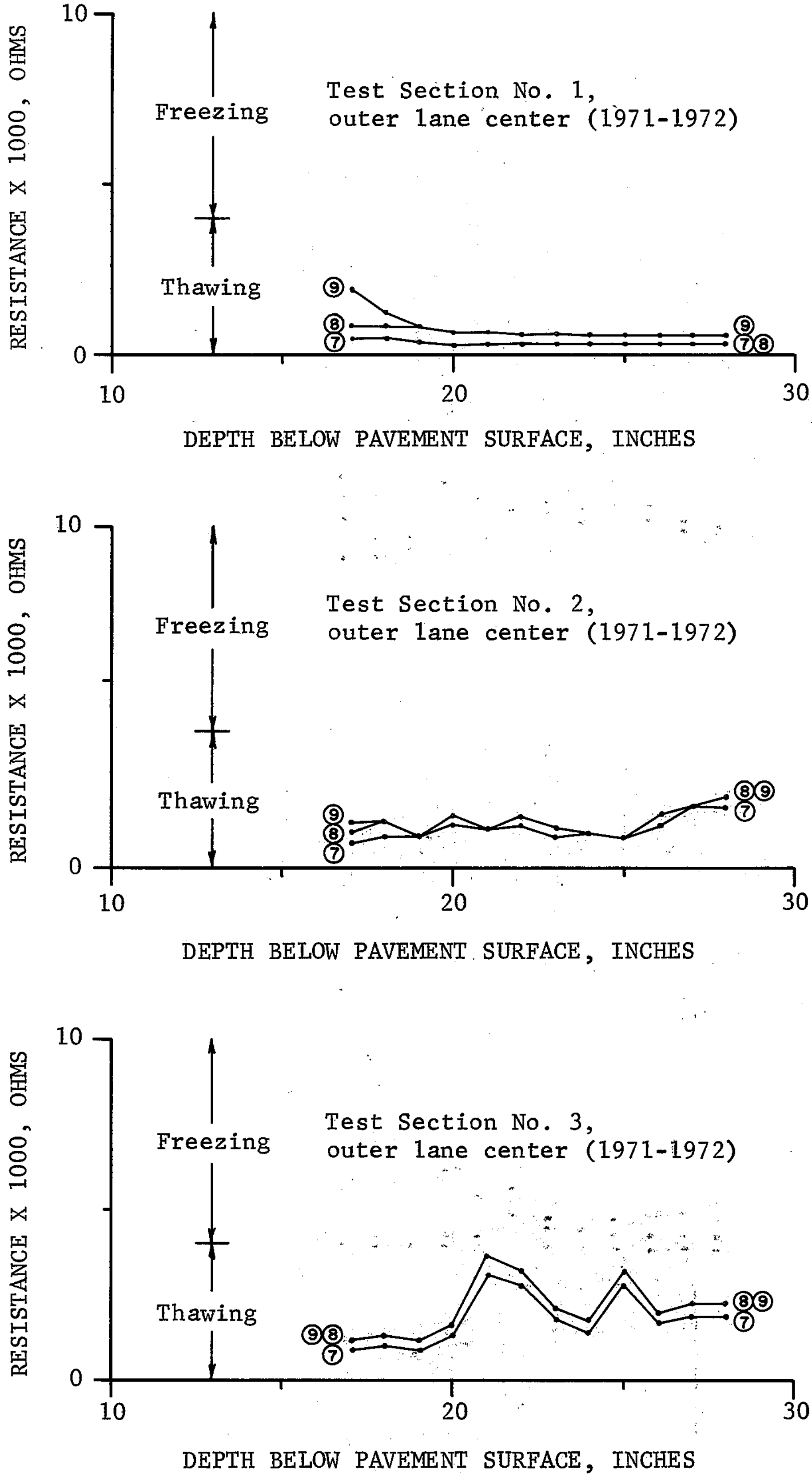
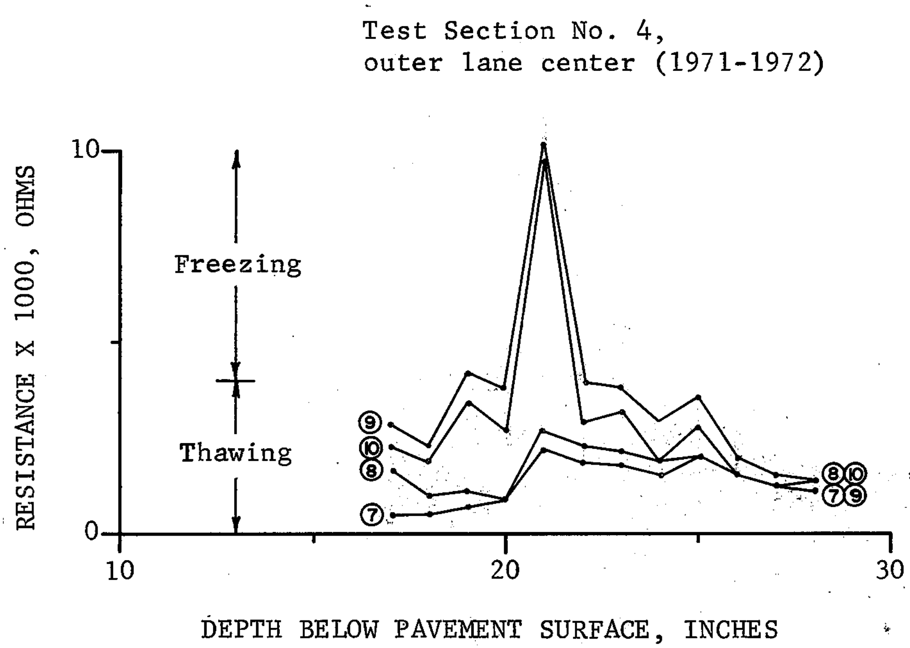


Figure B-38. Typical soil depth versus resistance relationships.



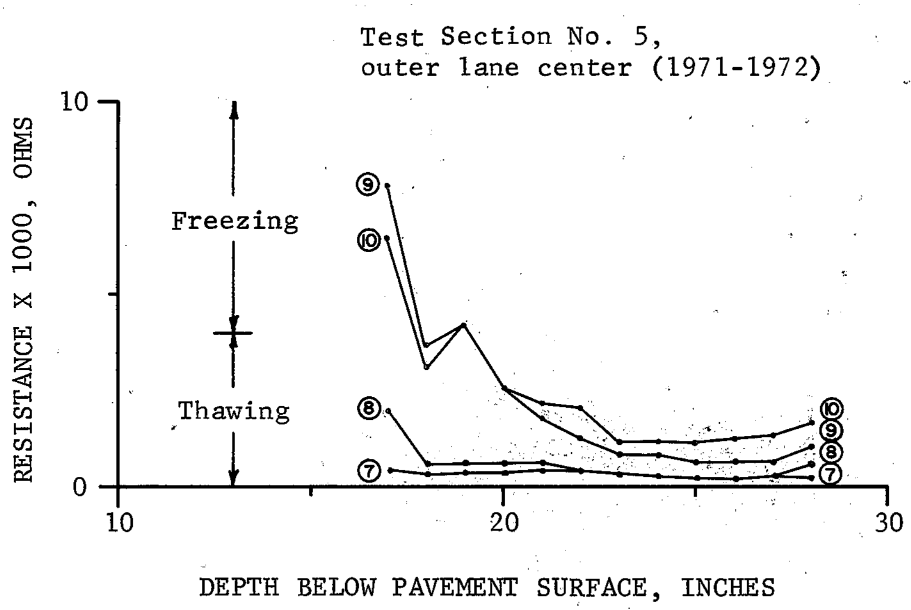


Figure B-39. Typical soil depth versus resistance relationships.

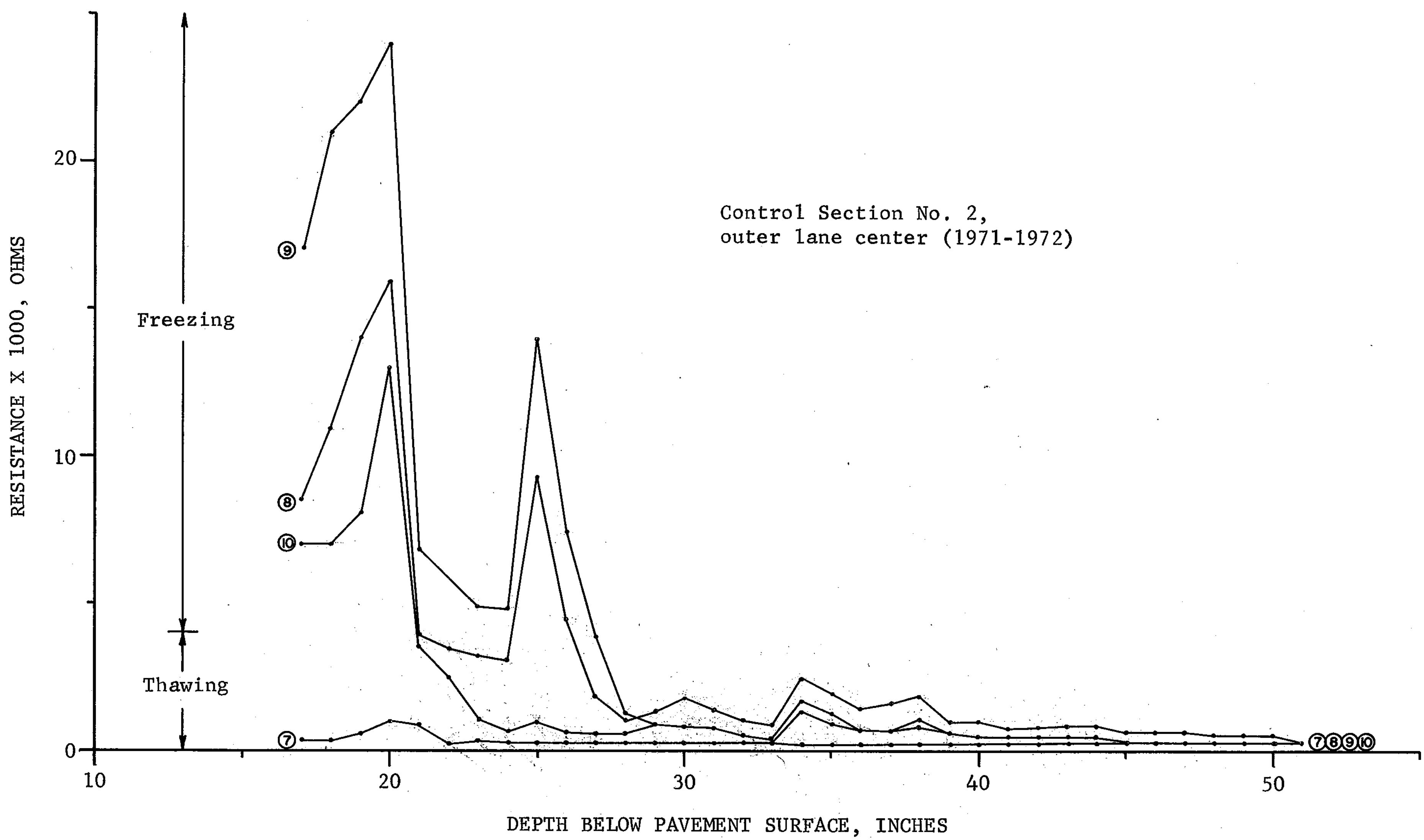


Figure B-40. Typical soil depth versus resistance relationships.

APPENDIX C

SURFACE ELEVATION MEASUREMENTS

Measurements of pavement cross section were conducted once a month during the cold and warm seasons at three predetermined locations in each section. At each location relative changes of surface elevations were determined by differential leveling at six marked points across the pavement cross section. These changes are shown in Tables C-1 to C-7 for all sections in the AWC experimental project.

TABLE C-1

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet) 1	6	11	13	18	23	MAXIMUM CHANGE NEGATIVE	MAXIMUM CHANGE POSITIVE
Control No. 1	2-10-71	401+00	-	+ .08	+ .09	+ .08	+ .09	-	0	+ .09
		401+50	-	+ .09	+ .08	+ .09	+ .09	-	0	+ .09
		402+00	-	+ .10	+ .10	+ .10	+ .09	-	0	+ .10
	3-12-71	401+00	-	- .03	- .02	- .03	- .02	-	- .03	0
		401+50	-	- .02	- .02	- .02	- .01	-	- .02	0
		402+00	-	- .02	- .02	- .02	- .02	-	- .02	0
	4-14-71	401+00	-	- .03	- .02	- .03	- .03	-	- .03	0
		401+50	-	- .03	- .02	- .02	- .01	-	- .03	0
		402+00	-	- .03	- .03	- .03	- .04	-	- .04	0
	11- 9-71	401+00	+ .02	+ .02	+ .01	+ .02	+ .02	+ .02	0	+ .02
		401+50	+ .02	0	0	+ .02	+ .02	+ .01	0	+ .02
		402+00	+ .01	+ .01	0	0	+ .01	+ .02	0	+ .02
	12- 7-71	401+00	+ .05	+ .04	+ .03	+ .04	+ .05	+ .04	0	+ .05
		401+50	+ .04	+ .02	+ .03	+ .03	+ .03	+ .03	0	+ .04
		402+00	+ .02	+ .02	+ .01	+ .01	+ .02	+ .02	0	+ .02
	1- 4-72	401+00	+ .04	+ .03	+ .03	+ .03	+ .04	-	0	+ .04
		401+50	+ .02	+ .01	+ .02	+ .02	+ .02	-	0	+ .02
		402+00	-	+ .01	+ .01	+ .01	+ .01	-	0	+ .01
	2- 1-72	401+00	+ .03	+ .01	+ .01	+ .01	+ .01	+ .03	0	+ .03
		401+50	+ .01	0	- .01	- .02	0	- .01	- .02	+ .01
		402+00	0	0	0	0	+ .01	0	0	+ .01
	3- 7-72	401+00	+ .02	0	0	- .01	- .01	+ .02	- .01	+ .02
		401+50	+ .01	- .01	- .01	0	0	- .02	- .02	+ .01
		402+00	- .03	0	- .01	- .02	- .01	- .02	- .03	0

TABLE C-2

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet)						MAXIMUM CHANGE	
			1	6	11	13	18	23	NEGATIVE	POSITIVE
Test No. 1	2-10-71	403+50	-	- .05	- .05	- .05	- .04	-	- .05	0
		404+00	-	- .04	- .03	- .03	- .02	- .02	- .04	0
		404+50	-	- .04	- .03	- .04	- .03	- .04	- .04	0
	3-12-71	403+50	-	- .03	- .02	- .03	- .02	-	- .03	0
		404+00	-	- .02	- .01	- .01	- .02	- .01	- .02	0
		404+50	-	- .02	- .01	- .01	- .02	- .02	- .02	0
	4-14-71	403+50	-	- .02	- .02	- .03	- .01	-	- .03	0
		404+00	-	- .03	- .01	- .01	- .01	0	- .03	0
		404+50	-	- .02	- .01	- .02	0	- .01	- .02	0
	11- 9-71	403+50	+ .01	0	0	0	0	0	0	+ .01
		404+00	+ .01	0	0	0	+ .01	0	0	+ .01
		404+50	+ .01	+ .01	+ .01	0	+ .01	+ .01	0	+ .01
	12- 7-71	403+50	- .03	- .03	- .03	- .05	- .03	0	- .05	0
		404+00	- .01	- .03	- .04	- .03	- .03	- .01	- .04	0
		404+50	- .01	- .02	- .03	0	- .01	- .02	- .03	0
	1- 4-72	403+50	0	- .01	0	0	0	-	- .01	0
		404+00	+ .01	0	0	0	0	-	0	+ .01
		404+50	0	0	0	0	0	-	0	0
	2- 1-72	403+50	0	- .01	0	- .01	0	- .02	- .02	0
		404+00	0	- .01	0	0	0	+ .01	- .01	+ .01
		404+50	- .02	- .03	- .02	- .03	- .02	0	- .03	0
	3- 7-72	403+50	0	0	- .02	- .01	- .01	- .01	- .02	0
		404+00	- .02	- .01	- .02	0	- .02	- .01	- .02	0
		404+50	- .02	- .02	- .01	- .01	0	0	- .02	0

TABLE C-3

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet)						MAXIMUM CHANGE	
			1	6	11	13	18	23	NEGATIVE	POSITIVE
Test No. 2	2-10-71	406+00	-	- .01	- .02	- .02	- .01	-	- .02	0
		406+50	-	- .03	- .03	- .02	- .02	-	- .03	0
		407+00	-	- .02	- .01	- .01	- .01	-	- .02	0
	3-12-71	406+00	-	- .01	- .02	- .02	0	-	- .02	0
		406+50	-	- .02	- .03	- .02	- .01	-	- .03	0
		407+00	-	- .02	- .02	- .02	- .03	-	- .03	0
	4-14-71	406+00	-	- .01	- .01	- .01	- .01	-	- .01	0
		406+50	-	- .03	- .02	- .01	0	-	- .03	0
		407+00	-	- .02	0	0	- .01	-	- .02	0
	11- 9-71	406+00	0	0	- .01	0	+ .01	0	- .01	+ .01
		406+50	- .01	- .01	- .01	- .01	0	0	- .01	0
		407+00	- .01	- .02	- .01	- .02	- .01	- .02	- .02	0
	12- 7-71	406+00	0	0	0	0	0	0	0	0
		406+50	- .01	- .01	- .01	- .01	- .01	- .01	- .01	0
		407+00	- .01	- .04	- .03	- .03	- .03	- .03	- .04	0
	1- 4-72	406+00	+ .01	0	0	+ .01	-	-	0	+ .01
		406+50	+ .01	0	0	0	+ .01	+ .01	0	+ .01
		407+00	0	0	+ .01	0	+ .01	0	0	+ .01
	2- 1-72	406+00	- .01	- .02	- .01	0	0	+ .01	- .02	+ .01
		406+50	- .02	- .02	- .02	- .03	- .01	- .01	- .03	0
		407+00	0	0	+ .01	+ .01	0	+ .02	0	+ .02
	3- 7-72	406+00	- .01	- .01	- .02	- .02	- .01	- .02	- .02	0
		406+50	- .03	- .03	- .02	- .01	0	0	- .03	0
		407+00	- .03	- .03	0	0	0	0	- .03	0

TABLE C-4

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet) 1	6	11	13	18	23	MAXIMUM CHANGE NEGATIVE	MAXIMUM CHANGE POSITIVE
Test No. 3	2-10-71	409+00	-	- .02	- .01	- .02	0	-	- .02	0
		409+50	-	- .01	- .02	- .02	- .03	-	- .03	0
		410+00	-	- .01	- .01	0	0	-	- .01	0
	3-12-71	409+00	-	- .02	- .03	- .03	- .02	-	- .03	0
		409+50	-	- .02	- .03	- .03	- .04	-	- .04	0
		410+00	-	- .03	- .03	- .01	- .02	-	- .03	0
	4-14-71	409+00	-	- .03	- .02	- .03	- .02	-	- .03	0
		409+50	-	- .02	- .04	- .04	- .04	-	- .04	0
		410+00	-	- .02	- .02	- .01	- .02	-	- .02	0
	11- 9-71	409+00	0	- .01	- .01	- .01	- .01	- .01	- .01	0
		409+50	- .01	- .01	- .01	- .02	- .01	0	- .02	0
		410+00	- .01	- .02	- .02	- .01	- .01	0	- .02	0
	12- 7-71	409+00	- .03	- .05	- .04	- .05	- .04	- .06	- .06	0
		409+50	- .04	- .05	- .03	- .06	- .04	- .06	- .06	0
		410+00	- .03	- .04	- .04	- .02	- .03	- .03	- .04	0
	1- 4-72	409+00	- .01	- .01	0	0	0	0	- .01	0
		409+50	- .01	- .01	- .01	- .02	- .01	- .01	- .02	0
		410+00	- .01	- .02	- .01	- .01	- .01	0	- .02	0
	2- 1-72	409+00	- .06	- .04	0	+ .01	+ .01	+ .01	- .06	+ .01
		409+50	- .01	- .02	- .01	- .02	- .01	- .01	- .02	0
		410+00	- .01	- .01	- .01	0	- .01	0	- .01	0
	3- 7-72	409+00	+ .03	- .01	- .01	- .01	- .01	0	- .01	+ .03
		409+50	- .03	- .02	- .02	- .01	0	- .02	- .03	0
		410+00	- .02	- .02	- .02	- .01	- .01	- .01	- .02	0

TABLE C-5

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet) 1	6	11	13	18	23	MAXIMUM CHANGE NEGATIVE	MAXIMUM CHANGE POSITIVE
Test No. 4	2-10-71	412+00	-	- .02	+ .04	- .01	- .01	-	- .02	+ .04
		412+50	-	- .01	- .02	- .02	- .03	-	- .03	0
		413+00	-	- .03	0	- .01	- .02	-	- .03	0
	3-12-71	412+00	-	- .01	+ .04	- .01	- .01	-	- .01	+ .04
		412+50	-	0	- .02	- .03	- .02	-	- .03	0
		413+00	-	- .01	0	0	0	-	- .01	0
	4-14-71	412+00	-	0	+ .05	+ .01	0	-	0	+ .05
		412+50	-	0	- .02	- .02	- .02	-	- .02	0
		413+00	-	- .01	0	0	0	-	- .01	0
	11- 9-71	412+00	0	0	0	0	0	0	0	0
		412+50	+ .01	0	0	0	0	0	0	+ .01
		413+00	- .02	0	- .01	0	+ .01	+ .01	- .02	+ .01
	12- 7-71	412+00	+ .01	+ .01	+ .01	- .02	0	+ .01	- .02	+ .01
		412+50	+ .03	+ .01	+ .02	+ .02	+ .02	+ .02	0	+ .03
		413+00	0	+ .01	0	+ .01	+ .03	0	0	+ .03
	1- 4-72	412+00	+ .02	+ .01	+ .01	+ .01	+ .02	+ .02	0	+ .02
		412+50	+ .03	+ .02	+ .03	+ .02	+ .02	+ .02	0	+ .03
		413+00	+ .01	+ .02	+ .02	+ .03	+ .04	+ .03	0	+ .04
	2- 1-72	412+00	+ .02	+ .01	+ .01	+ .01	+ .01	+ .01	0	+ .02
		412+50	- .04	+ .02	+ .02	+ .02	+ .02	0	- .04	+ .02
		413+00	+ .03	+ .03	+ .02	+ .03	+ .04	+ .03	0	+ .04
	3- 7-72	412+00	- .01	- .02	- .01	- .02	- .02	- .02	- .02	0
		412+50	+ .01	- .01	0	0	- .01	- .03	- .03	+ .01
		413+00	- .02	- .01	- .01	0	0	- .02	- .02	0

TABLE C-6

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet)						MAXIMUM CHANGE	
			1	6	11	13	18	23	NEGATIVE	POSITIVE
Test No. 5	2-10-71	415+00	-	0	0	0	+ .01	-	0	+ .01
		415+50	-	- .02	- .02	- .01	- .01	-	- .02	0
		416+00	-	0	+ .01	+ .01	+ .01	-	0	+ .01
	3-12-71	415+00	-	- .01	0	0	+ .01	-	- .01	+ .01
		415+50	-	- .02	- .01	0	0	-	- .02	0
		416+00	-	- .01	- .01	0	+ .02	-	- .01	+ .02
	4-14-71	415+00	-	0	0	0	+ .01	-	0	+ .01
		415+50	-	- .01	0	0	0	-	- .01	0
		416+00	-	- .01	0	0	+ .01	-	- .01	+ .01
	11- 9-71	415+00	+ .02	+ .02	+ .01	+ .02	+ .02	+ .02	0	+ .02
		415+50	+ .01	0	0	0	+ .01	+ .01	0	+ .01
		416+00	0	0	- .01	- .01	- .01	- .01	- .01	0
	12- 7-71	415+00	- .06	- .04	- .05	- .06	- .04	- .05	- .06	0
		415+50	- .04	- .05	- .05	- .05	- .05	- .04	- .05	0
		416+00	- .03	- .04	- .04	- .04	- .05	- .05	- .05	0
	1- 4-72	415+00	+ .04	+ .05	+ .04	+ .04	+ .04	+ .04	0	+ .05
		415+50	+ .03	+ .02	+ .01	+ .03	+ .02	+ .03	0	+ .03
		416+00	+ .02	0	0	0	- .01	0	- .01	+ .02
	2- 1-72	415+00	+ .01	+ .01	+ .01	+ .01	+ .03	+ .03	0	+ .03
		415+50	0	- .02	- .02	- .01	0	0	- .02	0
		416+00	- .01	- .02	- .03	- .02	- .02	- .02	- .03	0
	3- 7-72	415+00	- .01	- .02	- .01	- .01	- .01	- .02	- .02	0
		415+50	- .03	- .03	- .03	- .02	- .01	0	- .03	0
		416+00	- .01	- .01	- .03	- .03	- .02	- .03	- .03	0

TABLE C-7

RELATIVE ELEVATION CHANGES OF PAVEMENT CROSS SECTION
(1971-1972)

SECTION	DATE	STATION	DISTANCE FROM INNER EDGE OF PAVEMENT (Feet) 1	6	11	13	18	23	MAXIMUM CHANGE NEGATIVE	MAXIMUM CHANGE POSITIVE
Control No. 2	2-10-71	418+00	-	+ .01	+ .01	+ .01	+ .01	-	0	+ .01
		418+50	-	+ .01	+ .01	+ .01	+ .01	-	0	+ .01
		419+00	-	+ .02	+ .03	+ .02	+ .02	-	0	+ .03
	3-12-71	418+00	-	0	+ .01	+ .01	0	-	0	+ .01
		418+50	-	- .01	0	0	0	-	- .01	0
		419+00	-	0	+ .01	0	+ .01	-	0	+ .01
	4-14-71	418+00	-	- .01	0	0	0	-	- .01	0
		418+50	-	- .02	- .02	- .01	- .01	-	- .02	0
		419+00	-	- .02	- .01	- .02	- .02	-	- .02	0
	11- 9-71	418+00	+ .01	- .01	0	+ .01	0	0	- .01	+ .01
		418+50	0	- .02	0	0	0	0	- .02	
		419+00	- .01	- .02	0	0	+ .01	+ .02	- .02	+ .02
	12- 7-71	418+00	+ .01	0	+ .01	+ .02	+ .02	+ .02	0	+ .02
		418+50	+ .02	0	+ .02	+ .02	+ .02	+ .02	0	+ .02
		419+00	+ .02	+ .02	+ .02	+ .01	+ .02	+ .03	0	+ .03
	1- 4-72	418+00	0	0	+ .01	+ .01	+ .01	+ .01	0	+ .01
		418+50	0	0	+ .01	0	+ .01	+ .02	0	+ .02
		419+00	+ .01	0	+ .01	+ .02	+ .02	+ .03	0	+ .03
	2- 1-72	418+00	+ .02	0	0	+ .01	0	0	0	+ .02
		418+50	+ .01	0	0	0	0	+ .01	0	+ .01
		419+00	+ .01	+ .01	+ .01	+ .01	+ .02	+ .03	0	+ .03
	3- 7-72	418+00	- .01	- .02	- .02	- .01	- .02	- .02	- .02	0
		418+50	0	- .01	- .01	- .01	- .02	- .02	- .02	0
		419+00	- .01	- .01	- .01	- .01	0	0	- .01	0