A REPORT ON COMPUTER STUDY OF VARIABLES WHICH AFFECT THE BEHAVIOR OF CONCRETE PILES DURING DRIVING

by

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A Progress Report on Research Project No. 2-5-62-33

Prepared for the Bridge Division

of the

Texas Highway Department

and the

Department of Commerce

Bureau of Public Roads

Texas Transportation Institute
Texas A&M University
College Station, Texas

August 1963

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INTRODUCTION

During the year 1960-61, engineers of the Texas Highway Department Bridge Division engaged the staff personnel at Texas A&M University to develop a computer program to accomplish the rigorous mathematical calculations for use of the wave equation to analyze the behavior of piling during driving. With the aid of Mr. Edward A. Smith* as a special consultant, a functioning computer program was developed and used successfully on a number of pile problems (2, 3).** This program was written for the IBM 709 Computer at the Texas A&M University Data Processing Center.

In order to gain confidence in the results computed by this program, it was considered necessary to conduct field tests to obtain actual stress and displacement data to correlate with the theory. During the 1961-62 year, three prestressed concrete piles 95 ft in length and two piles 92 ft in length were instrumented with strain gages and displacement transducers and were field tested during driving (4). During the current year, two prestressed concrete piles 26 ft in length were field tested (5). The correlation of these data with results from the computer program was considered very good and provided experimental evidence that this method could be used to analyze practical pile problems. Consequently, it was decided to use the computer solution of the wave equation to investigate the theoretical behavior of various size piles when driven by different equipment under different foundation conditions. The results from this study are presented in the form of graphs that can be used by office engineers in the design of prestressed concrete piles or can assist them in selecting or regulating driving equipment.

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*Formerly Chief Mechanical Engineer for Raymond International, now retired.

**Numbers thus (2, 3) refer to corresponding items in the list of References.

OBJECTIVES

Project No. 2-5-62-33 entitled "Study of Variables Which Affect Behavior of Concrete Piles During Driving" was initiated September 1, 1962. The objectives of the 1962-63 year were to

(1) make an orderly theoretical computer investigation of the influence of various factors on the behavior of piles during driving.

(2) present these results in the form of charts, diagrams, or tables for direct application by office design engineers, and

(3) instrument and field test at least two concrete piles to obtain data on dynamic stresses in piles to correlate with the computer results.

The results of objective 3 were presented in a report entitled "Field Tests of Prestressed Concrete Piles During Driving," which was prepared for the Bridge Division of the Texas Highway Department in August 1963.

The results of objectives 1 and 2 are presented in this report.

GENERAL DISCUSSION OF STUDY

A theoretical analysis was conducted to determine the effects of ram weight, ram energy output, cushion stiffness, pile cross-sectional area, pile length, soil resistance, and distribution of soil resistance on the driving stresses in and the permanent set of concrete piling. The computer solution of the wave equation (3) was used to solve the 2106 problems involved in this study and the results are presented in the form of graphs. This program was essentially the same as that described by E. A. Smith (1) and C. H. Samson (2), except that it has been modified to include the effect of gravity and a separate frictional and point force on the last pile segment.

Table 1 lists twenty factors known to affect the behavior of piles during driving. In this study only seven of the more significant factors were varied and the others were held constant.

Table 1
Factors Known to Affect the Behavior of Piling During Driving

Factor	Number of Variations	Values Used in This Investigation
Ram weight	4 } 13*	2, 5, 10, and 20 kips
Energy of Ram	5	4, 20, 40, 50, and 60 kip-ft
Cross-sectional area of pile = A	3	200, 400, and 600 sq in.
Stiffness of cushion block	3	5,000 A, 15,000 A, and 45,000 A lb/in.
Length of pile	3	30, 65, and 100 ft
Soil resistance	2	Equivalent to 800 psf and 400 psf on a friction pile embedded 0.8 of its length
Distribution of soil resistance	3**	All friction on embedded length, 0.5 friction and 0.5 point bearing, all point bearing.
Stiffness of cap block	1	80,000 A lb/in.
Coefficient of restitution of cap block	1	0.5
Weight of pile cap (helmet)	1	1000 lb
Coefficient of restitution of cushion block	1	0.5
Unit weight of pile concrete		150 pcf
Modulus of elasticity of pile concrete	1	5,000,000 psi
Coefficient of restitution of pile concrete	1	1.0
Soil quake at point	1	0.1 in.
Soil quake in friction	1	0.02 in.
Damping constant of point	1	0.15 sec/ft
Damping constant in friction	1	0.05 sec/ft
Pile configuration	1	Prism with square cross section
Diesel hammer explosive force	1	None

Total Number of Problems = 13 x 3 x 3 x 3 x 2 x 3 = 2106

*Only 13 different combinations of ram weights and energies were used. See Table 2.

**See Table 3 for total magnitudes of soil resistances used in investigation.

Ram Weights and Energies

In this study 13 different combinations of ram weights and energies were used as shown in Table 2. These values will encompass the ram weights and energy ratings of most steam and diesel pile drivers now available. The velocity of a given ram corresponding to a given energy can be determined using the equation

$$V = \sqrt{2 g E'/W}$$

where

V = velocity of ram in ft/sec,
g = acceleration due to gravity in ft/sec^2,
E' = Energy of ram in kip-ft, and
W = ram weight in kips.

Table 2
Combinations of Ram Weight and Energy Used in Investigation

Ram Weight (kips)	Energy of Ram (kip-feet)			
2	4	20		
5	4	20	40	
10	4	20	40	50
20	4	20	40	60

Areas and Lengths of Piles

The cross-sectional areas (200, 400 and 600 sq in.) and lengths (30, 65, and 100 ft) of piles used will encompass a large number of concrete pile sizes now available. The pile configuration considered was a prism with a square cross section.

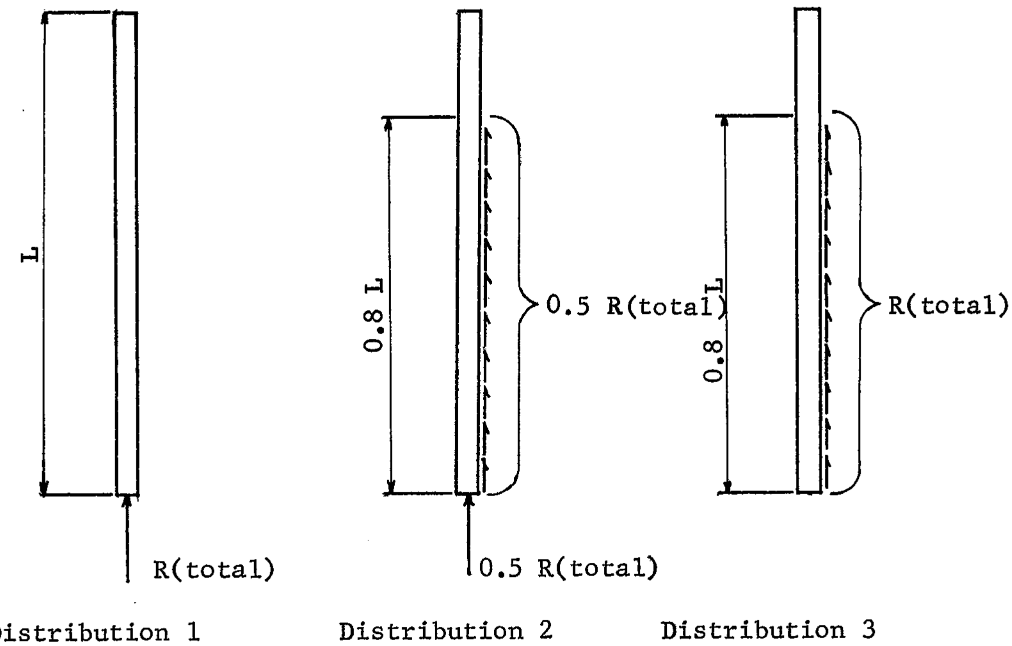

Figure 1A. Distribution of total magnitude of soil resistance.

Table 3. Total magnitude of soil resistance in kips.

Pile Length (ft)	Pile Area (in.^{2})	TOTAL MAGNITUDE OF SOIL RESISTANCE kips					
		Soil Resistance H (800 psf)			Soil Resistance S (400 psf)		
		Distr. 1	Distr. 2	Distr. 3	Distr. 1	Distr. 2	Distr. 3
30	200	90.5	90.5	90.5	45.3	45.3	45.3
	400	128.0	128.0	128.0	64.0	64.0	64.0
	600	156.8	156.8	156.8	78.4	78.4	78.4
65	200	196.1	196.1	196.1	98.1	98.1	98.1
	400	277.3	277.3	277.3	138.7	138.7	138.7
	600	339.7	339.7	339.7	169.9	169.9	169.9
100	200	301.7	301.7	301.7	150.8	150.8	150.8
	400	426.7	426.7	426.7	213.3	213.3	213.3
	600	522.7	522.7	522.7	261.3	261.3	261.3

Stiffnesses of Cushion Blocks

The cushion block stiffnesses 5000 A, 15,000 A, and 45,000 A lb/in. are approximately equivalent to 9, 3, and 1 in. of compressed oak, respectively. "A" is the loaded area or cross-sectional area of the pile in square inches.

Soil Resistances

The soil resistances used were equivalent to shear strengths of 800 psf and 400 psf on a friction pile embedded 0.8 of its length. Consequently, the total magnitude of the soil resistance used on a given pilewas a function of its length, its perimeter and the soil shear strength. The total resistance on a given pile was found by

$$R(\text{total}) = T \times 0.8\,L \times 4\sqrt{A}$$

where

R(total) = total magnitude of soil resistance in kips,
T = shear strength of soil (0.8 ksf of 0.4 ksf),
L = length of pile in ft, and
A = cross-sectional area of square pile in in.^{2}.

Table 3 shows the total magnitudes of soil resistance used in this investigation. The 800 psf soil shear strength is designated Soil Resistance H and the 400 psf soil shear strength designated Soil Resistance S.

Distribution of Soil Resistance

After the total magnitude of soil resistance was determined for the friction pile with embedded length of 0.8 L, it was distributed as shown in Figure 1A.

Other Factors

The other factors known to affect the behavior of piling during driving were assigned a reasonable value that was kept constant for all problems (See Table 1). The properties of the concrete pile such as unit weight and modulus of elasticity were assigned values based on typical hard rock concrete. The value of the coefficient of restitution of the concrete, or concrete damping parameters, was not known and, therefore, the concrete was assumed to be perfectly elastic. The soil damping constants and quakes were assigned values recommended by E. A. Smith (1) except that a value of quake in side friction of 0.02 in. was used.

RESULTS OF STUDY

The effects of the ram weight, ram energy output, cushion stiffness, pile cross-sectional area, pile length, soil resistance, and distribution of soil resistance on the maximum tensile and compressive stresses produced in a pile are illustrated by Figures 1 through 54. Each of the 54 figures contain 3 graphs making a total of 162 graphs. These result from the possible combinations of three pile lengths, three pile areas, three cushion stiffnesses, two soil resistances, and three soil distributions. Table 4 gives the values for each of the 5 variables corresponding to a given figure number. The 13 combinations of ram weights and ram energy outputs are shown on each of the graphs. The curve designations 2, 5, 10, and 20 are the ram weights in kips.

These graphs can be used to estimate the driving stresses that may occur in piles under similar conditions. They can be used for ram weights other than those shown by interpolation.

Figures 55 through 108 illustrate the effect of ram weight, ram energy output, cushion stiffness, pile cross-sectional area, pile length, soil resistance, and distribution of soil resistance on the permanent set of piles for a single blow of the ram. Table 5 gives values of each of the 5 variables for a given figure number. These graphs can be used to estimate the effectiveness of different size and energy rams when driving similar piles.

Table 4
Key to Figure Numbers Illustrating Maximum Tensile and Compressive Stresses Produced in Piles Under the Given Conditions

Pile Length (ft)	Pile Area (in.^{2})	Cushion Stiffness (lb/in.)	FIGURE NUMBERS					
			Soil Resistance H			Soil Resistance S		
			Distr.	Distr.	Distr.	Distr.	Distr.	Distr.
30	200	5,000 A 15,000 A 45,000 A	1	2	3	4	5	6
	400	5,000 A 15,000 A 45,000 A	7	8	9	10	11	12
	600	5,000 A 15,000 A 45,000 A	13	14	15	16	17	18
65	200	5,000 A 15,000 A 45,000 A	19	20	21	22	23	24
	400	5,000 A 15,000 A 45,000 A	25	26	27	28	29	30
	600	5,000 A 15,000 A 45,000 A	31	32	33	34	35	36
100	200	5,000 A 15,000 A 45,000 A	37	38	39	40	41	42
	400	5,000 A 15,000 A 45,000 A	43	44	45	46	47	48
	600	5,000 A 15,000 A 45,000 A	49	50	51	52	53	54

Table 5
Key to Figure Numbers Illustrating the Permanent Set of Piles Under the Given Conditions

Pile Length (ft)	Pile Area (in.^{2})	Cushion Stiffness (lb/in.)	FIGURE NUMBERS: Soil Resistance H, Distr. 1	Soil Resistance H, Distr. 2	Soil Resistance H, Distr. 3	Soil Resistance S, Distr. 1	Soil Resistance S, Distr. 2	Soil Resistance S, Distr. 3
30	200	5,000 A 15,000 A 45,000 A	55	56	57	58	59	60
30	400	5,000 A 15,000 A 45,000 A	61	62	63	64	65	66
30	600	5,000 A 15,000 A 45,000 A	67	68	69	70	71	72
65	200	5,000 A 15,000 A 45,000 A	73	74	75	76	77	78
65	400	5,000 A 15,000 A 45,000 A	79	80	81	82	83	84
65	600	5,000 A 15,000 A 45,000 A	85	86	87	88	89	90
100	200	5,000 A 15,000 A 45,000 A	91	92	93	94	95	96
100	400	5,000 A 15,000 A 45,000 A	97	98	99	100	101	102
100	600	5,000 A 15,000 A 45,000 A	103	104	105	106	107	108

Conclusions

A study of the results presented in Figures 1 through 108 indicates the following general conclusions concerning the behavior of the piles investigated in this report. Any variables not mentioned in the specific conclusion below are held constant.

It should be recognized that some of these conclusions might not be applicable to problems that have variables different from those used in this study.

1. For a given energy output a heavy ram produces lower tensile and compressive stresses than a light ram. (See Figures 1 through 54)

2. For a given energy output a heavy ram produces more permanent set than a light ram. (See Figures 55 through 108.)

3. A soft cushion is very effective in reducing both tensile and compressive stresses in a pile. (See Figures 1 through 54).

4. A soft cushion gives more permanent set per blow than a hard cushion if both have the same coefficient of restitution. (See Figures 55 through 108.)

5. A soft soil resistance produces larger tensile stresses in the piles than a hard soil resistance. (See Figures 1 and 4, 2 and 5, 3, and 6.)

6. A greater permanent set per blow is obtained with a soft soil resistance than with a hard. (See Figures 55 and 58, 56 and 59, 57 and 60.)

7. In general, the tensile stresses produced in friction piles were higher than those in point bearing piles. No consistence change can be noted in the compressive stresses.

8. Friction piles 30 and 65 ft long experience greater permanent set than point bearing piles of the same length. On the other hand, point bearing piles 100 ft long experience greater permanent set than friction piles of the same length.

9. In general, long piles have higher tensile stresses than short piles. The length of the piles has no significant effect on the compressive stresses.

10. For a given soil condition, short piles experience much greater penetration per blow than long piles. It is noted, however, that the long piles have a greater total soil resistance to overcome.

11. Increasing the cross-sectional area of these piles produces a slight decrease in the compressive stress, but no consistent change is noted in the tensile stress.

As a final comment, it should be noted that the concrete material used in this study was assumed to be perfectly elastic. No damping or energy-absorbing parameters were used, since the values for concrete and other materials have not been established. Consequently, it is the writer's opinion that the magnitudes of the maximum tensile stresses shown on the figures are probably higher than actual piles would experience. However, the qualitative effects of the other variables on these tensile stresses are thought to be representative of what would be experienced in the field under similar conditions. The results of other studies have shown that the damping parameters have only a small effect on the maximum compressive stresses and permanent sets.

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2. Samson, Charles H., Jr., "Pile-Driving Analysis by the Wave Equation (Computer Application)", Report of the Texas Transportation Institute, A&M College of Texas, May, 1962.

3. Samson, C.H., Hirsch, T.J., and Lowery, L.L., "Computer Study of Dynamic Behavior of Piling," a paper presented to Third Conference on Electronic Computation, ASCE, Boulder, Colorado, June, 1963.

4. Hirsch, T.J., "Stresses in Long Prestressed Concrete Piles During Driving," Report of the Texas Transportation Institute, A&M College of Texas, September, 1962.

5. Hirsch, T.J., "Field Tests of Prestressed Concrete Piles During Driving," Report of the Texas Transportation Institute, Texas A&M University, August, 1963.

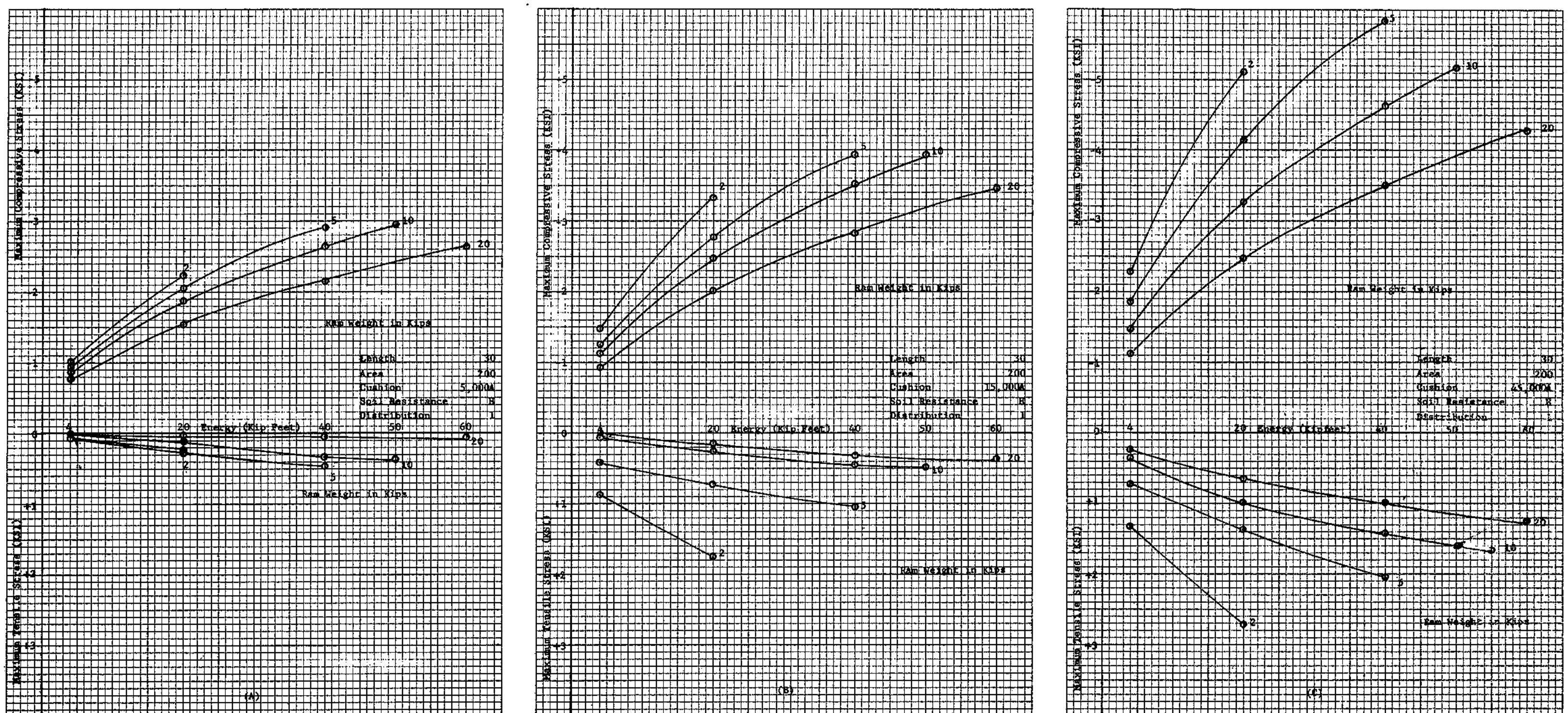
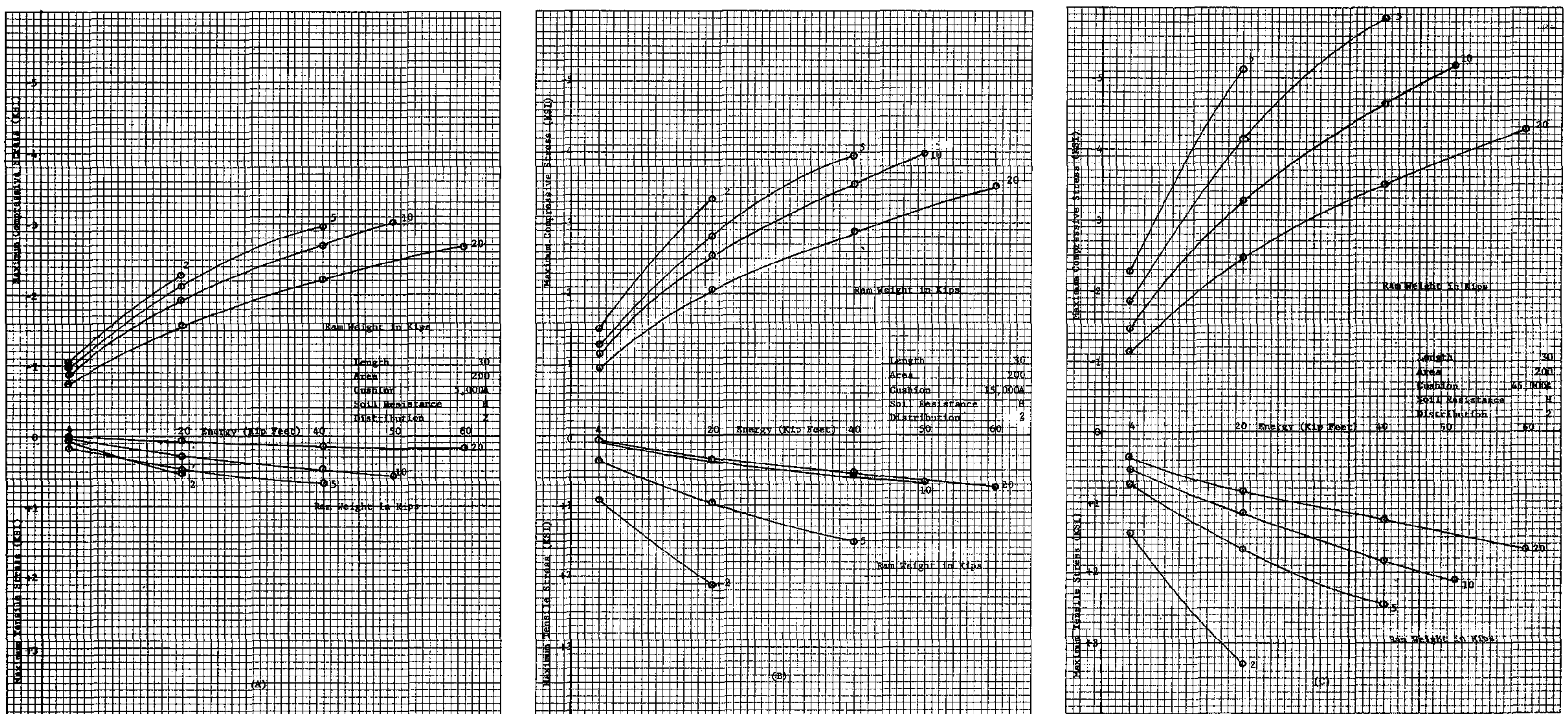

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance R
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 1



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 2

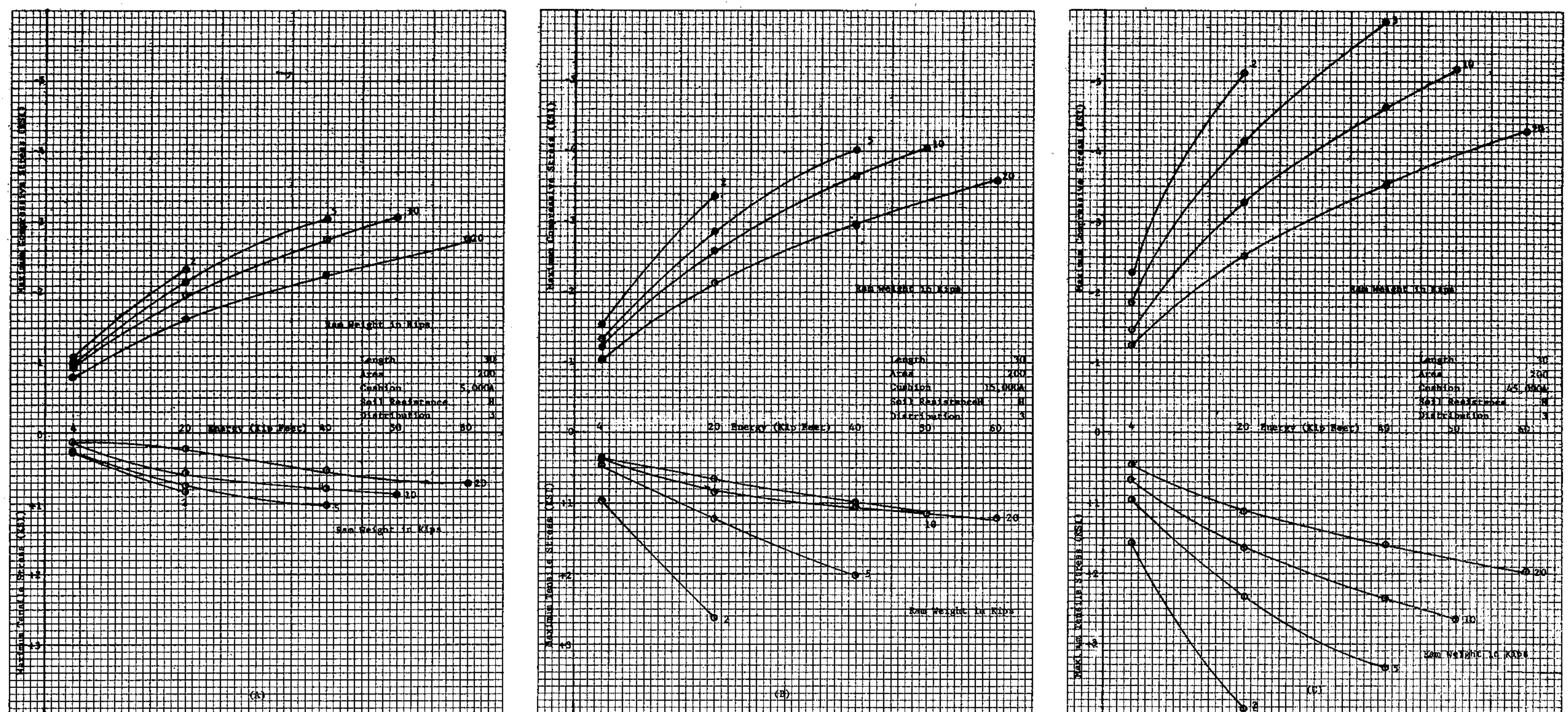

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Length 30
Area 200
Cushion 15,000A
Soil Resistance H
Distribution 3
(B)
Length 30
Area 200
Cushion 45,000A
Soil Resistance H
Distribution 3
(C)

FIGURE 3

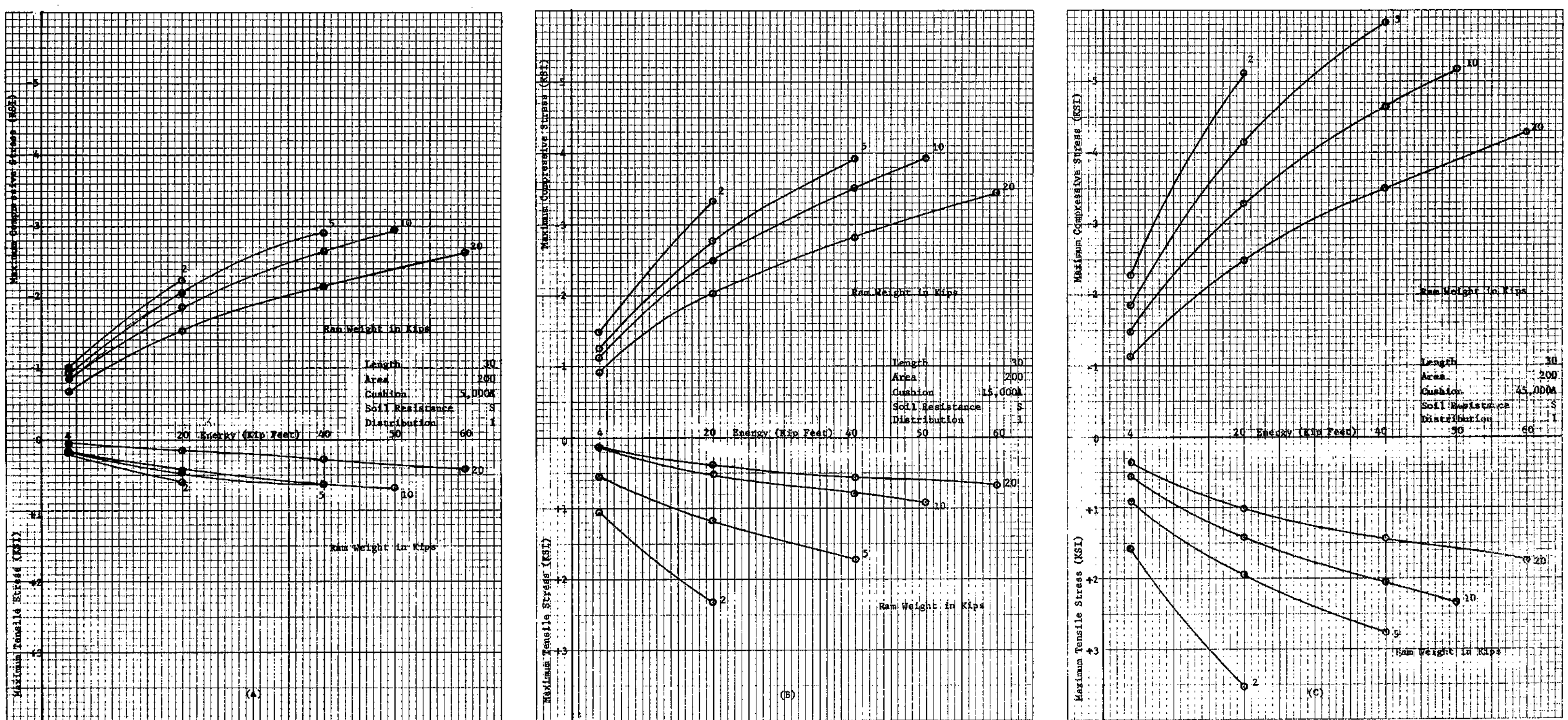

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 4

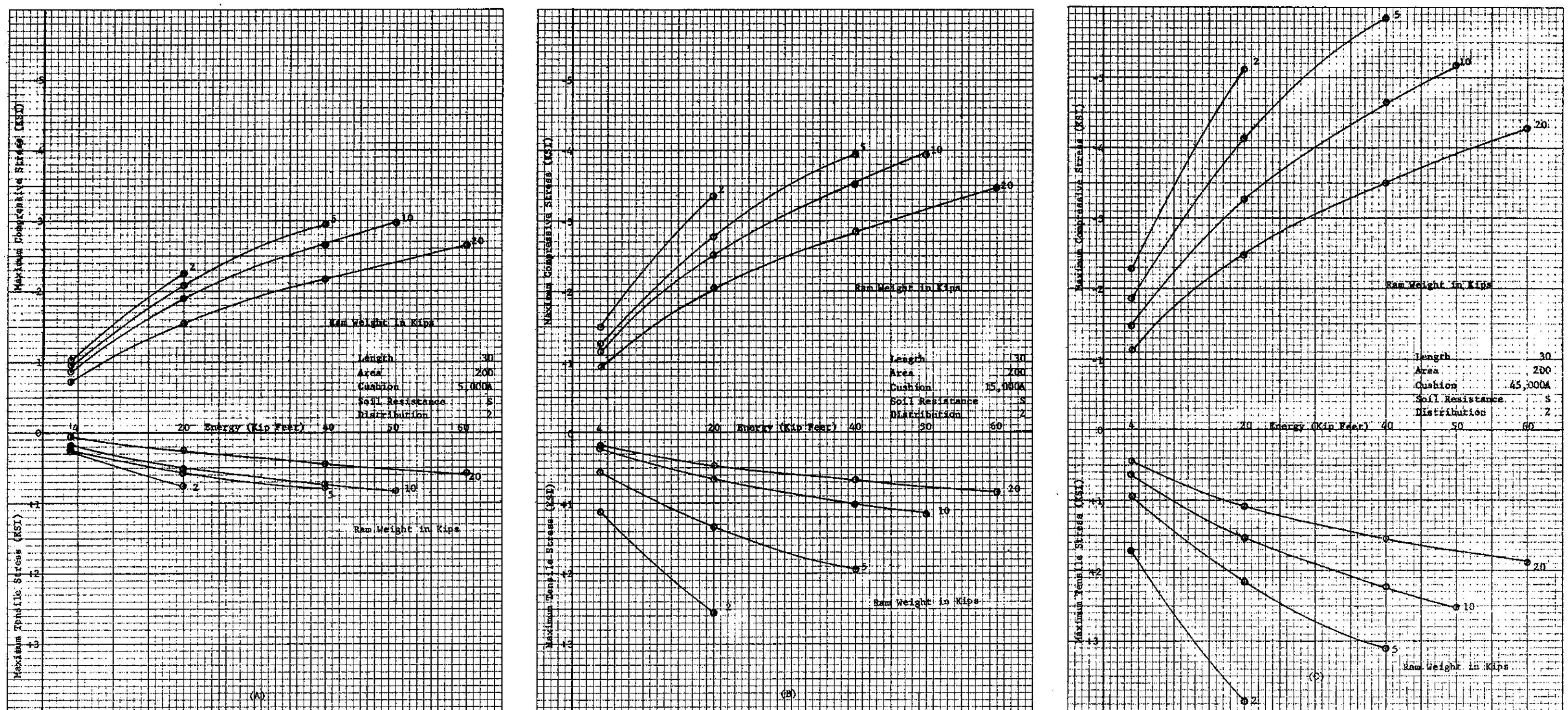

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance 5
Distribution 2
(A)
Length 30
Area 200
Cushion 15,000A
Soil Resistance 5
Distribution 2
(B)
Length 30
Area 200
Cushion 45,000A
Soil Resistance 5
Distribution 2
(C)

FIGURE 5

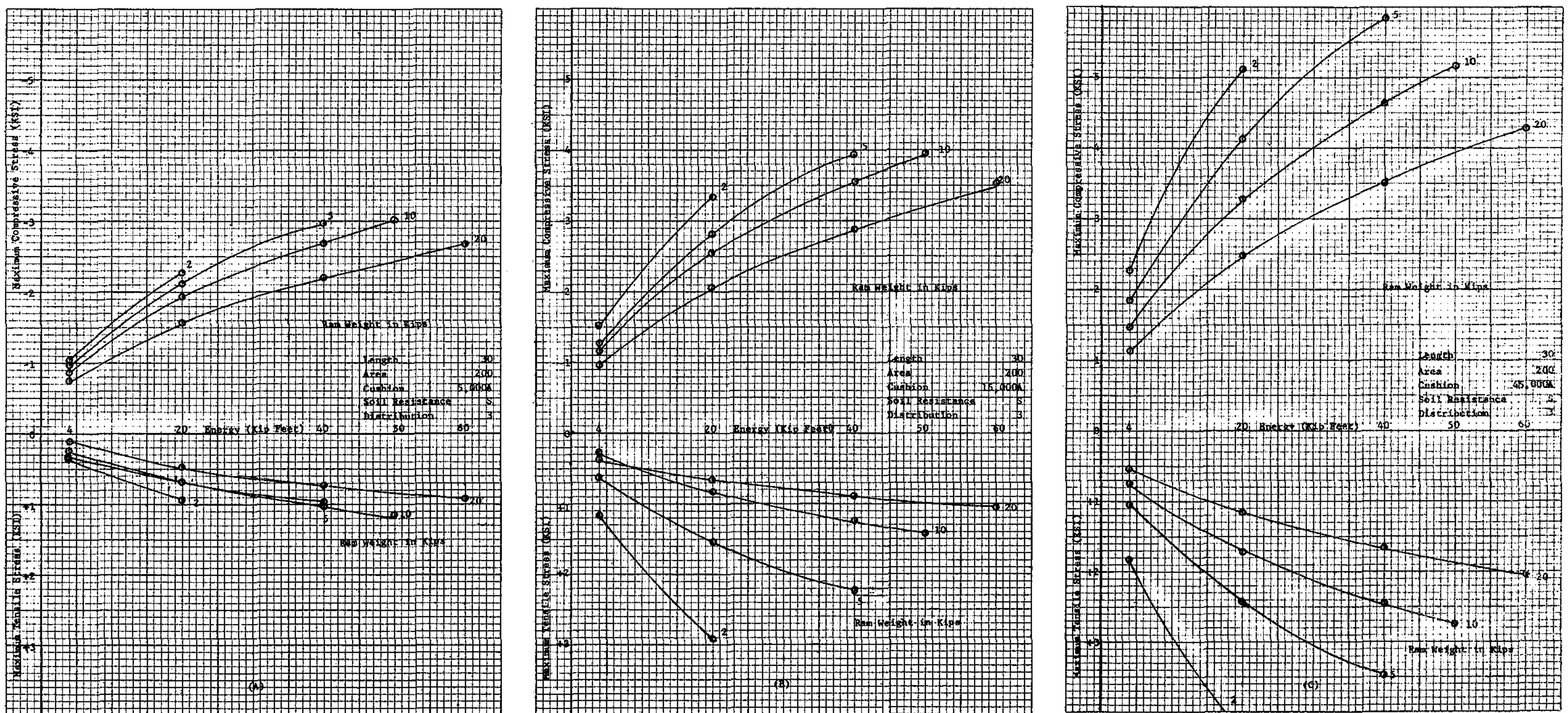

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 6

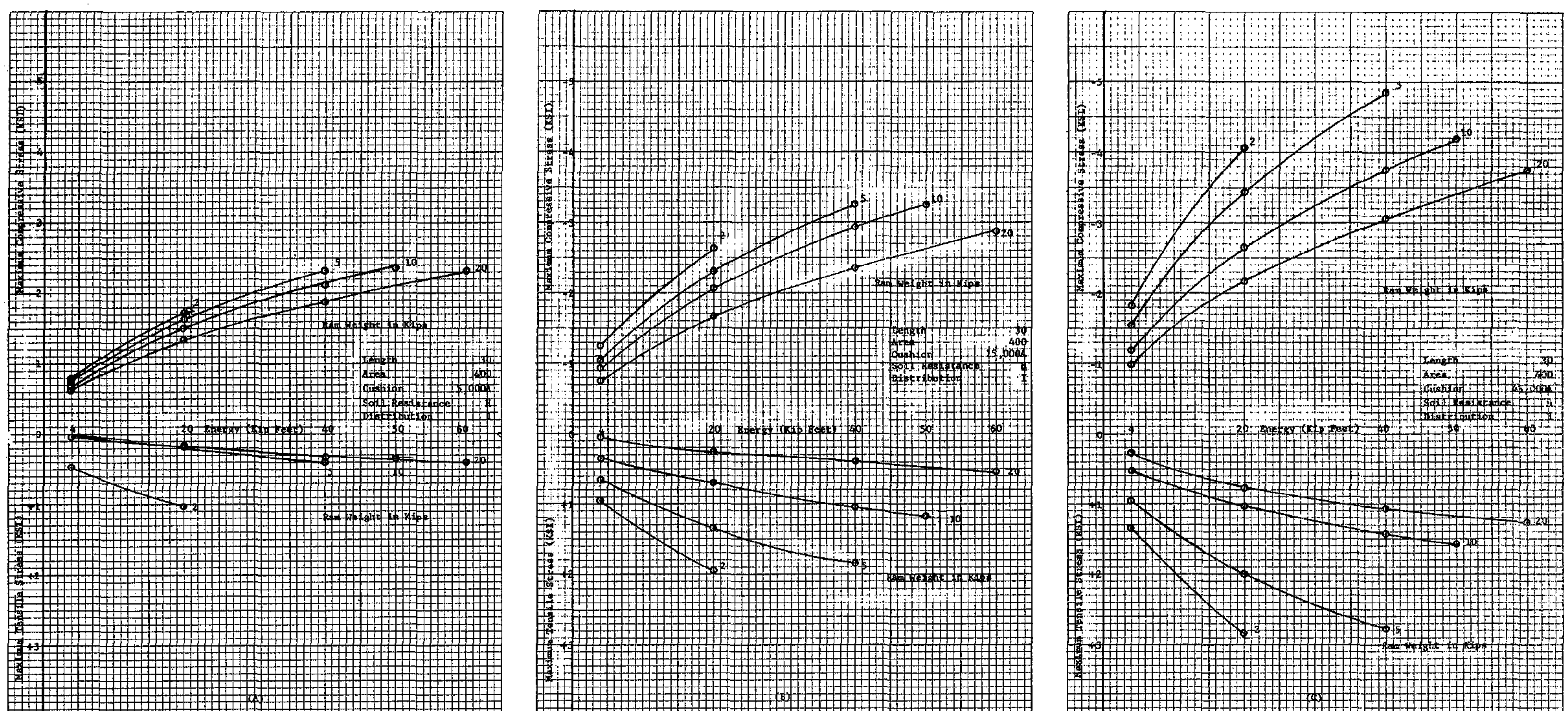

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 7

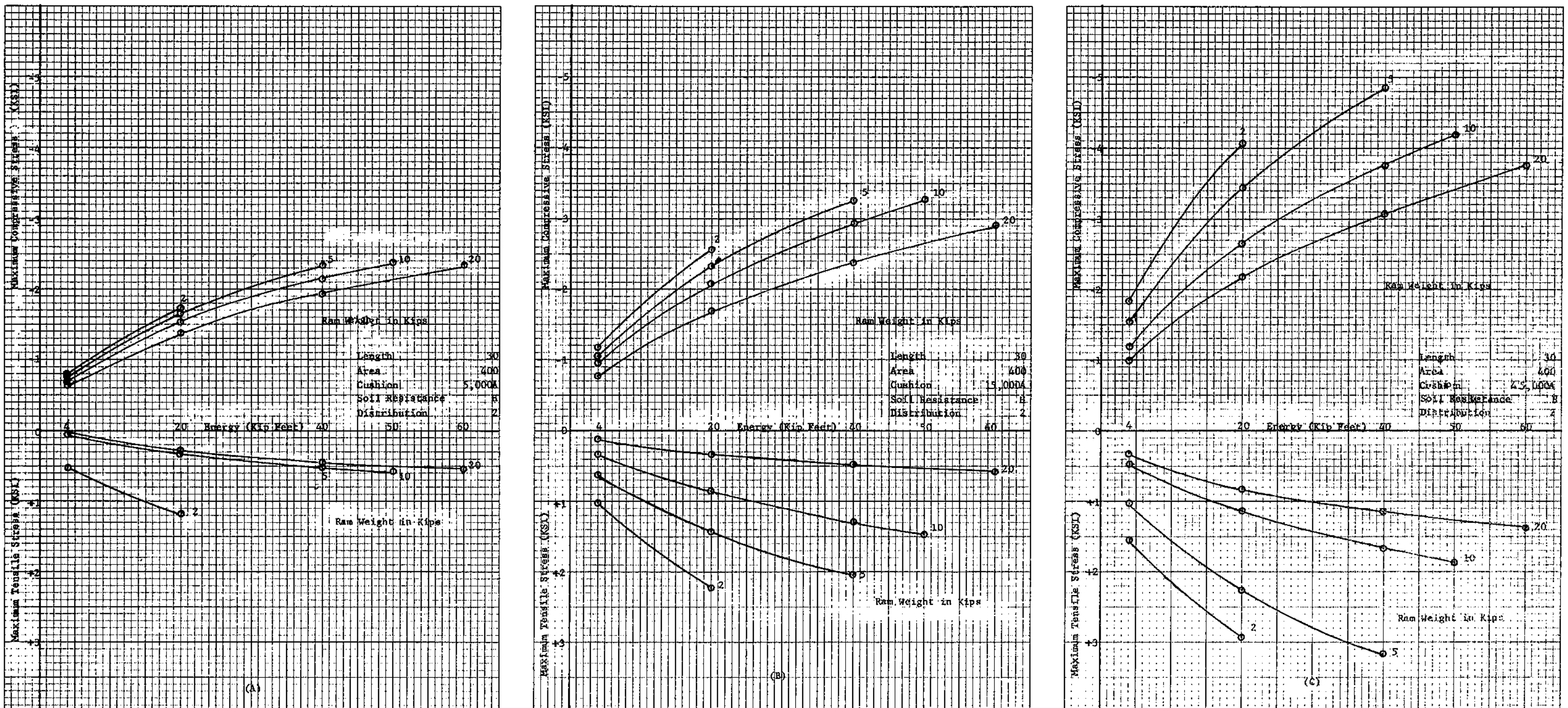

(A)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance 8
Distribution 2
(B)
Cushion 15,000A
(C)

FIGURE 8

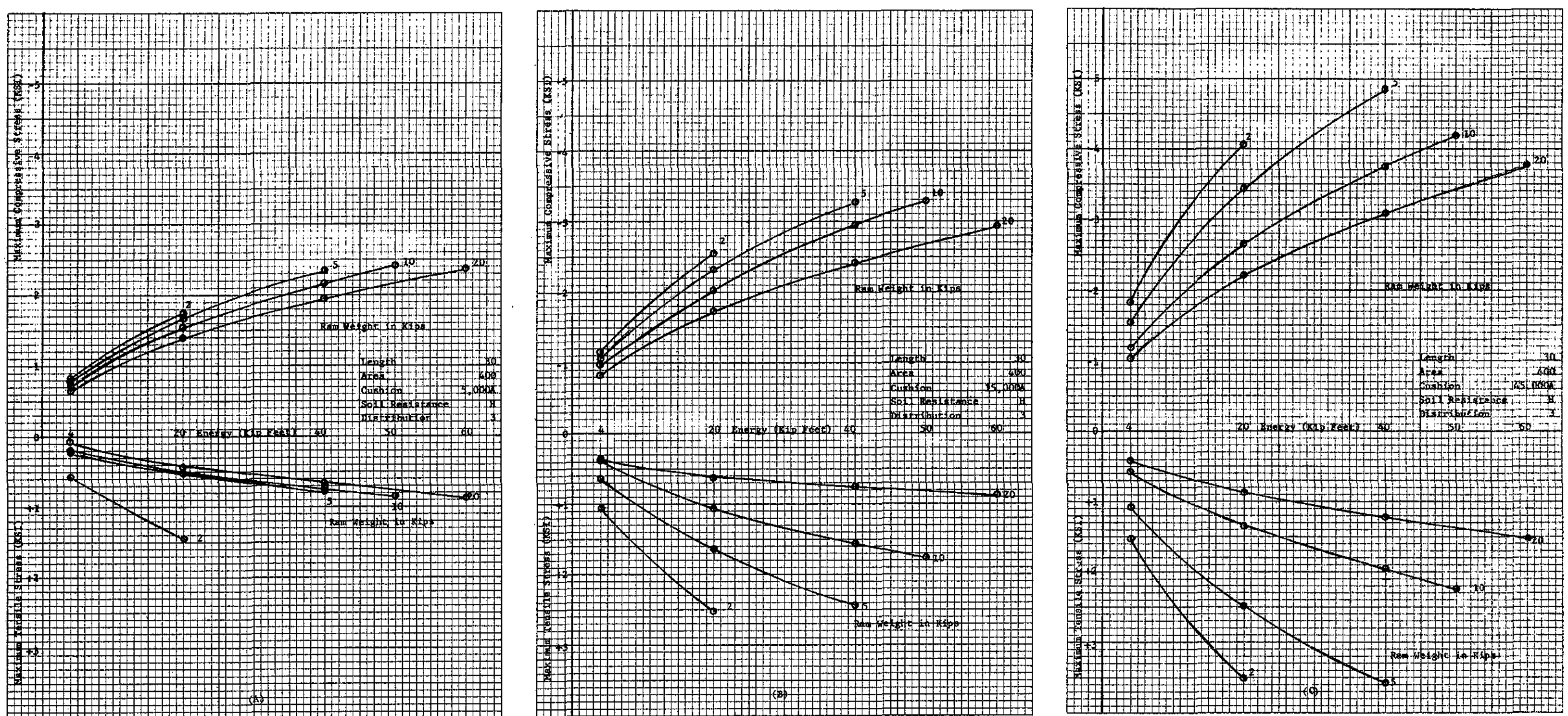
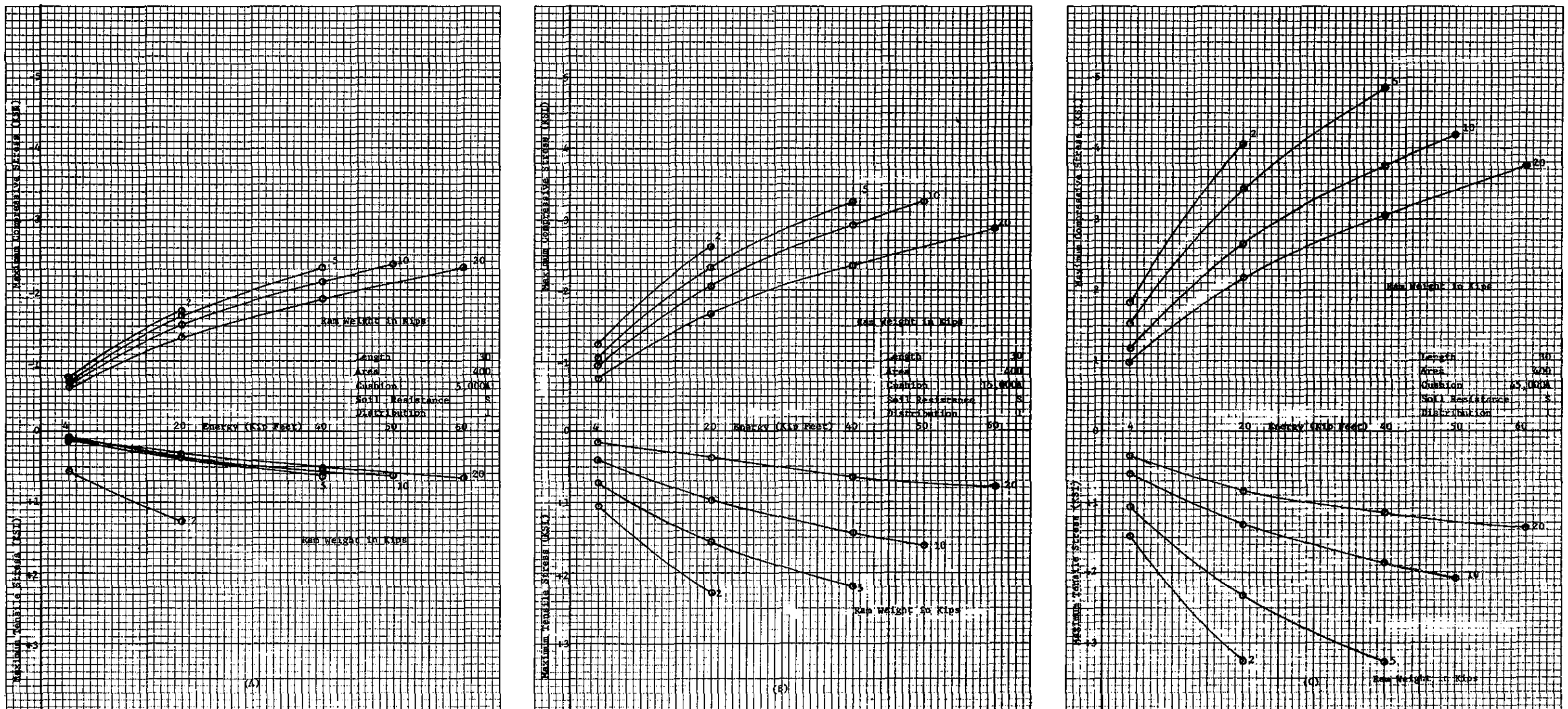
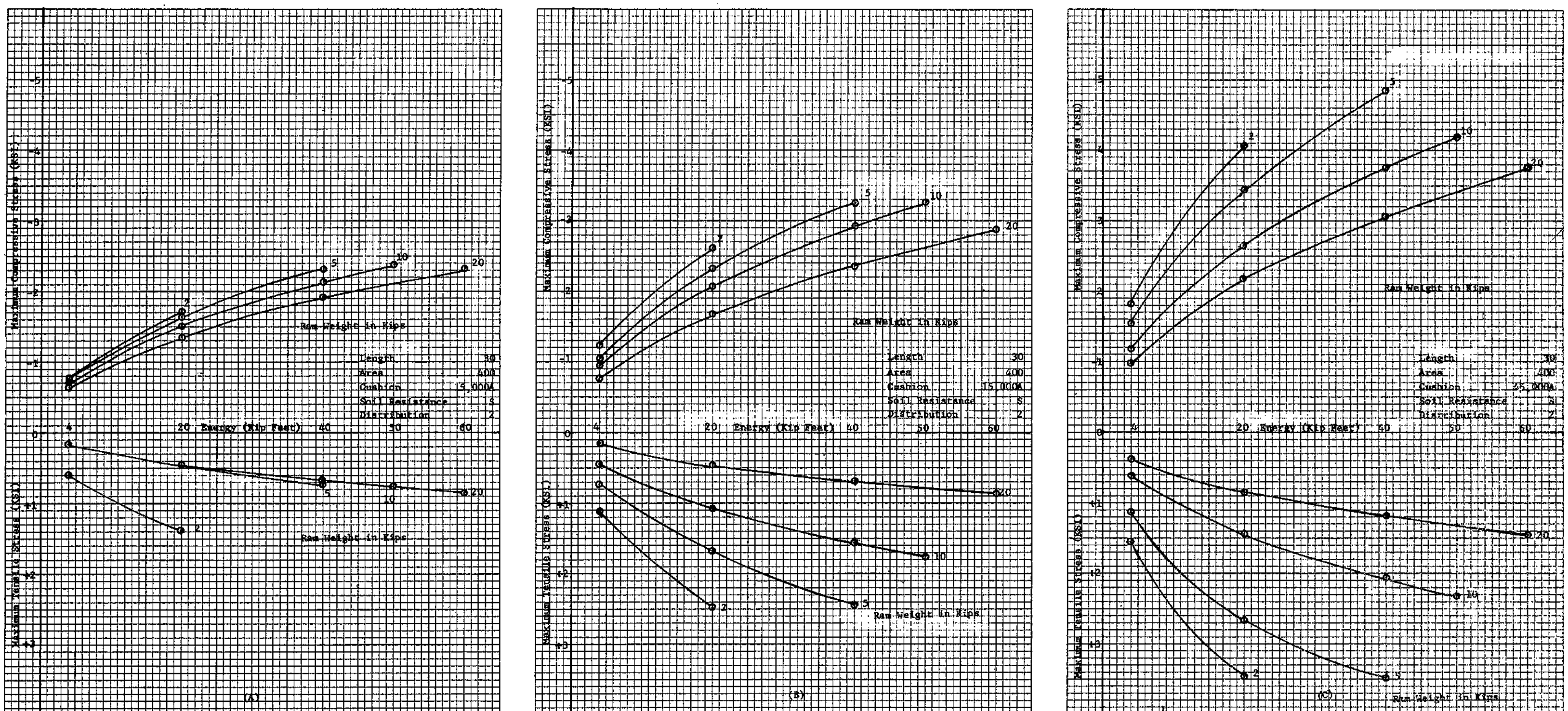

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 9



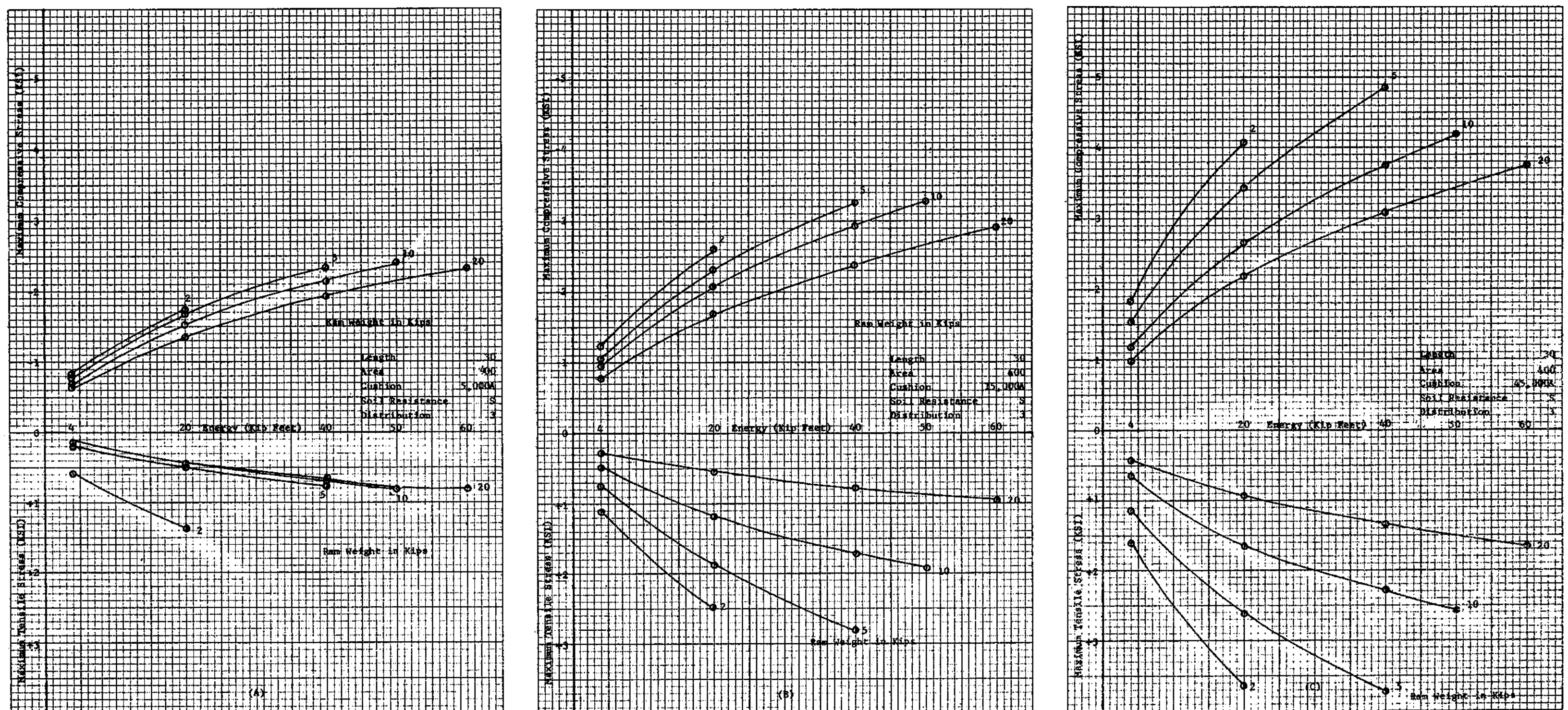
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance 5
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 10



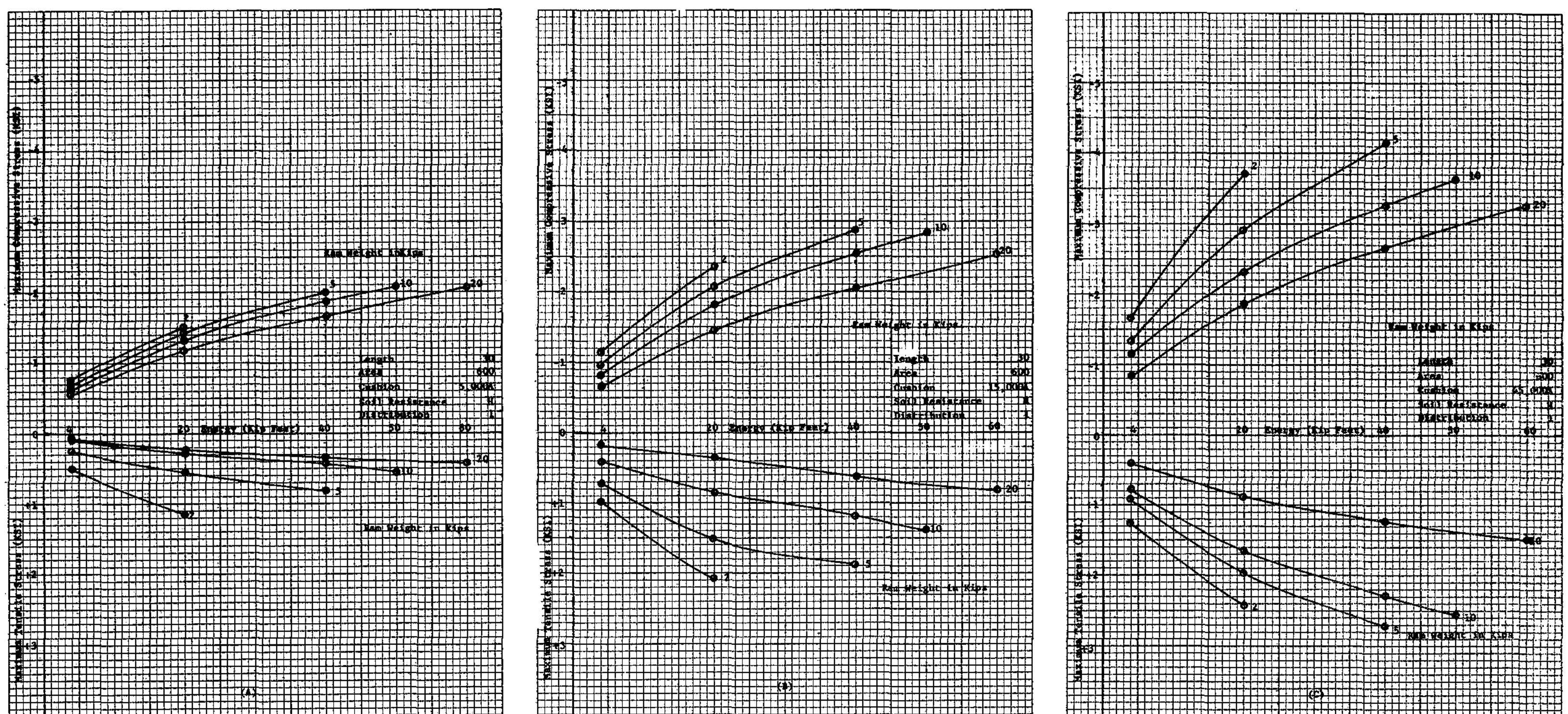
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Cushion 15,000A
(B)
Cushion 25,000A
(C)

FIGURE 11



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Length 30
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Length 30
Area 400
Cushion 45,000B
Soil Resistance S
Distribution 3
(C)

FIGURE 12



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 13

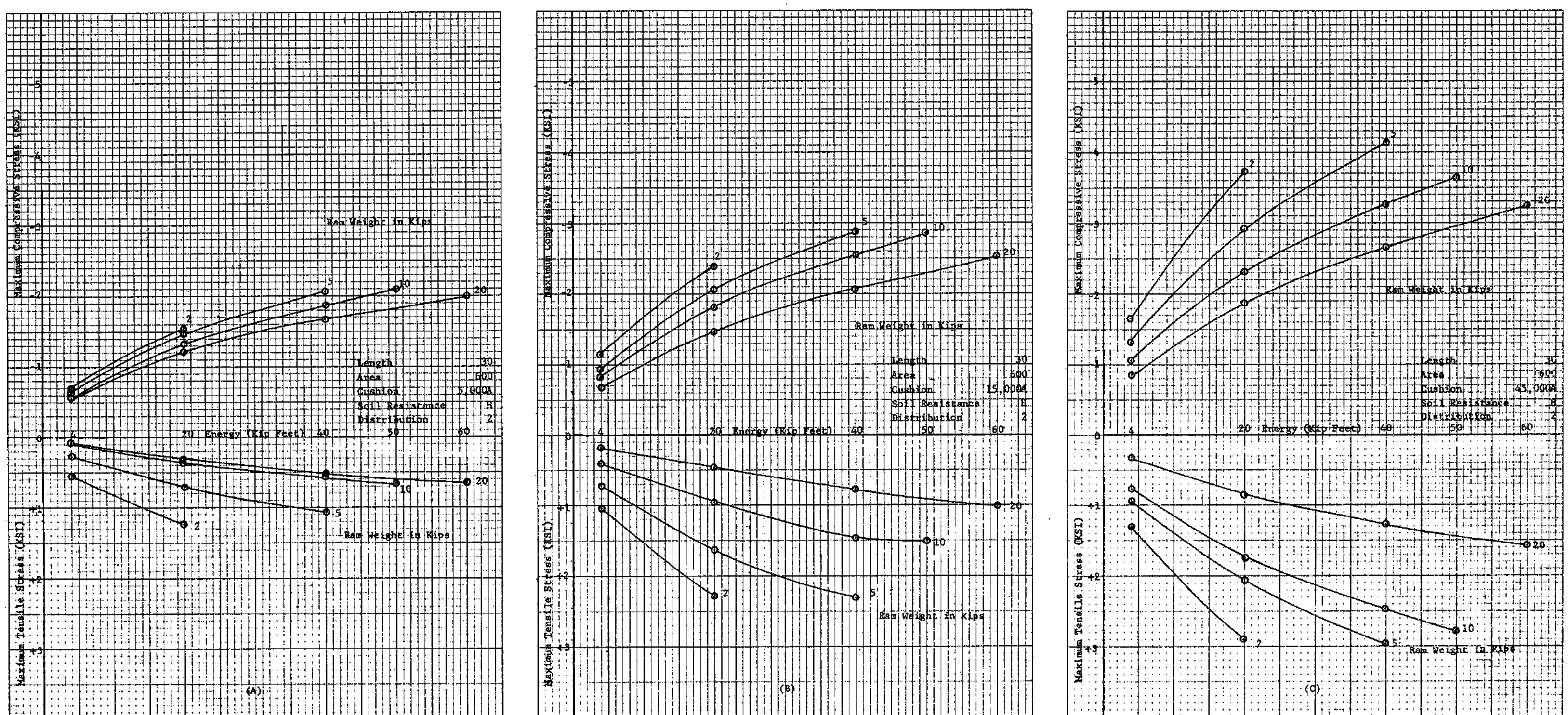
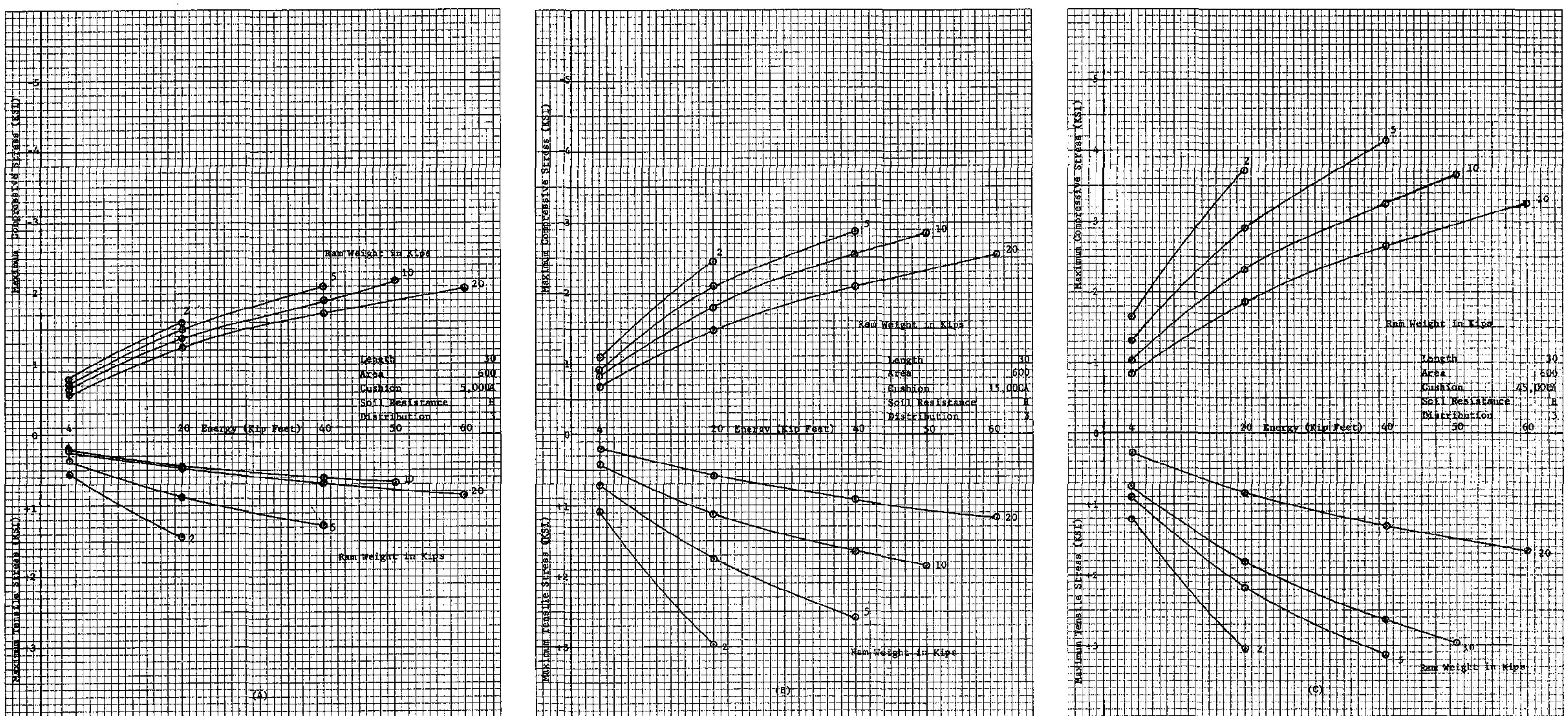
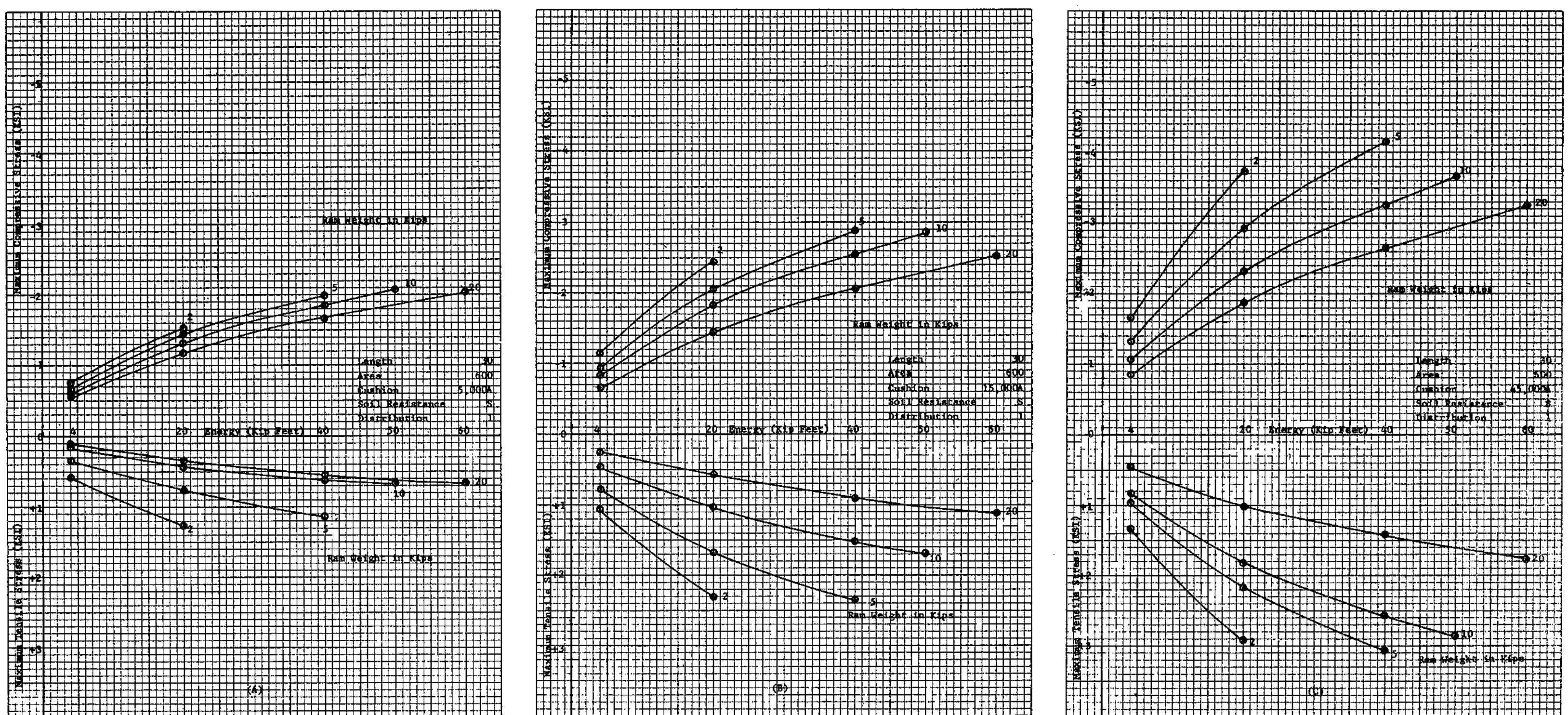

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance B
Distribution 2
(A)
Length 30
Area 600
Cushion 15,000A
Soil Resistance B
Distribution 2
(B)
Length 30
Area 600
Cushion 45,000A
Soil Resistance B
Distribution 2
(C)

FIGURE 14



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 15



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Length 30
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
(C)

FIGURE 16

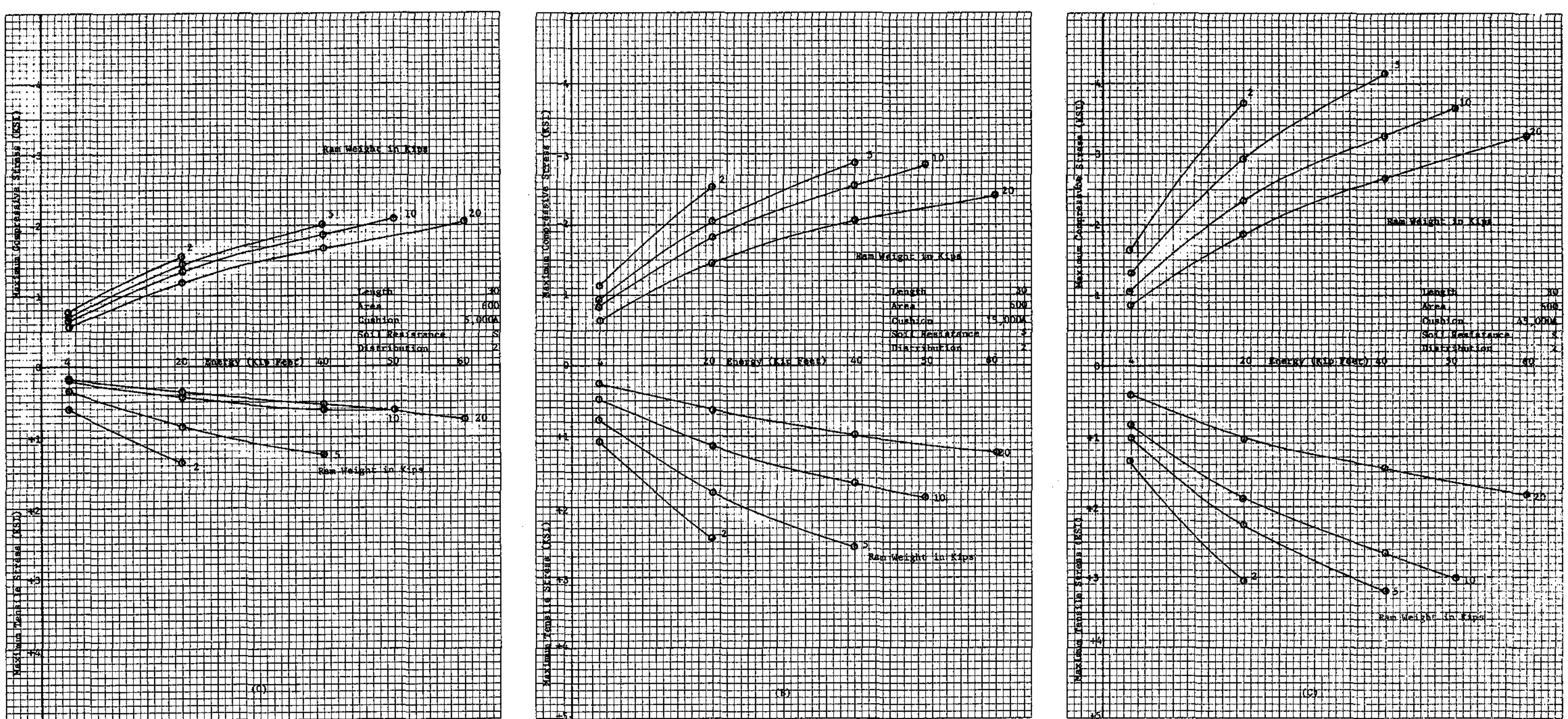

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 17

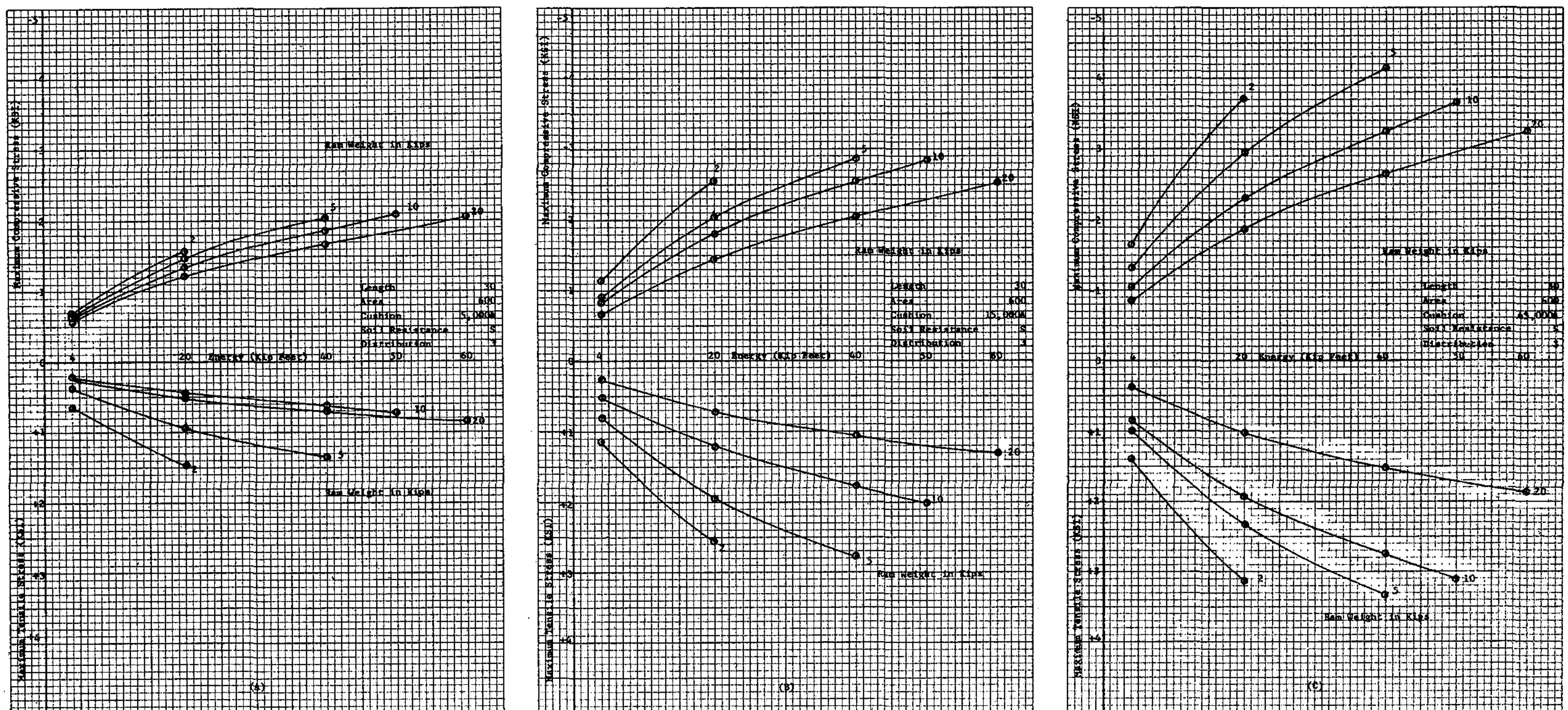

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(a)
(b)
(c)

FIGURE 18

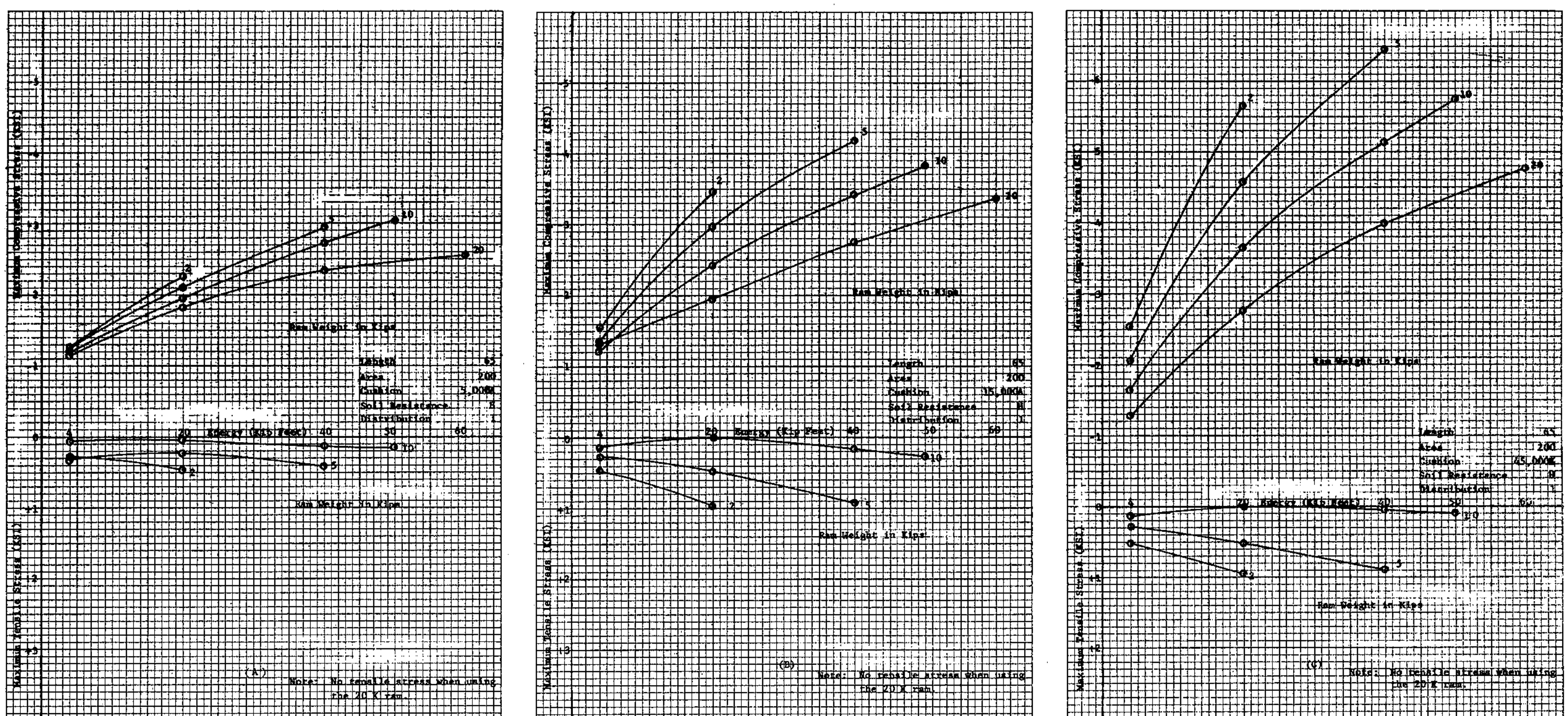

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Ram Weight in Kips
Energy (Kip Feet)
Length 65
Area 200
Cushion 5,000K
Soil Resistance
Distribution
(A)
Note: No tensile stress when using the 20 K ram.
Cushion 15,000K
(B)
Cushion 45,000K
(C)

FIGURE 19

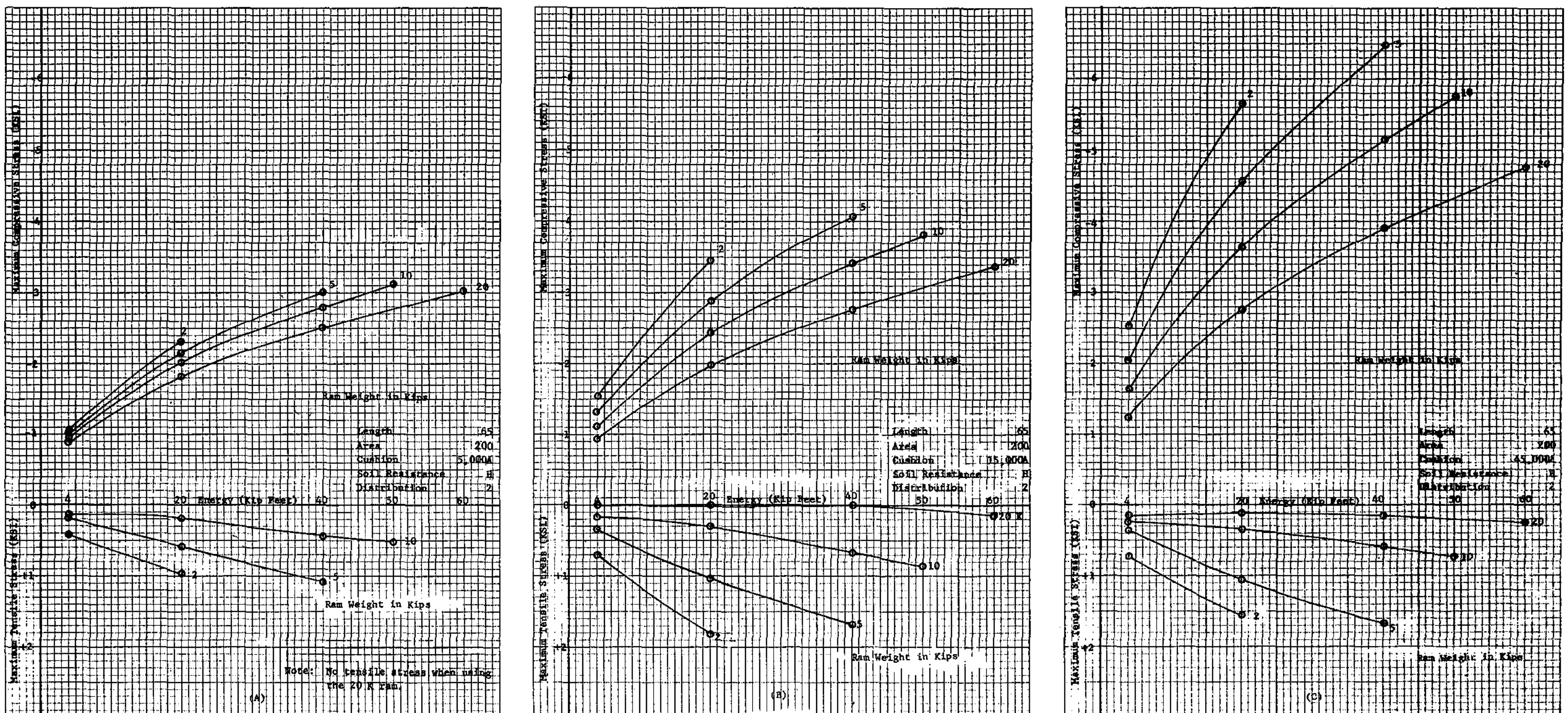

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 2
Note: No tensile stress when using the 20 K ram.
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 20

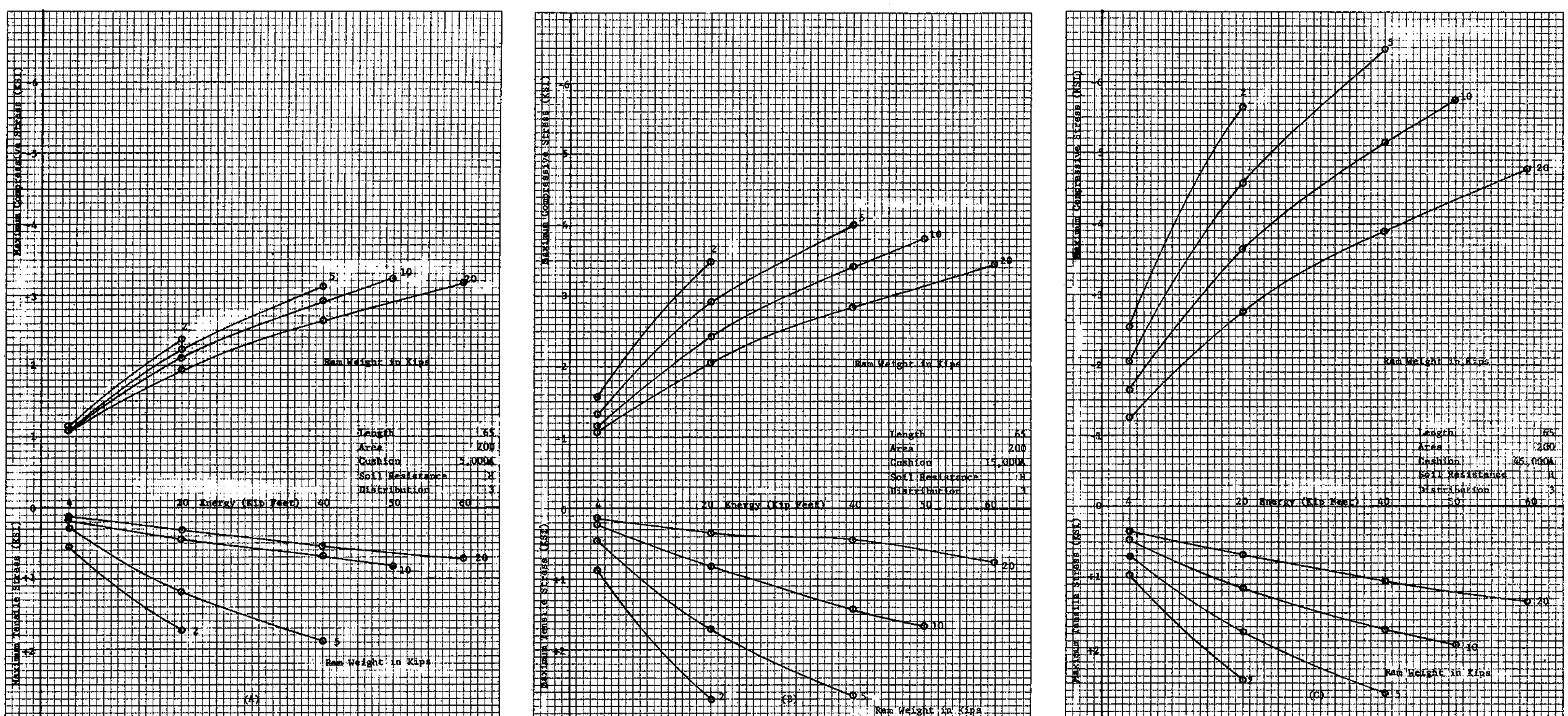

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Soil Resistance R
Distribution 3
(A)
(B)
(C)

FIGURE 21

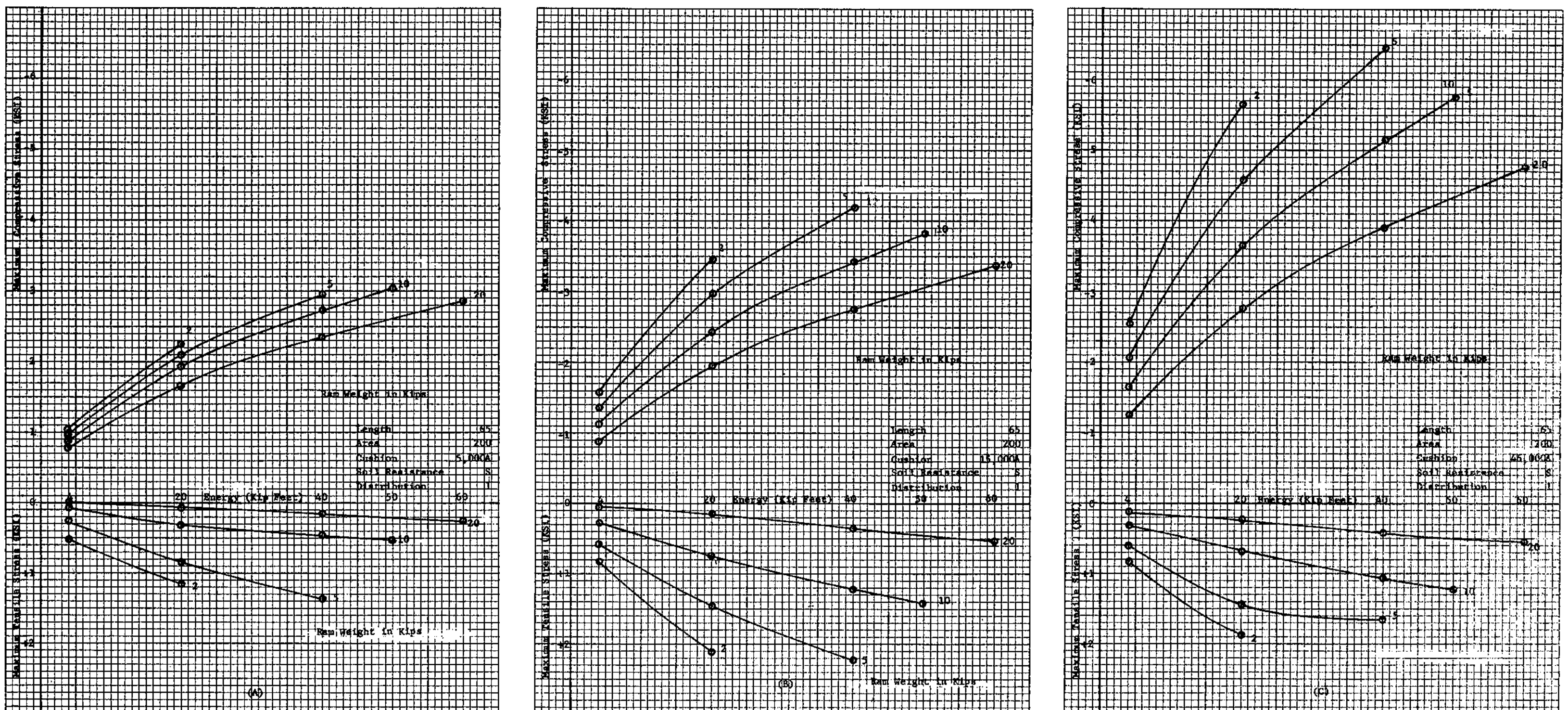

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Cushion 15,000A
Cushion 45,000A
Soil Resistance S
Distribution 1
(A)
(B)
(C)

FIGURE 22

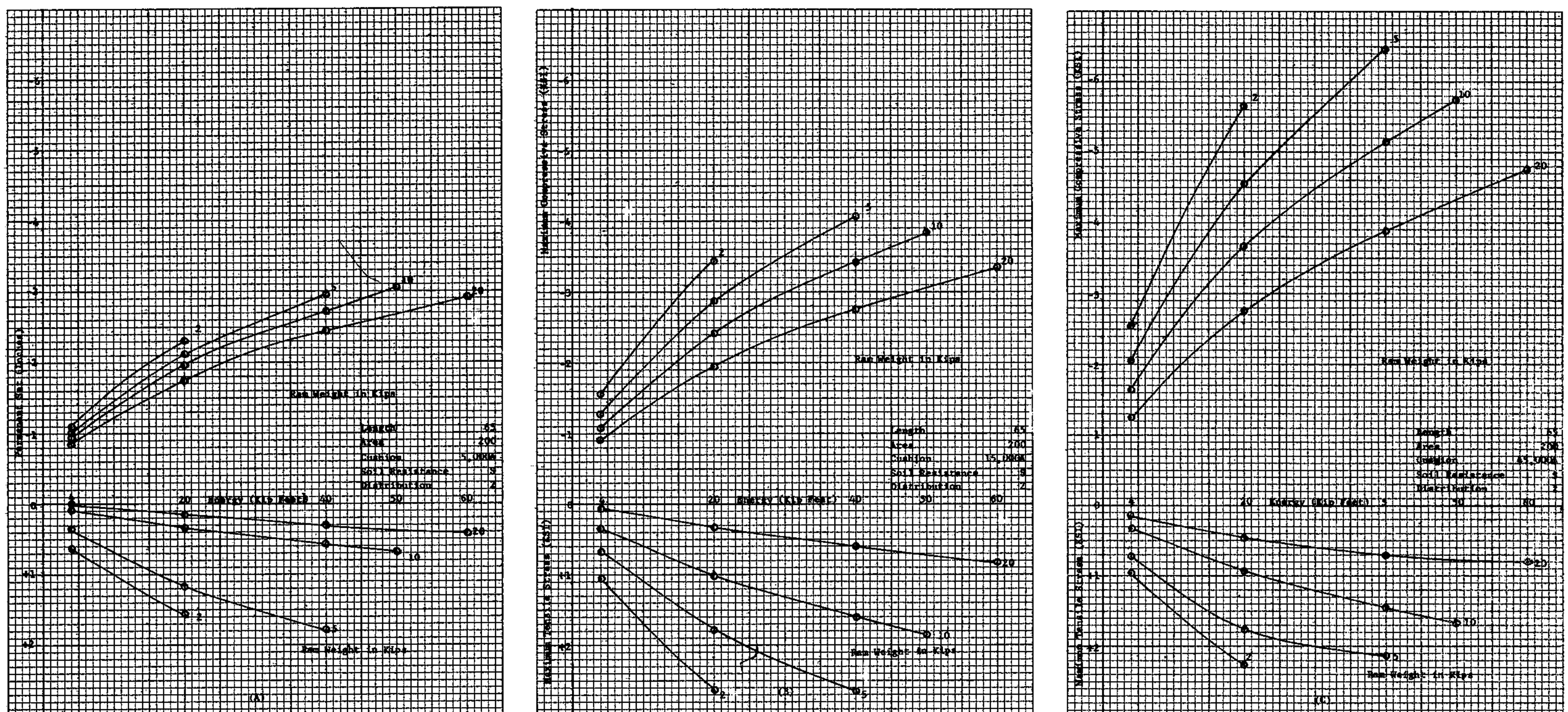
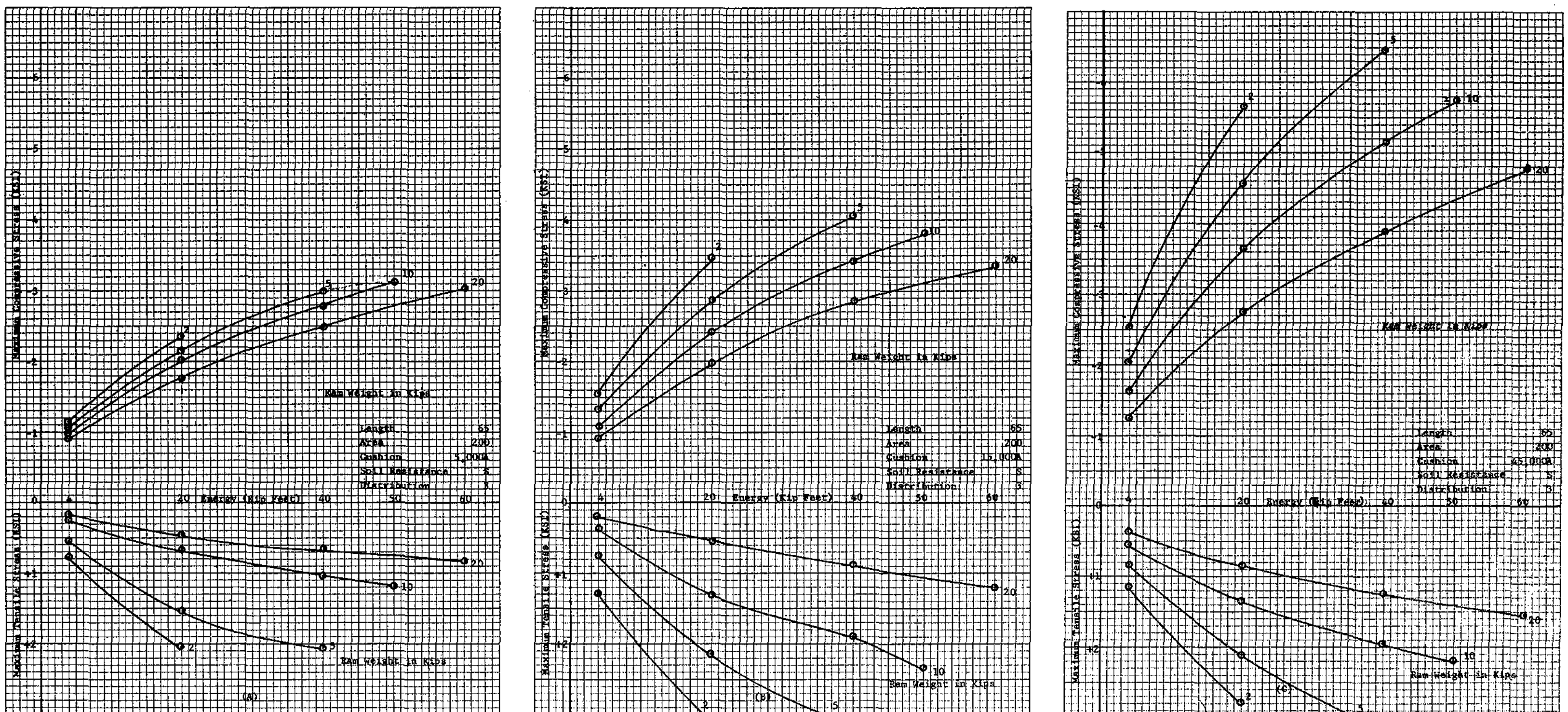
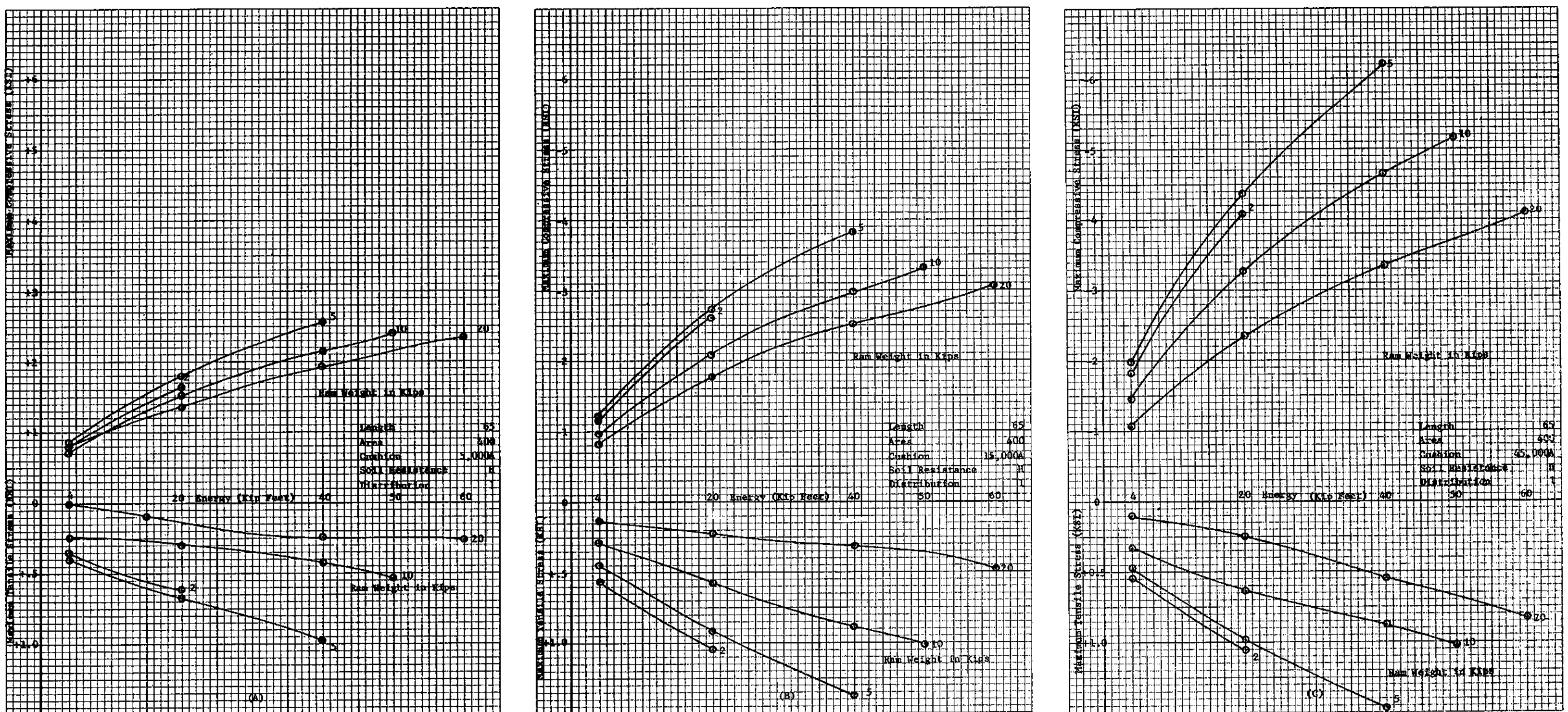


FIGURE 23



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 24



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 25

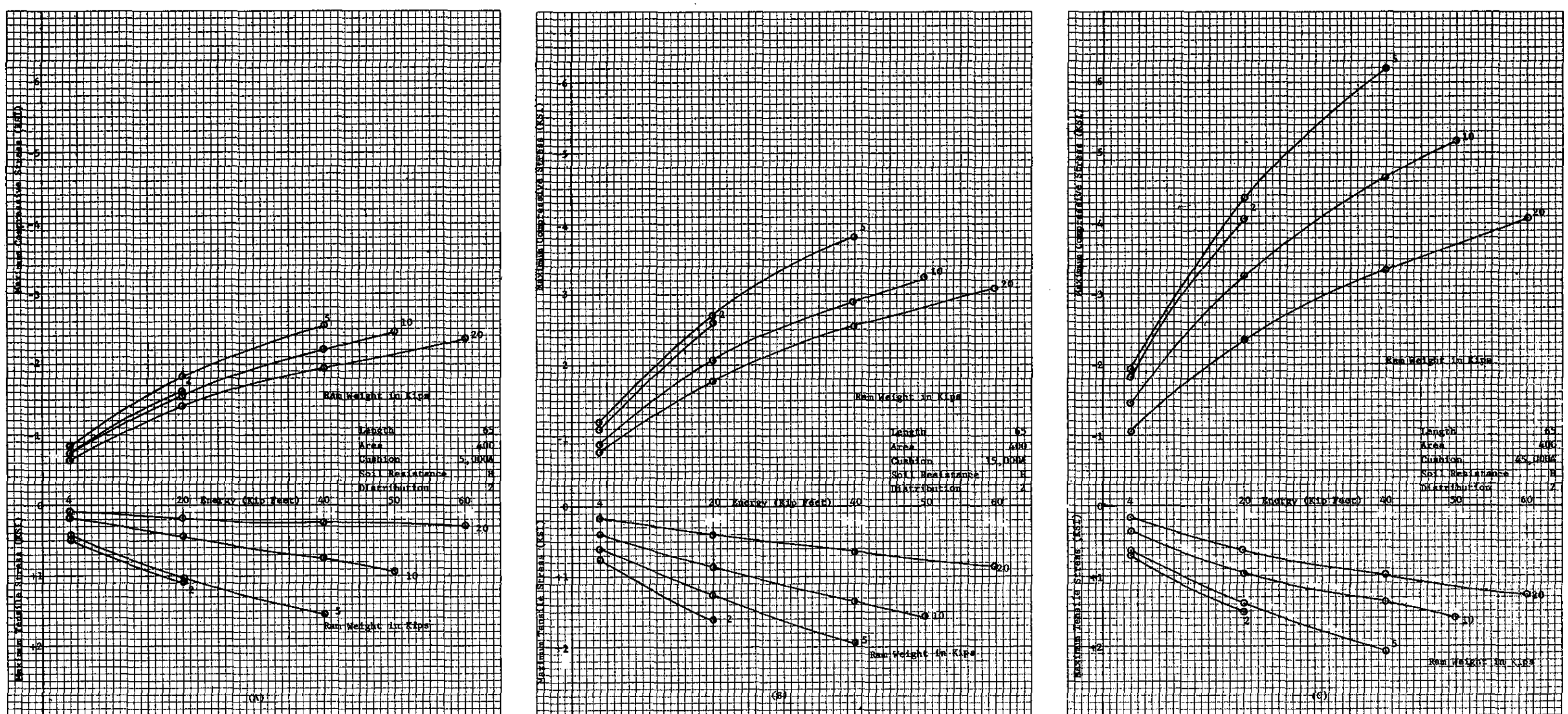

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000K
Cushion 15,000K
Cushion 45,000K
Soil Resistance B
Distribution 2
(A)
(B)
(C)

FIGURE 26

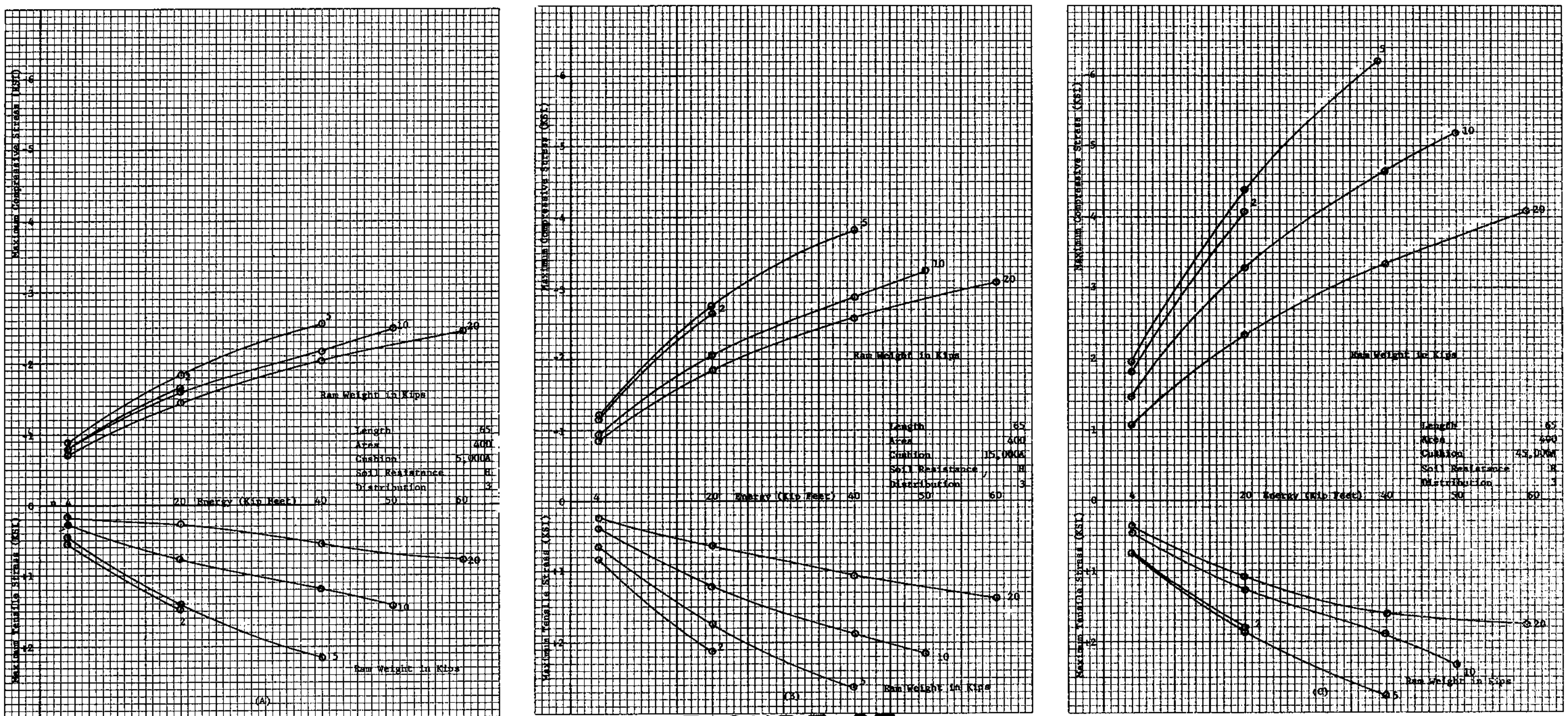

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 27

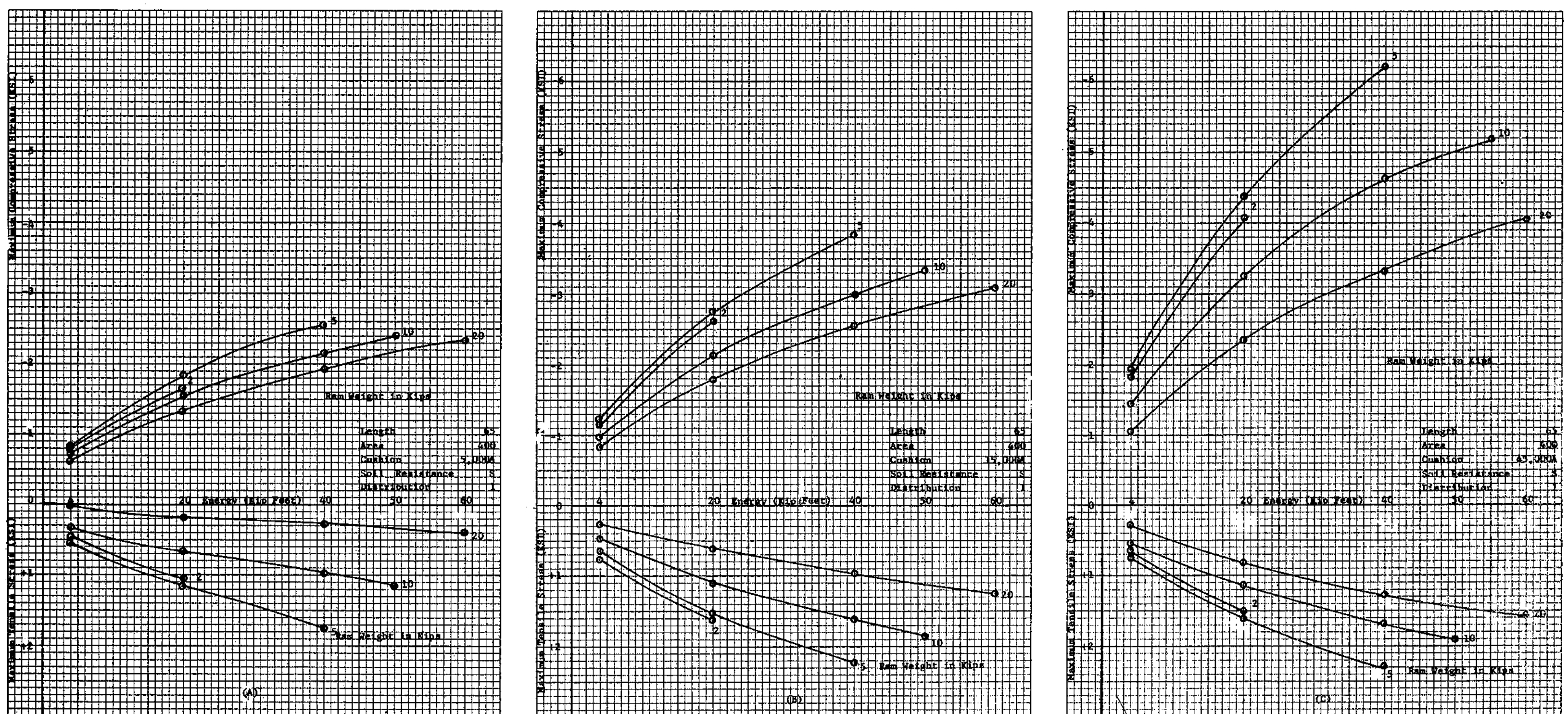

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 28

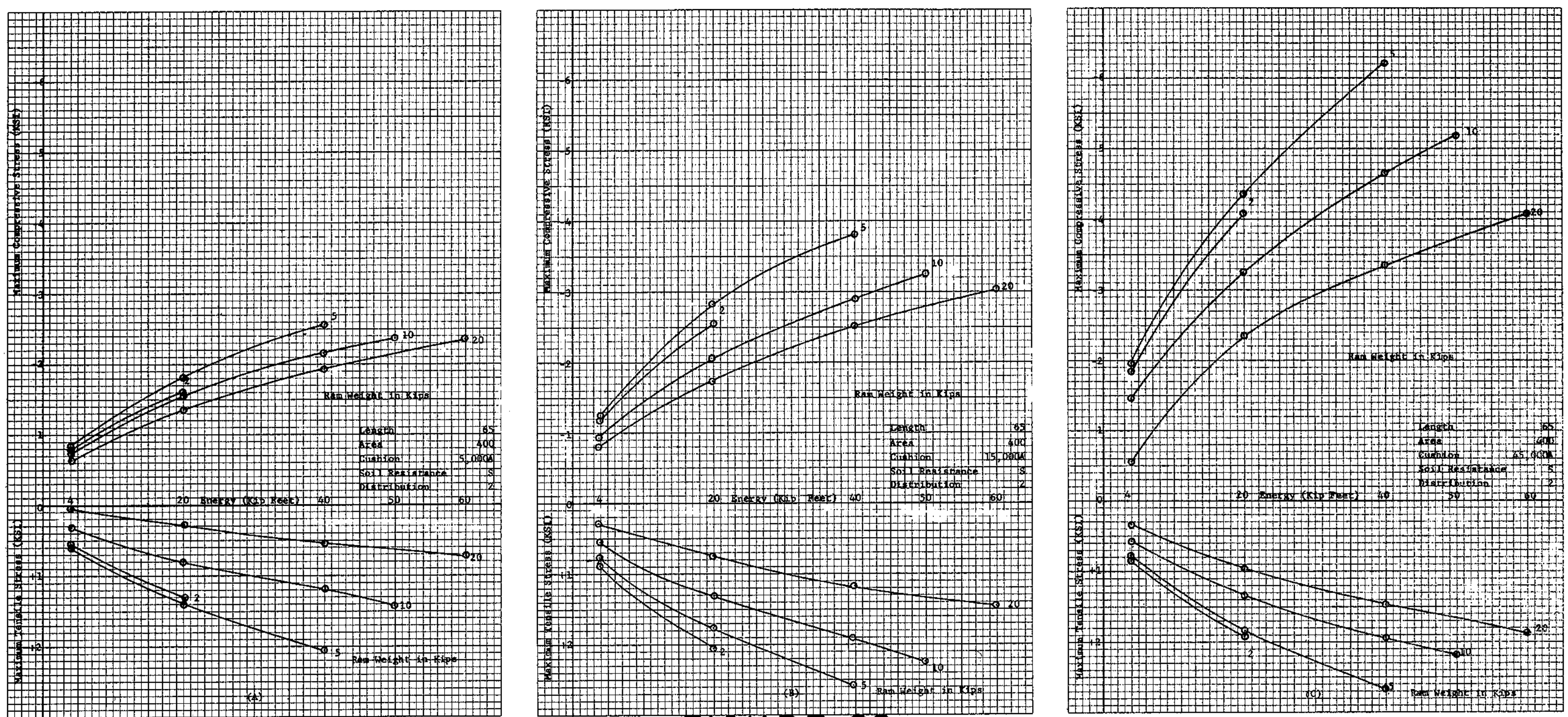

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 29

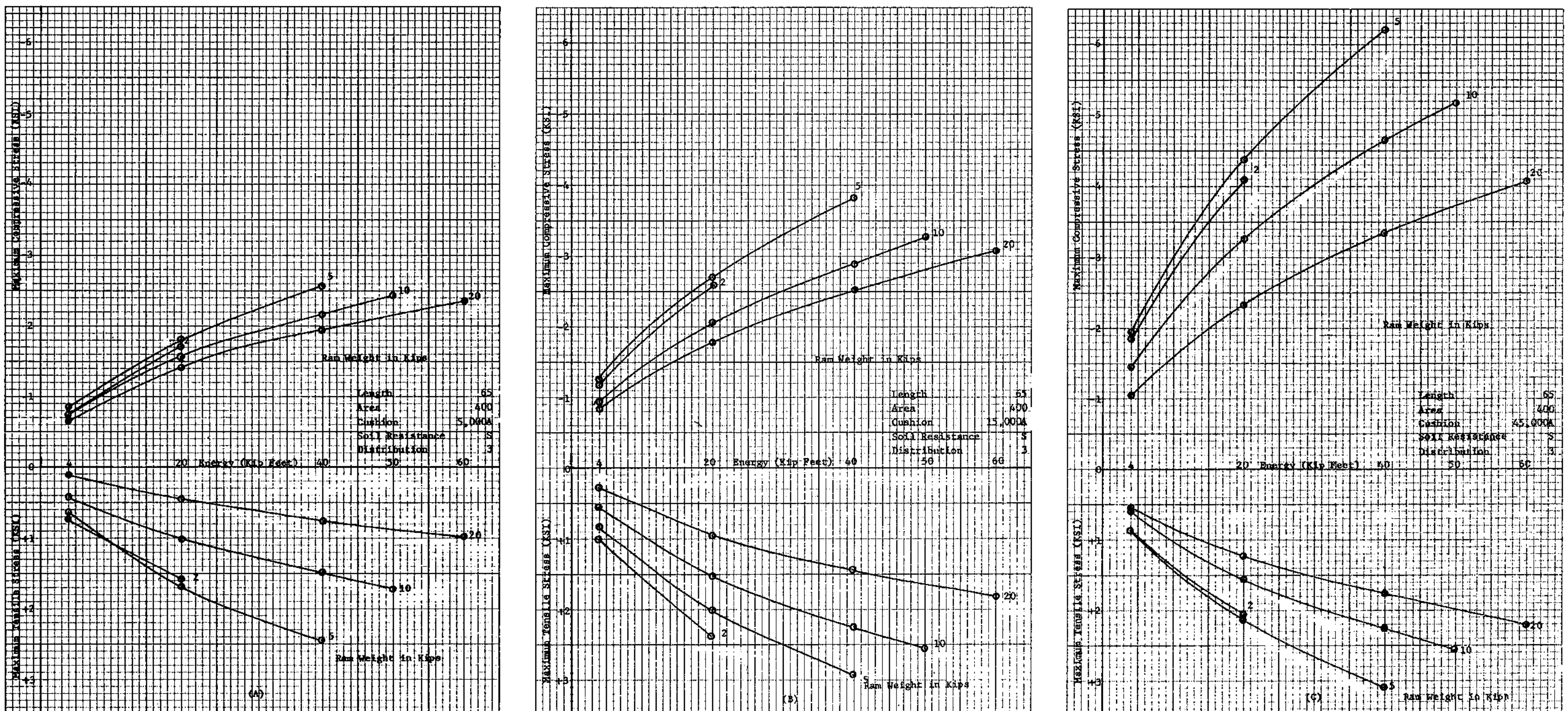
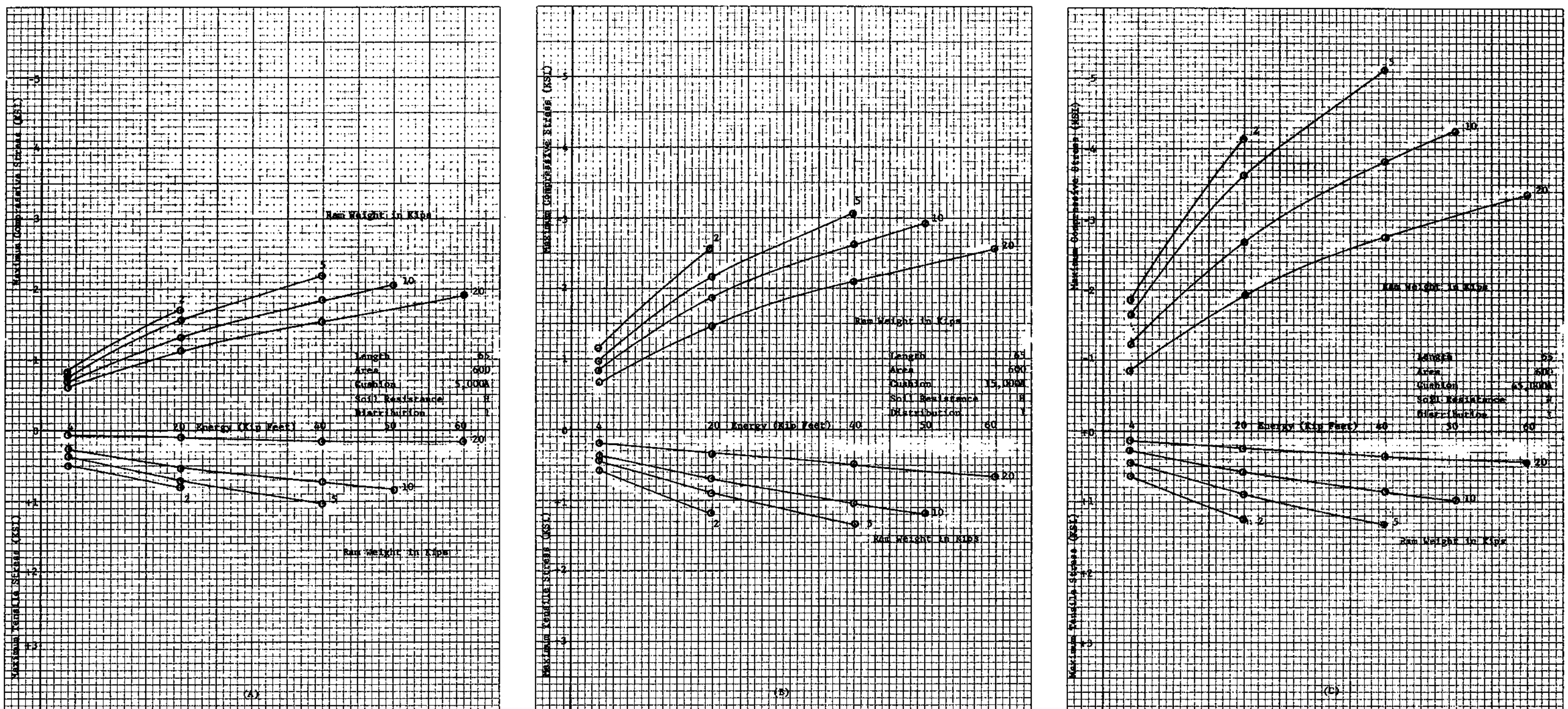
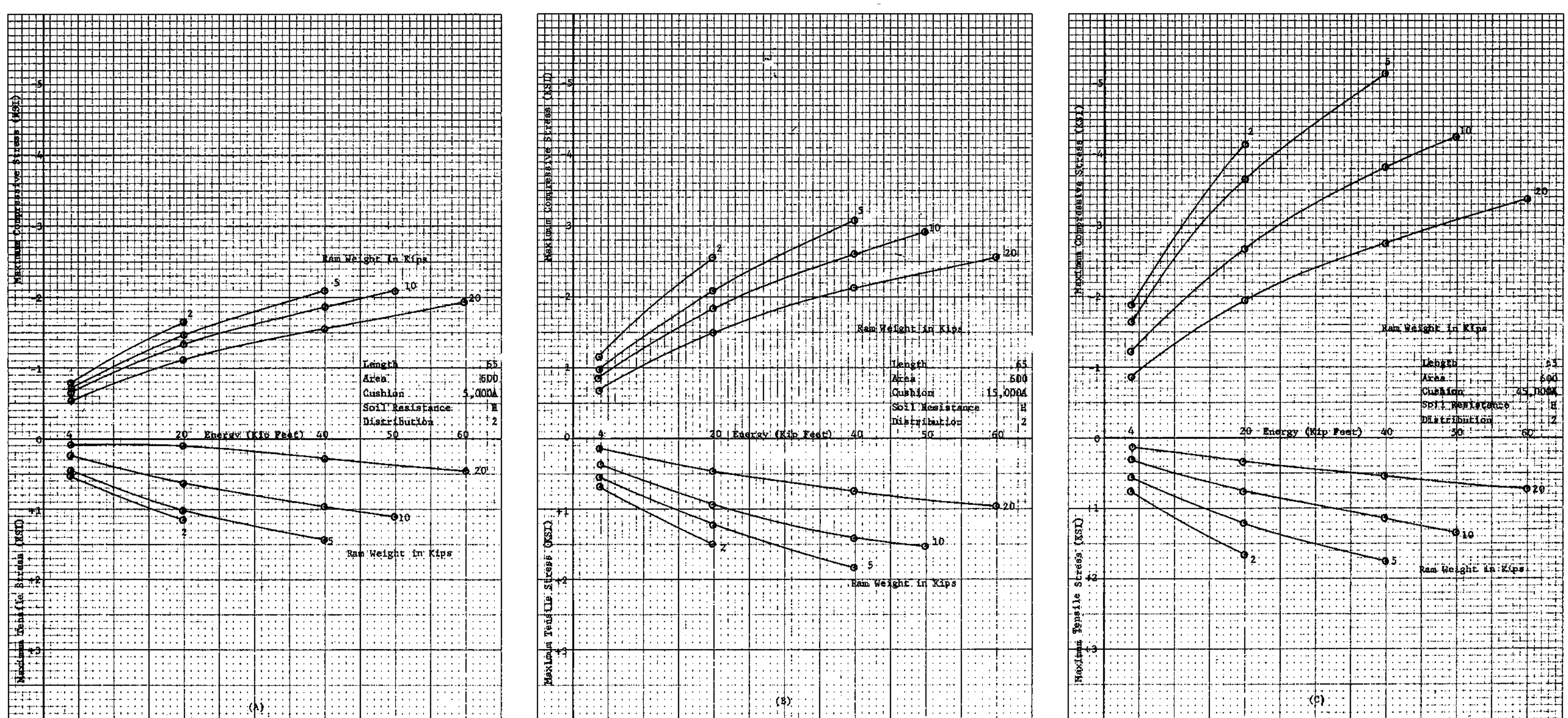

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance 5
Distribution 3
(A)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 15,000A
Soil Resistance 5
Distribution 3
(B)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 45,000A
Soil Resistance 5
Distribution 3
(C)

FIGURE 30



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance
Distribution 1
(A)
(B)
(C)

FIGURE 31



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Soil Resistance H
Distribution 2
(C)

FIGURE 32

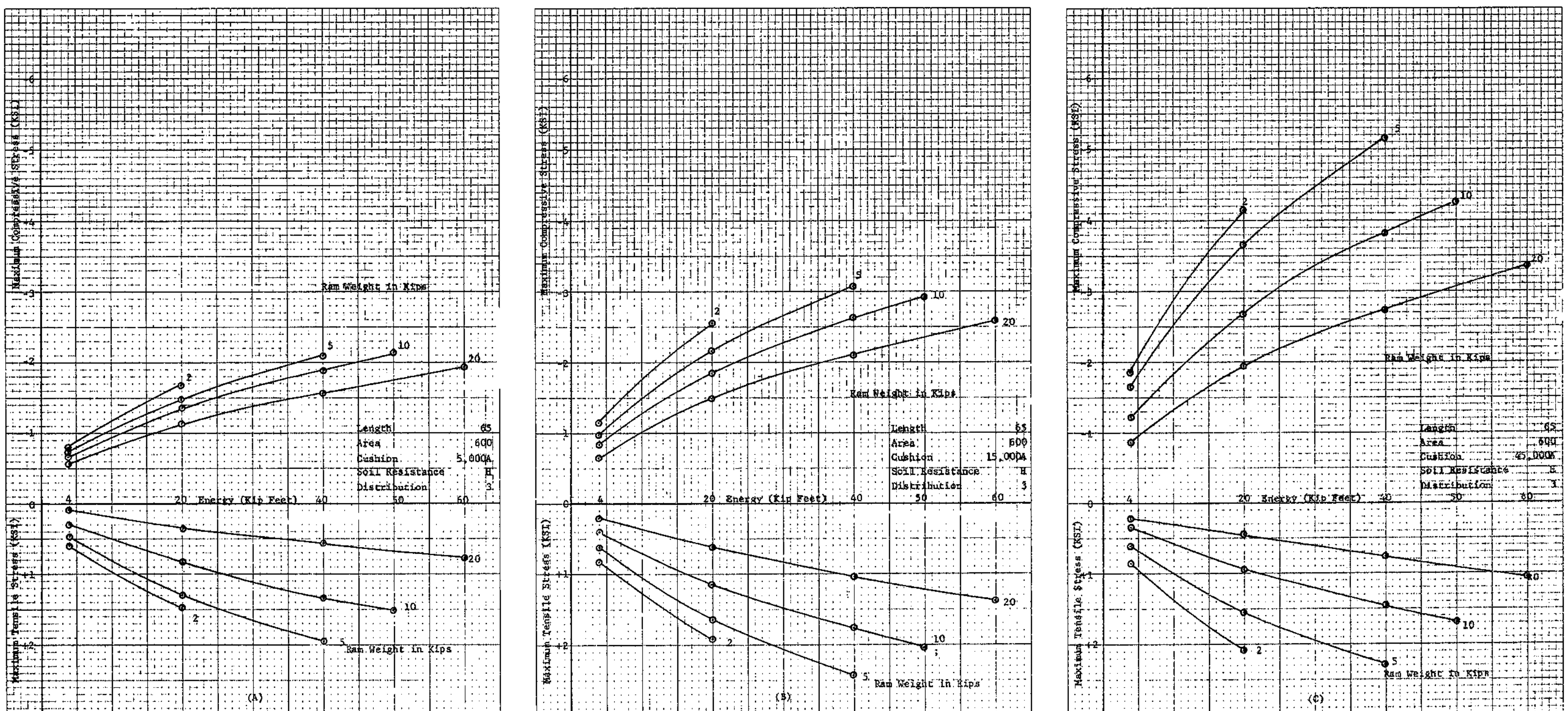

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Length 65
Area 600
Cushion 15,000A
Soil Resistance H
Distribution 3
(B)
Length 65
Area 600
(C)

FIGURE 33

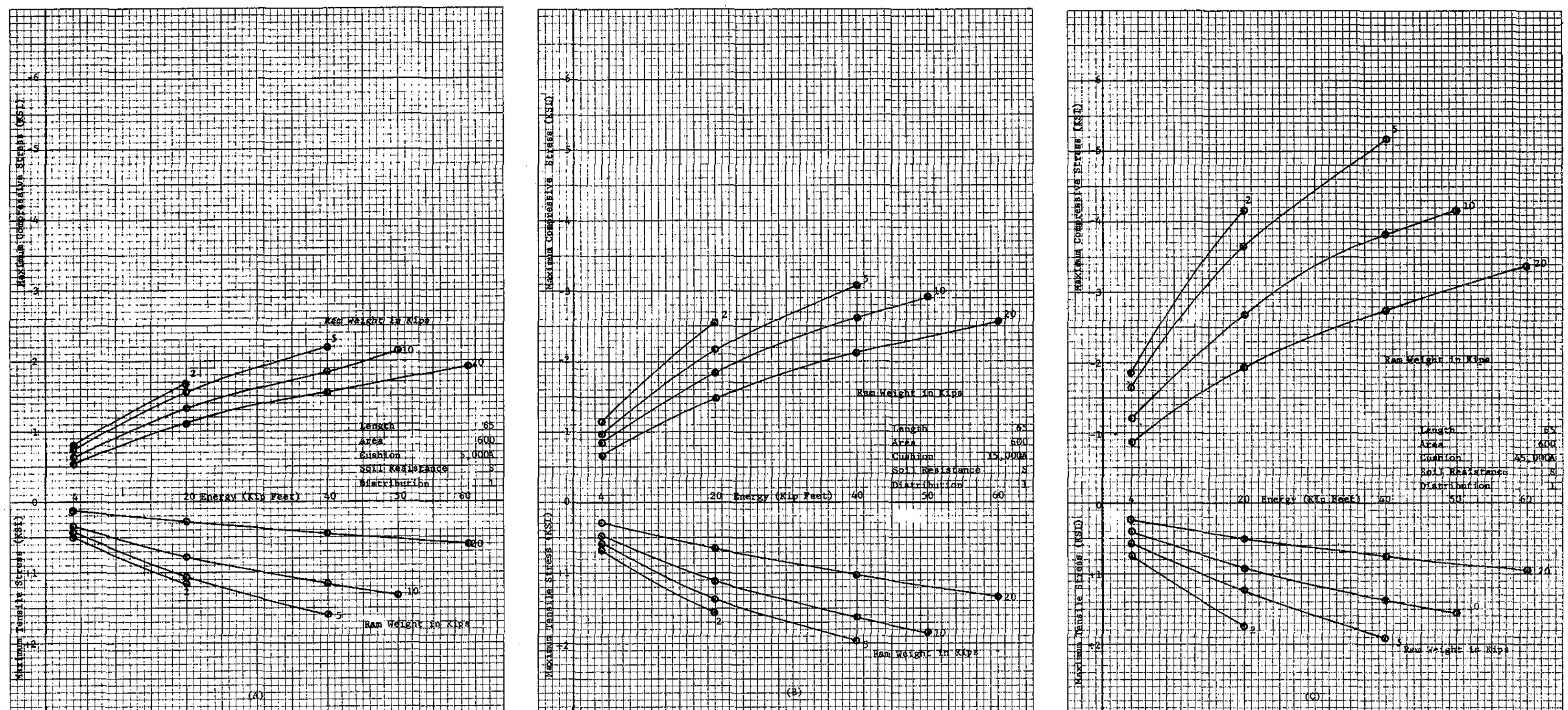

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 34

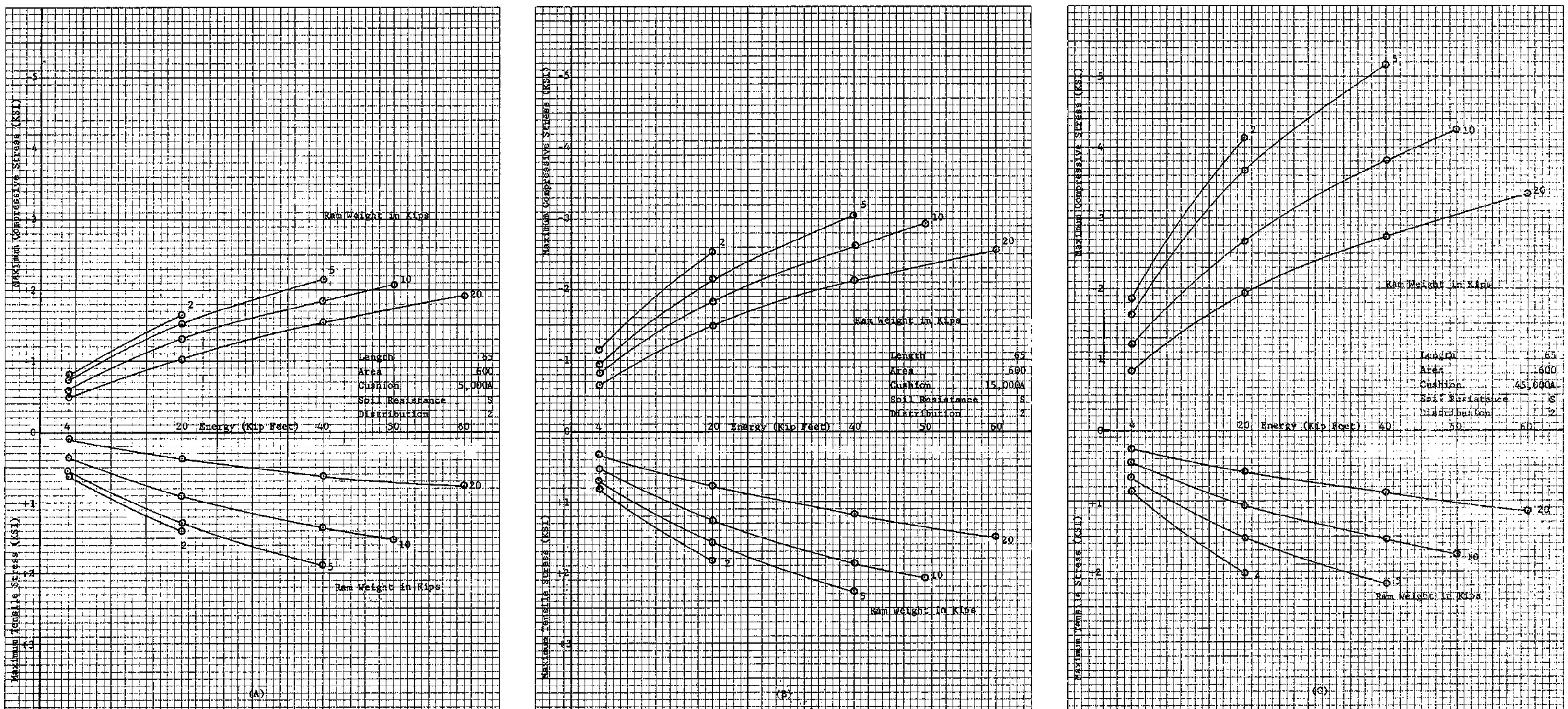

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Length 65
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 2
(B)
Length 65
Area 600
Cushion 45,000A
Soil Resistance S
Distribution 2
(C)

FIGURE 35

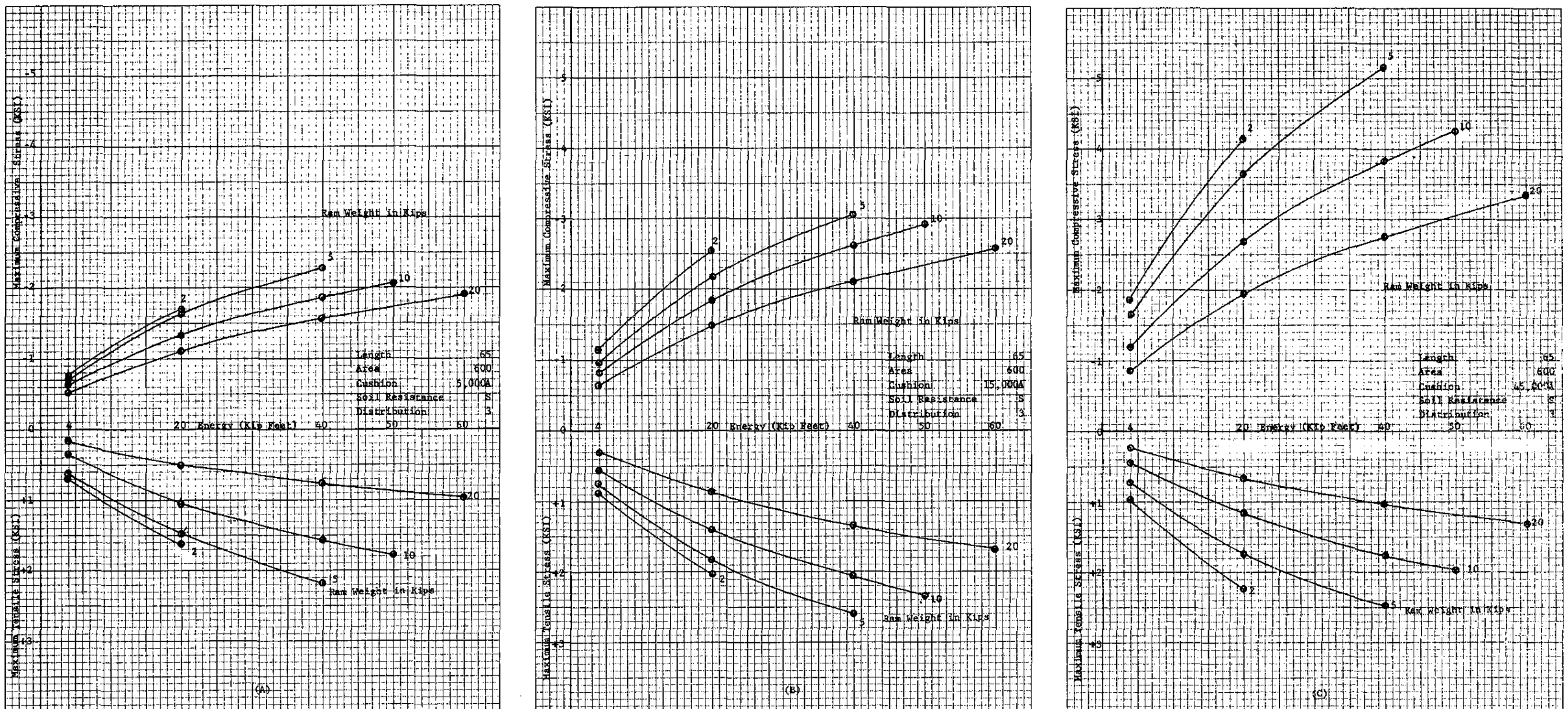

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
Distribution 1
(C)

FIGURE 36

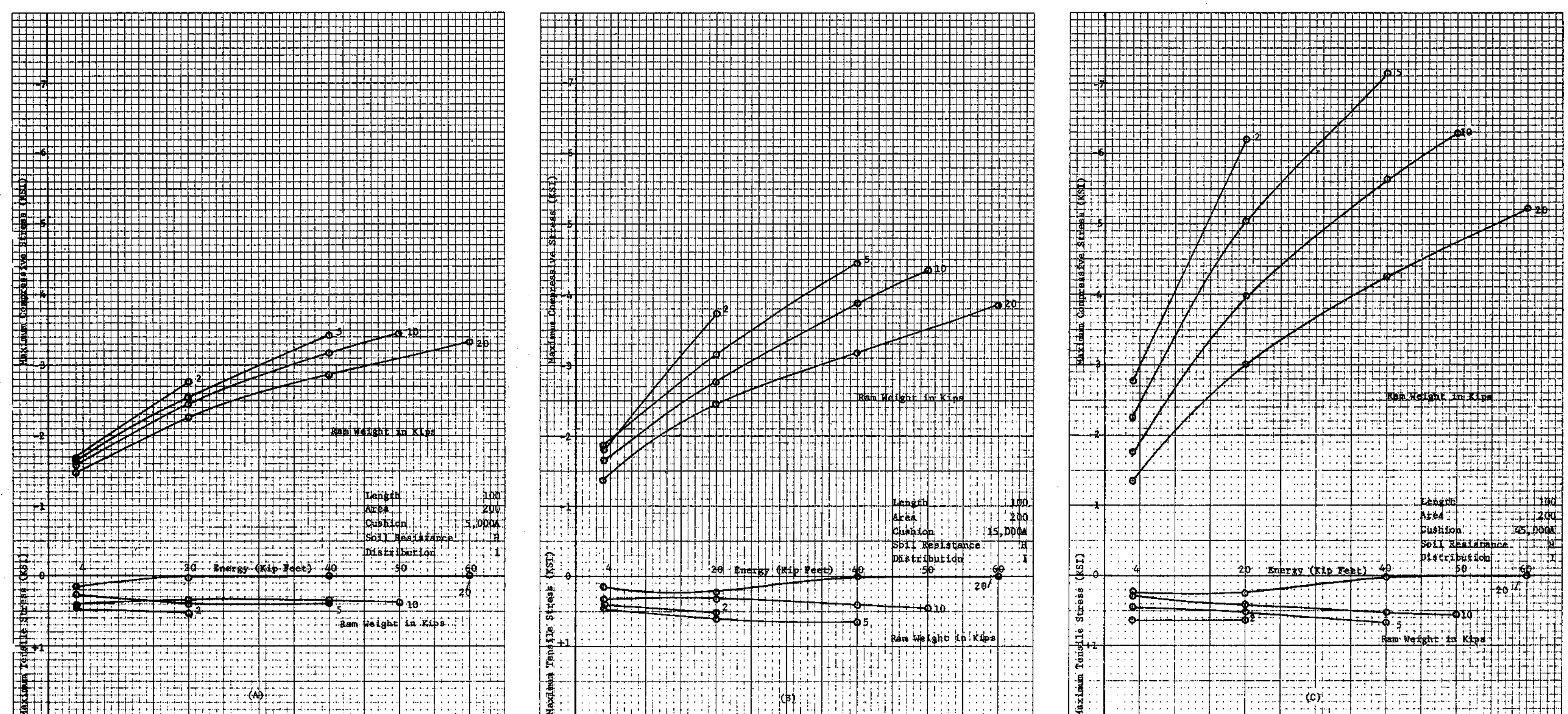

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance H
Distribution I
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 37

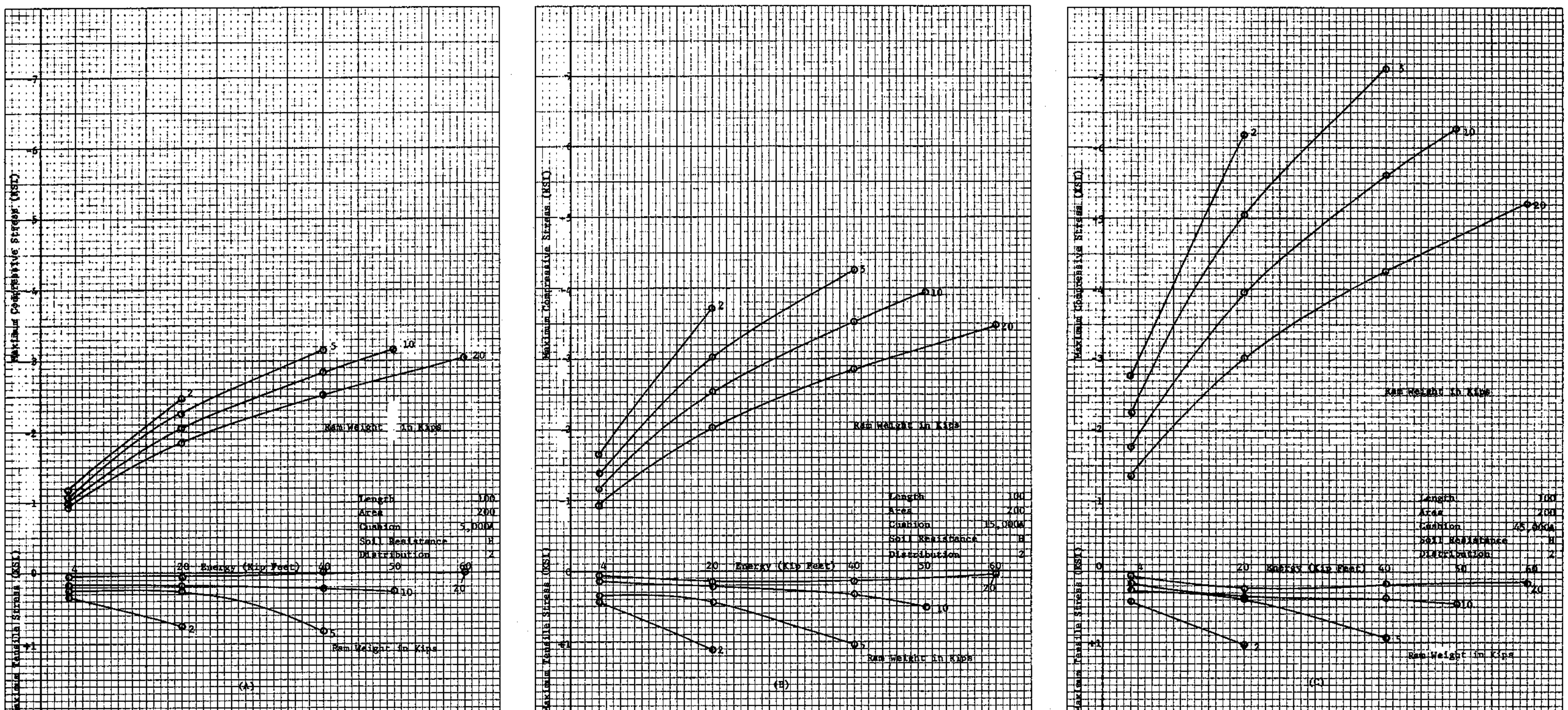
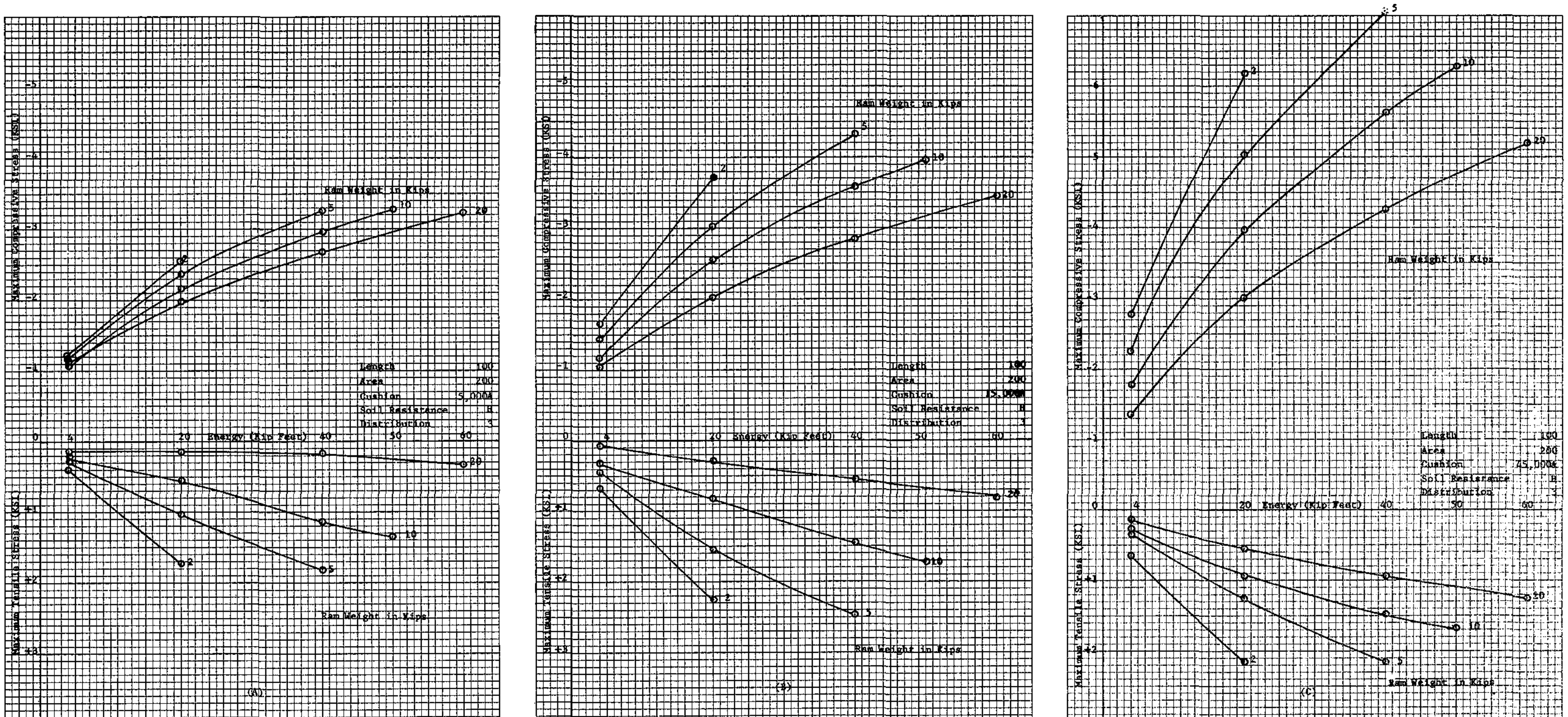

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000M
Soil Resistance B
Distribution 2
(A)
Cushion 15,000M
(B)
Cushion 45,000M
(C)

FIGURE 38



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000k
Soil Resistance H
Distribution 3
(A)
(C)

FIGURE 39

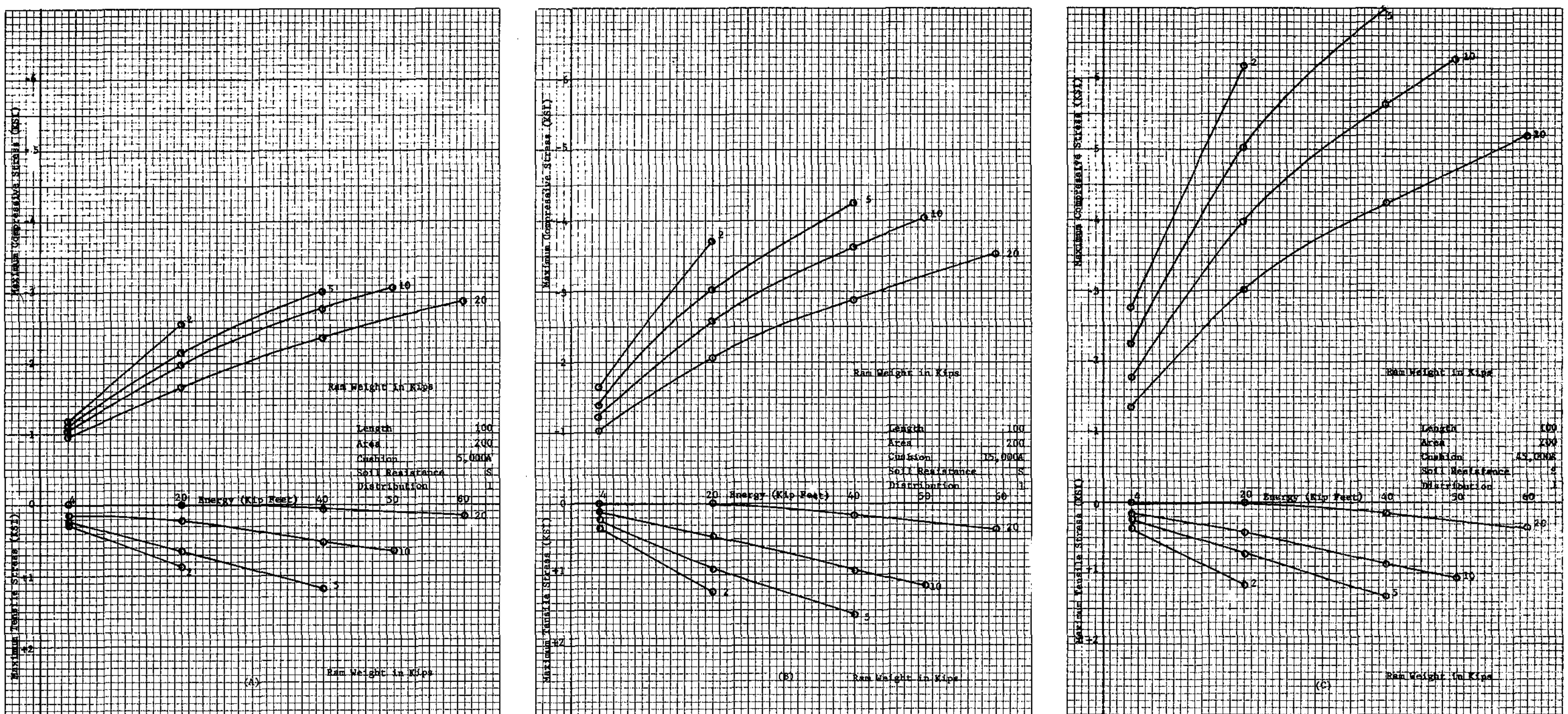
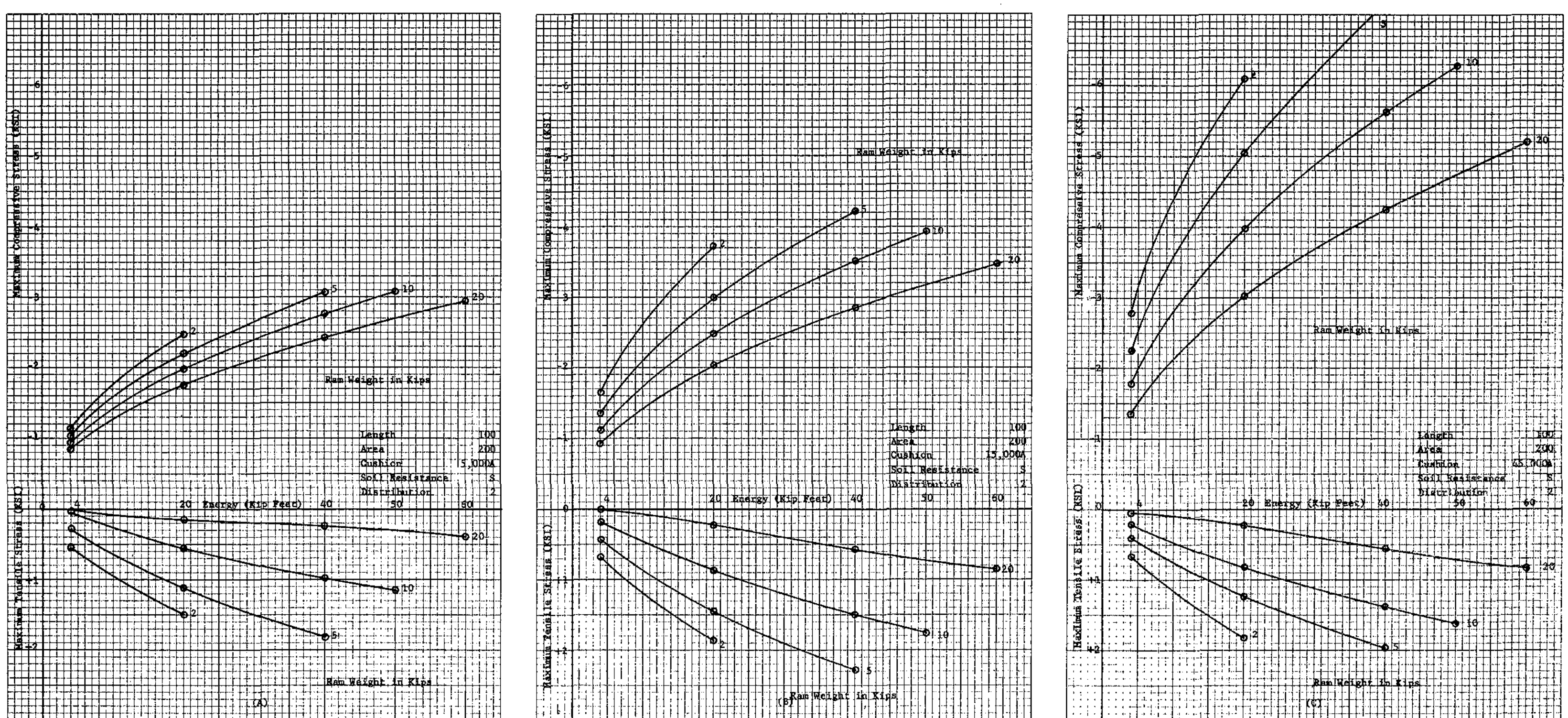

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Length 100
Area 200
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
Length
Area
Cushion
Soil Resistance
Distribution
(C)

FIGURE 40



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance 5
Distribution 2
(A)
Cushion 15,000A
(B)
Cushion 65,000A
(C)

FIGURE 41

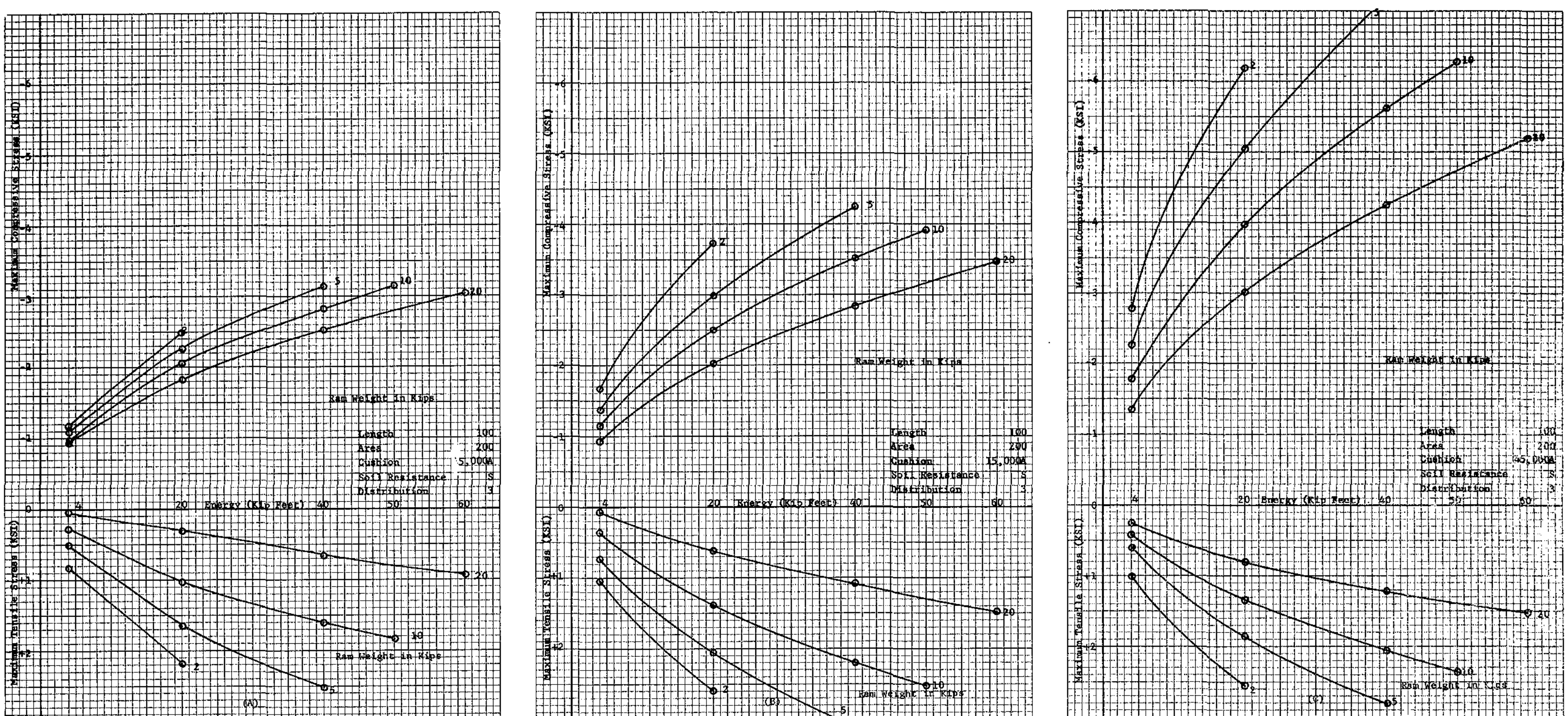
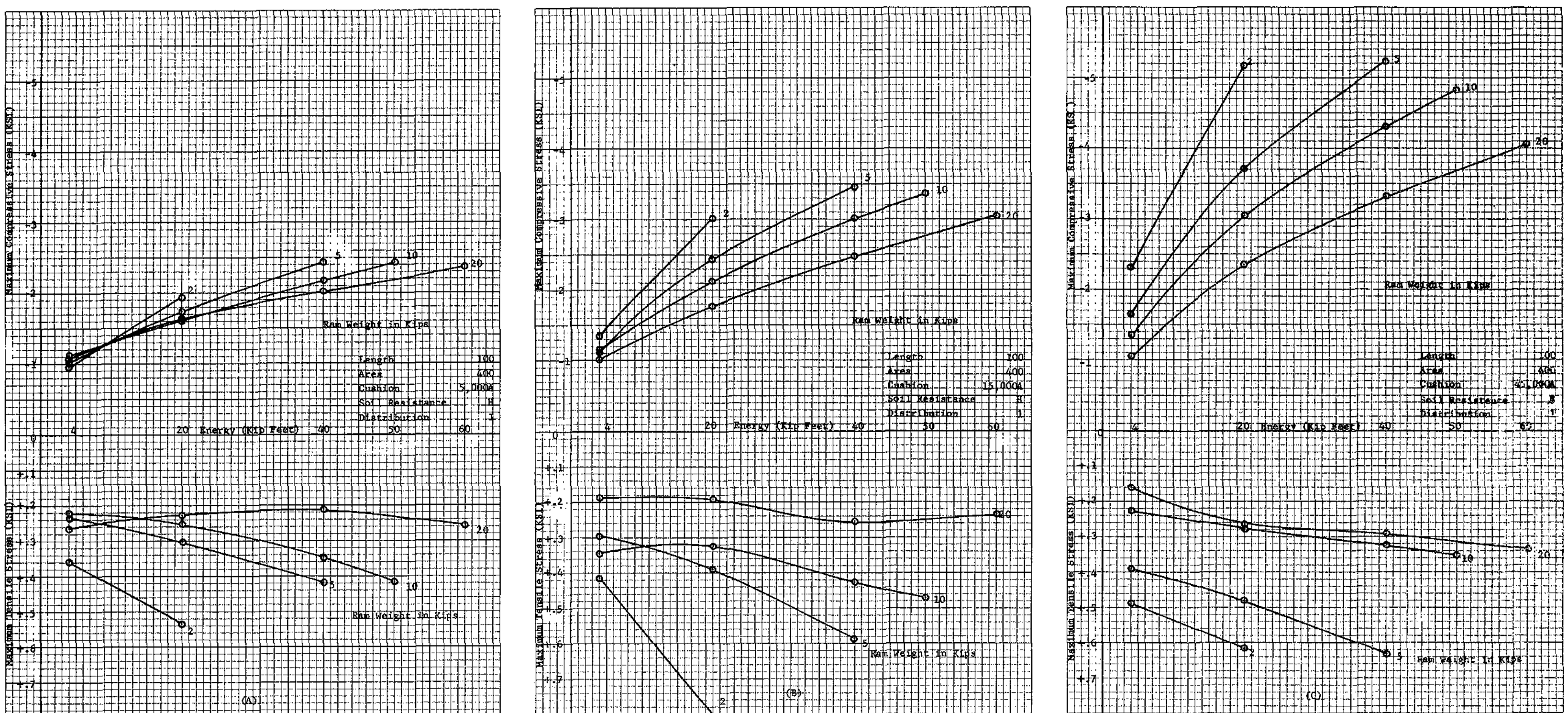
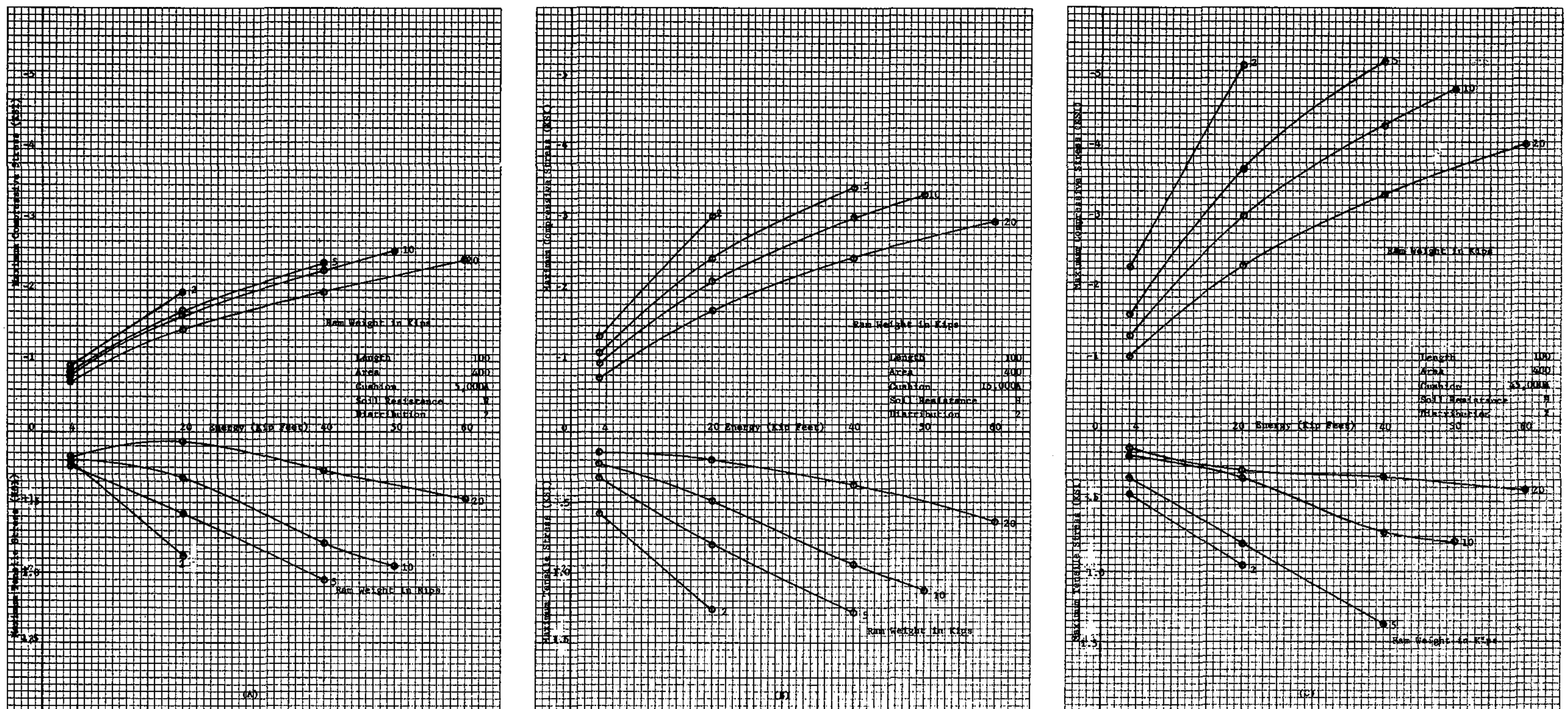

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 42



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 1
(A)
Cushion 15,000A
(B)
(C)

FIGURE 43



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 44

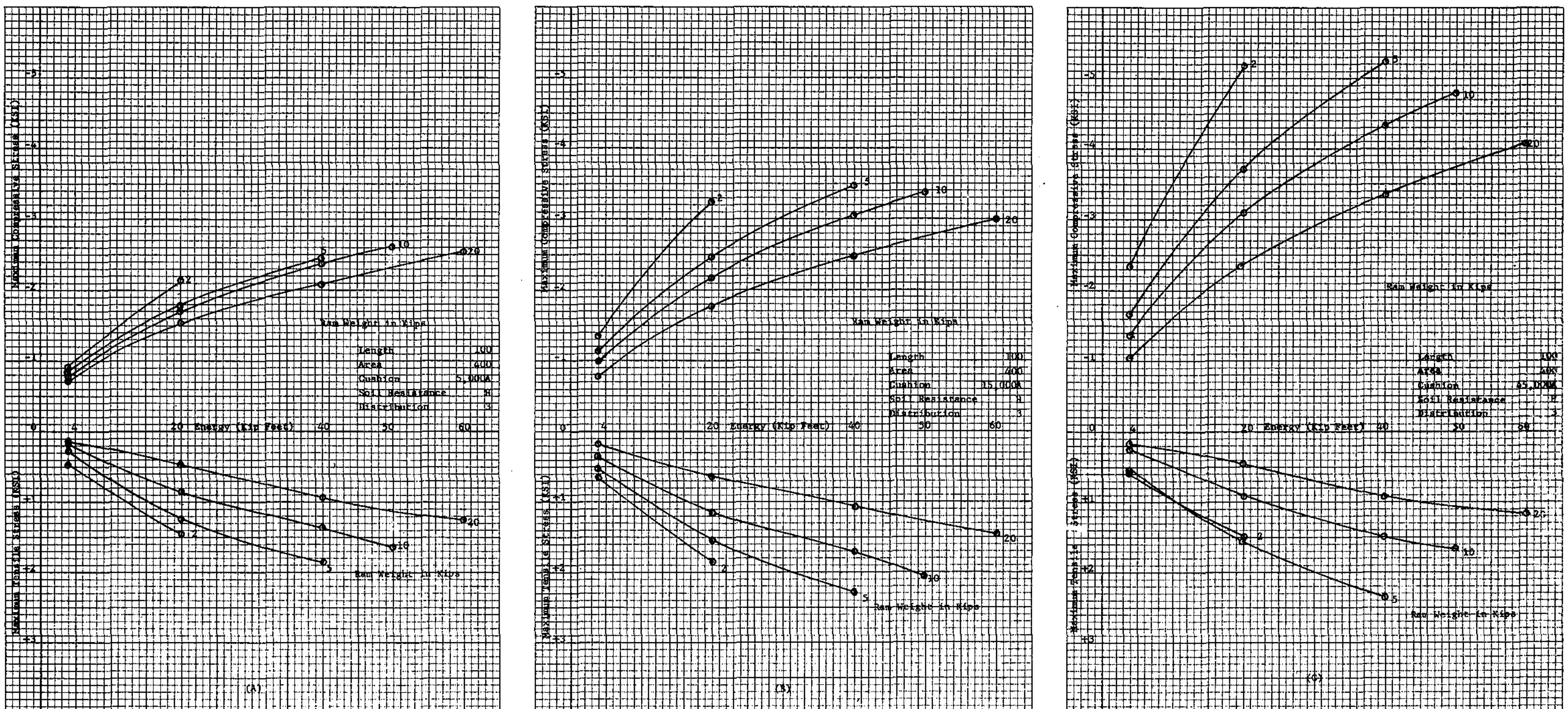
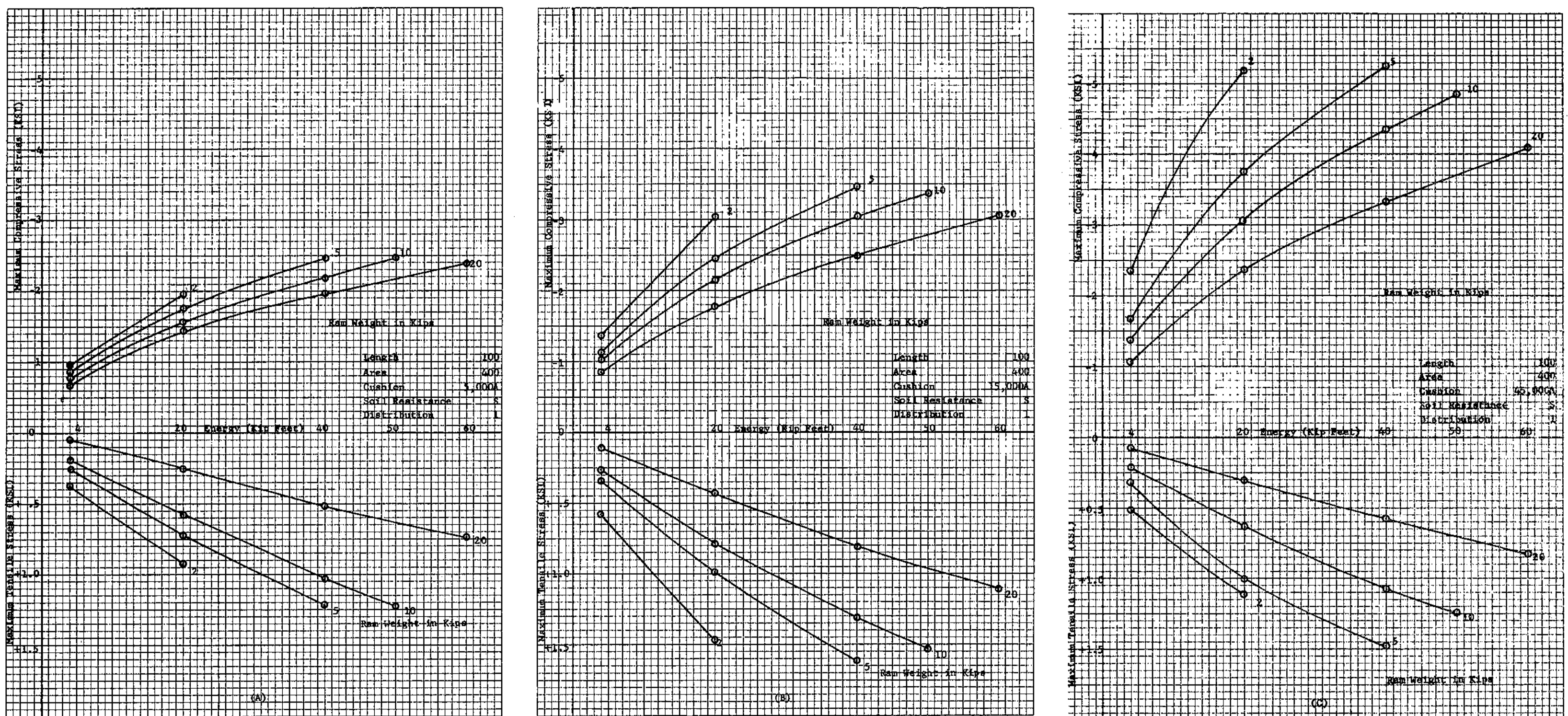
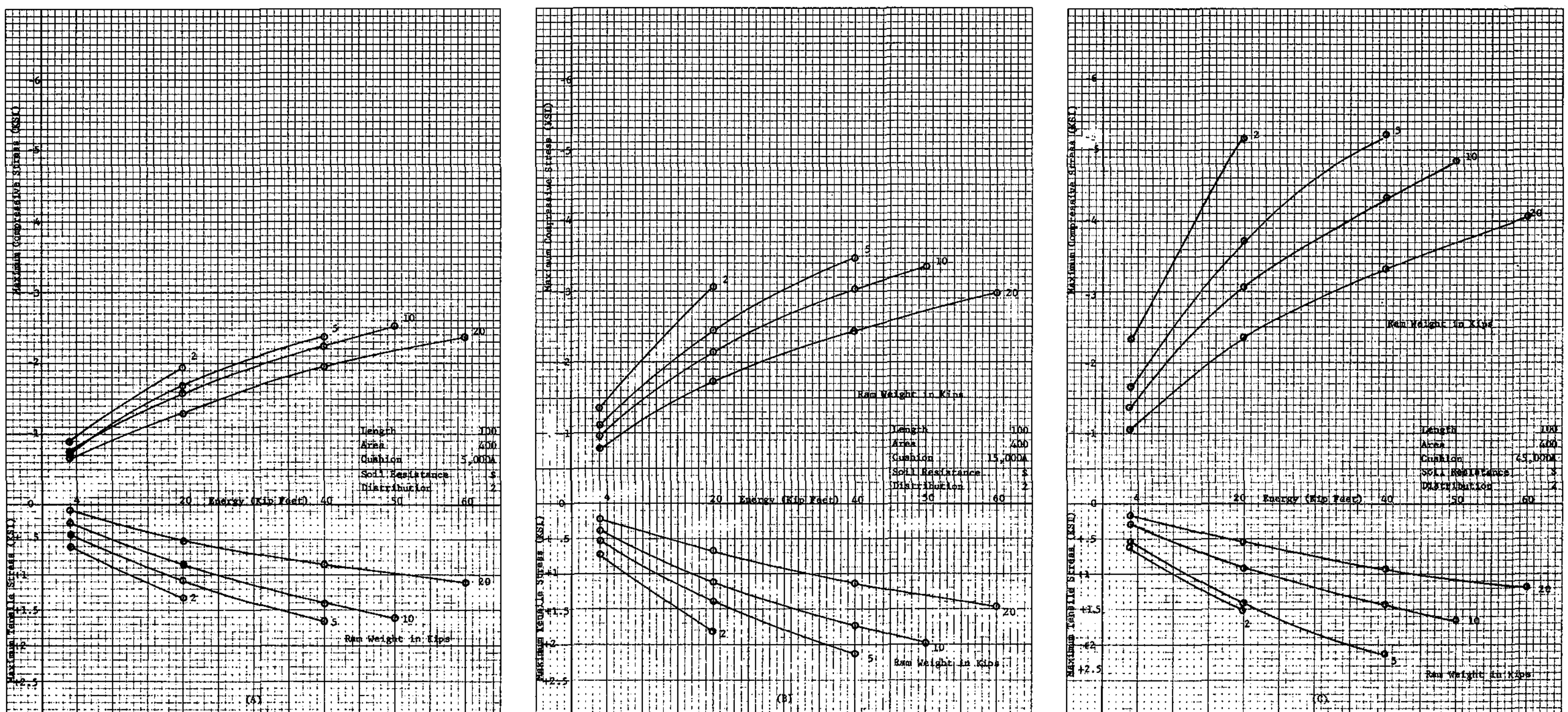

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)
(C)

FIGURE 45



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance 5
Distribution 1
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 46



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance 5
Distribution 2
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 47

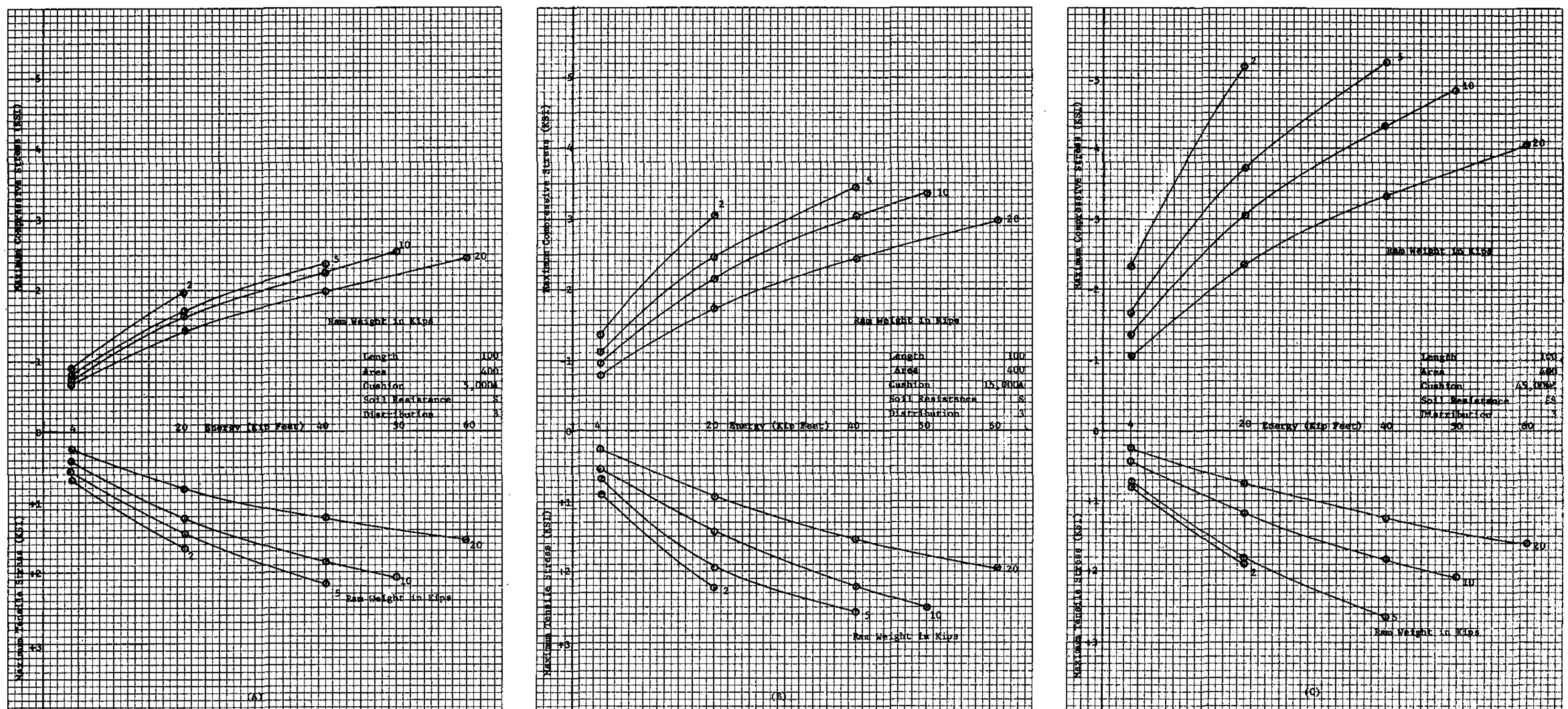
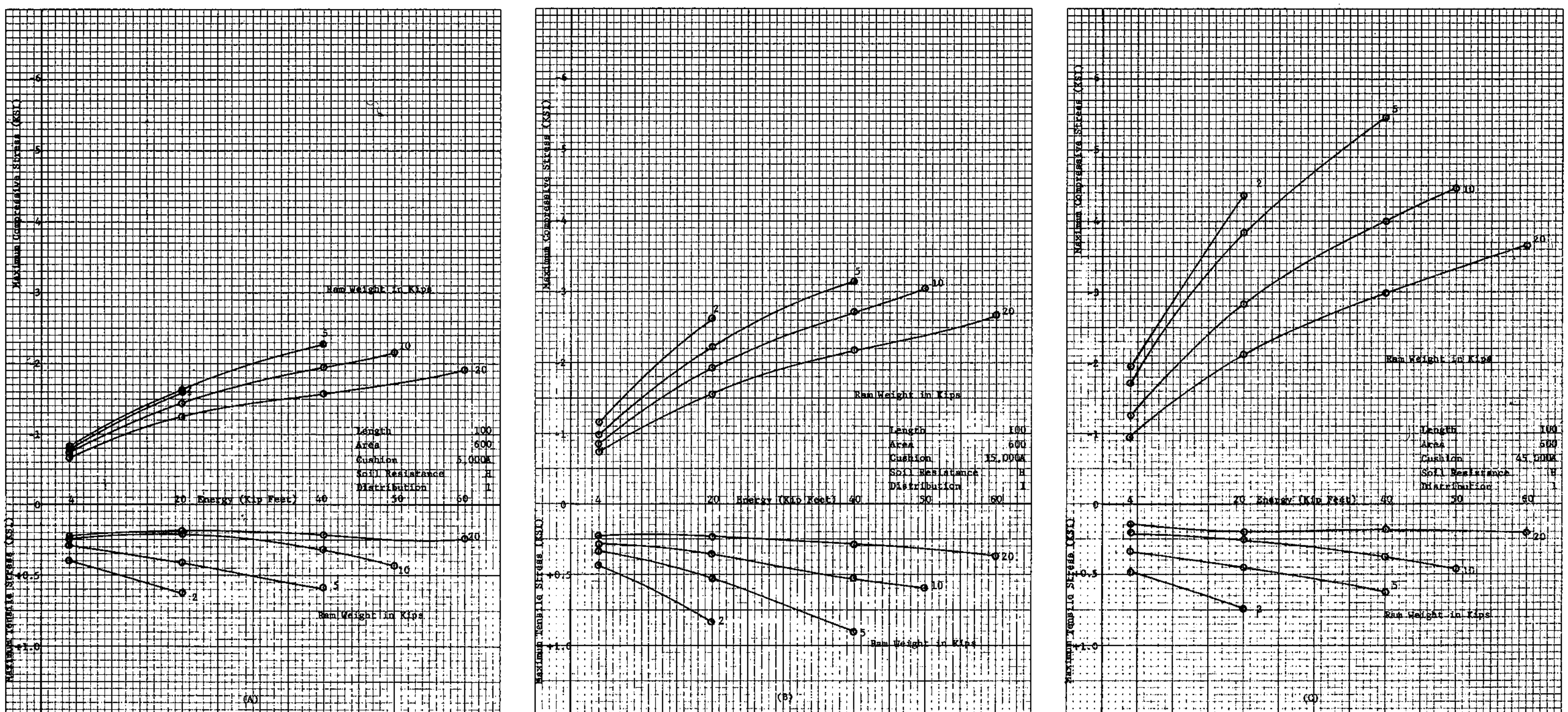
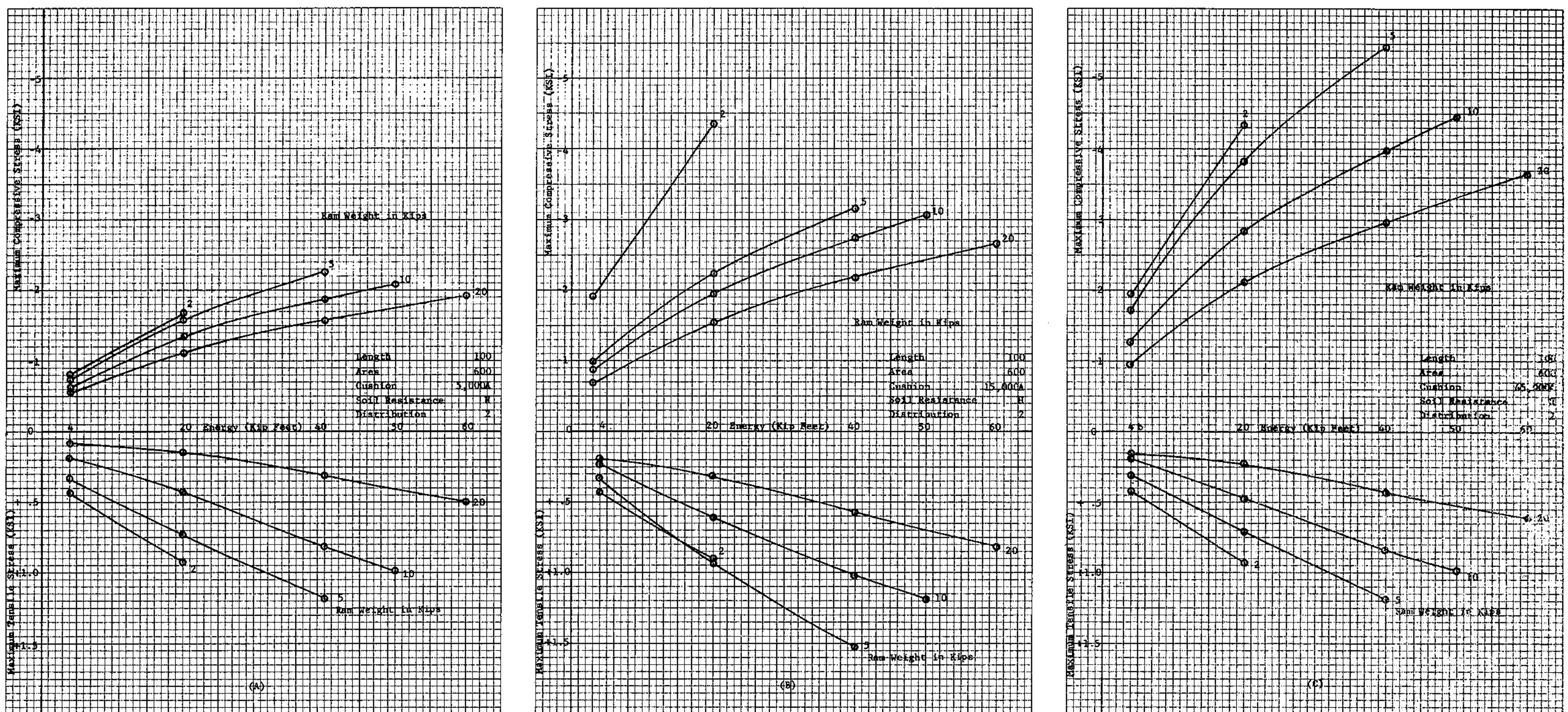

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 48



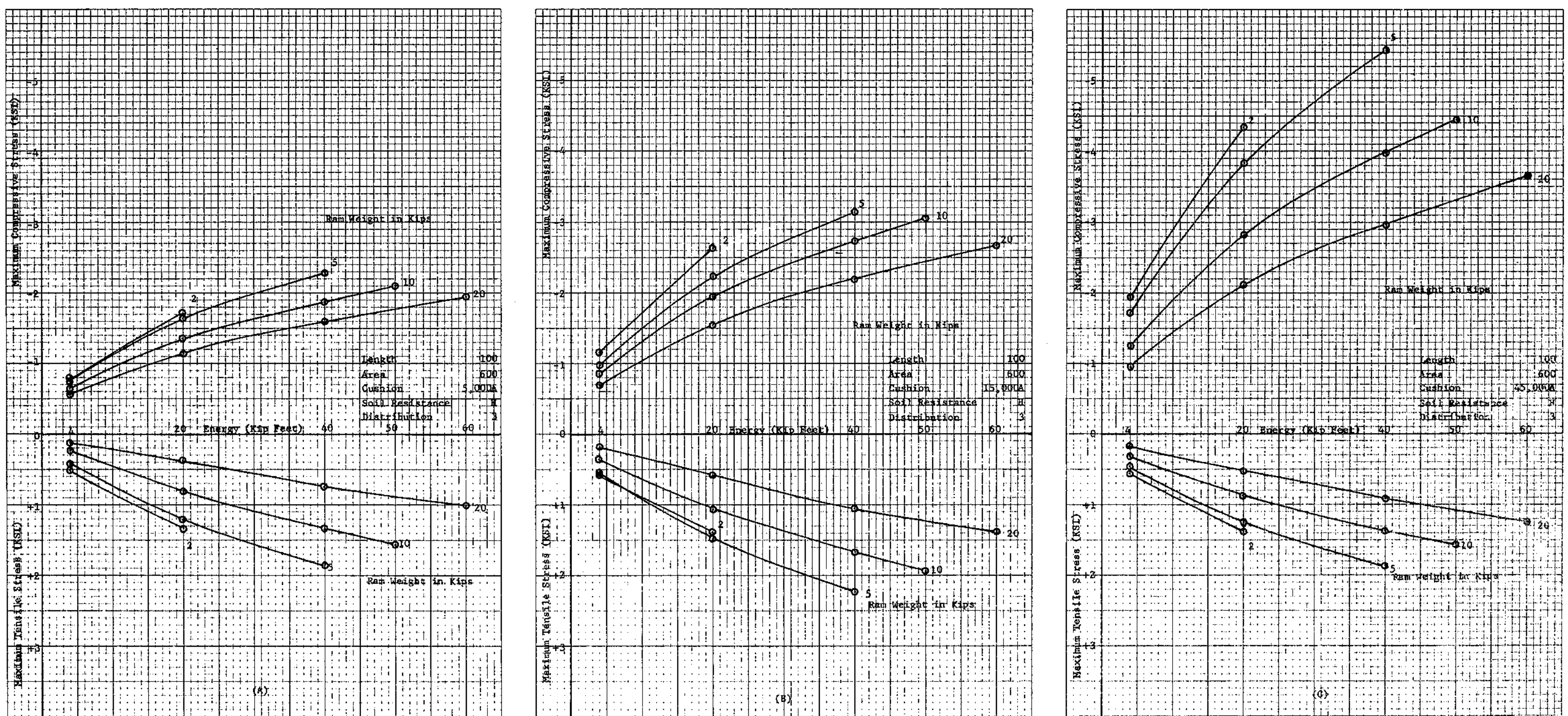
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000K
Soil Resistance H
Distribution 1
(A)
Cushion 15,000K
(B)
Cushion 45,000K
(C)

FIGURE 49



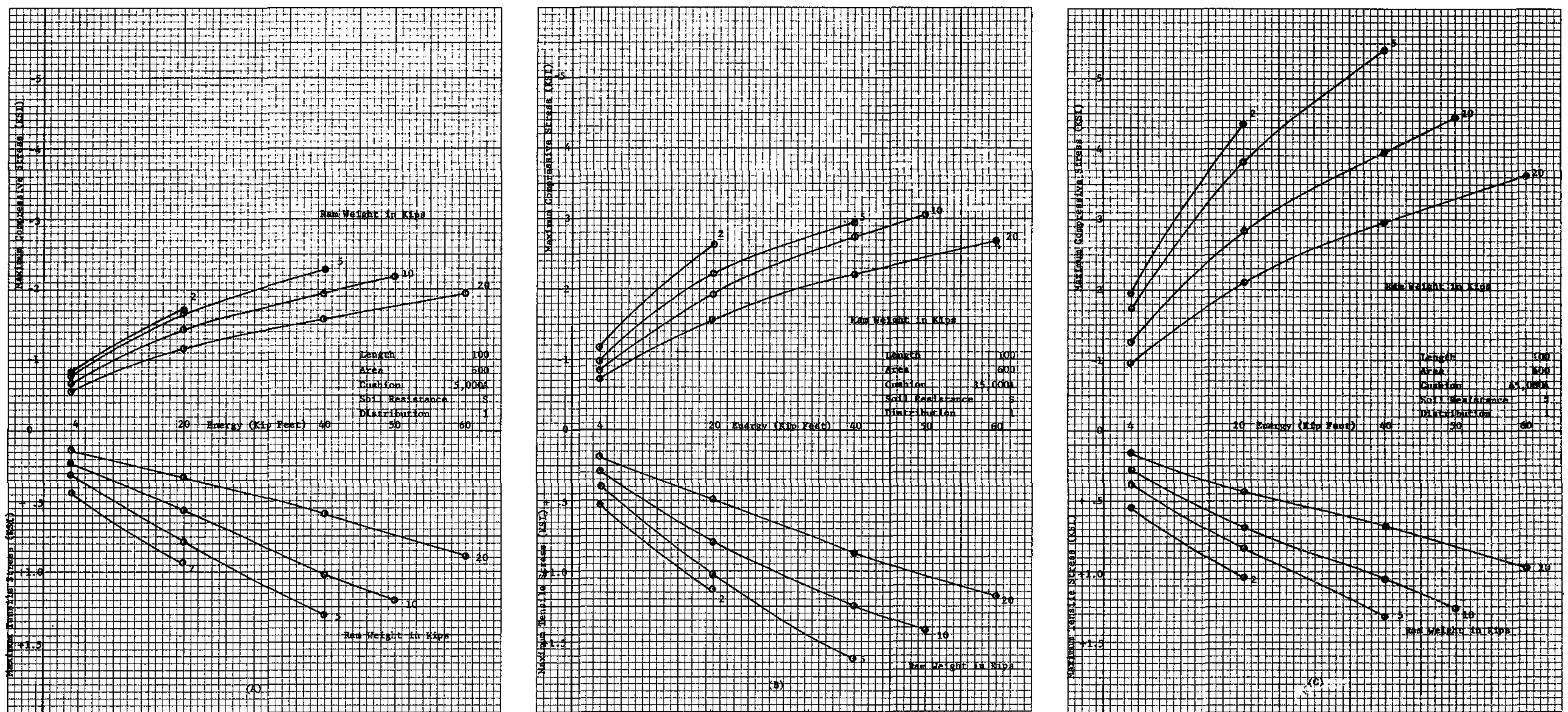
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance N
Distribution 2
(A)
Cushion 15,000A
(B)
(C)

FIGURE 50



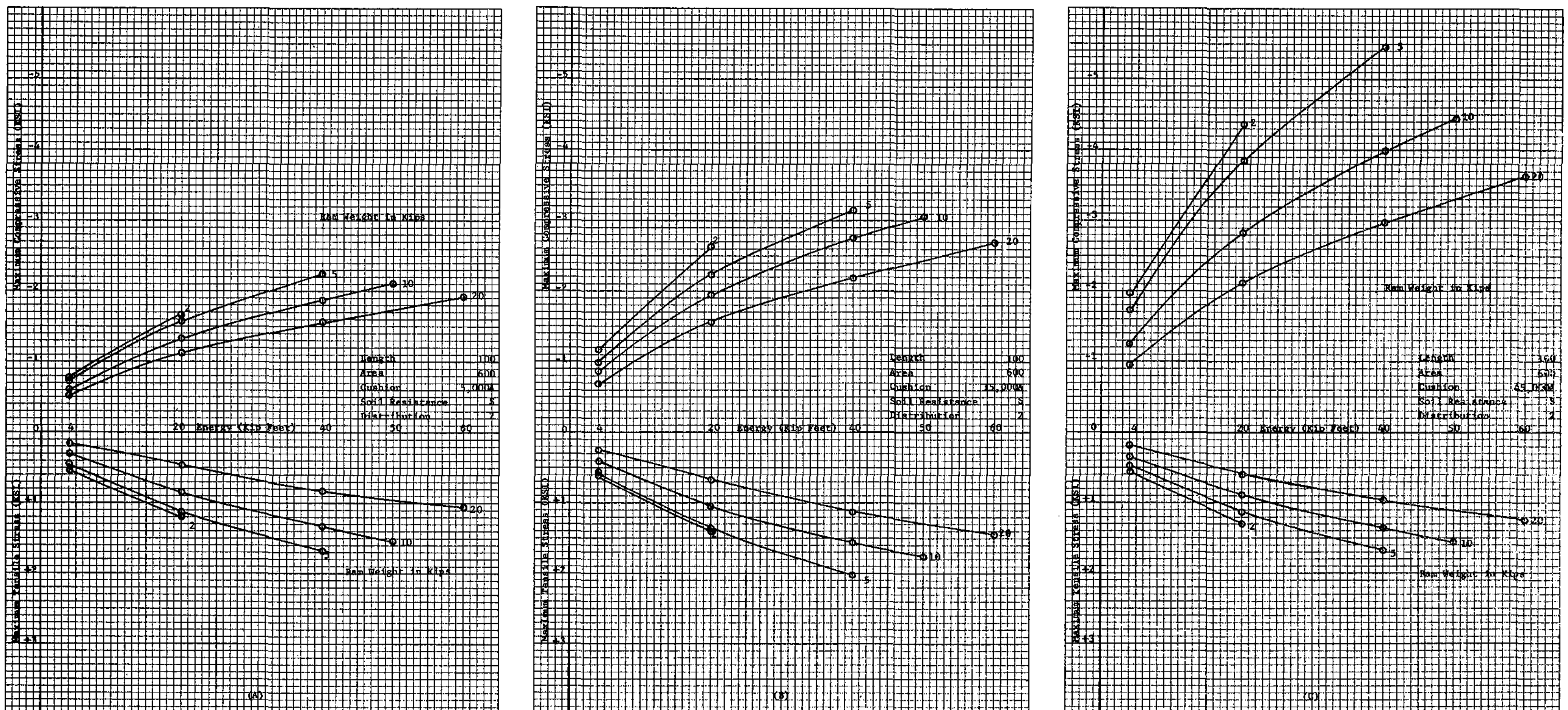
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 51



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
(B)
(C)

FIGURE 52



Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000K
Soil Resistance 5
Distribution 2
(A)
Length 100
Area 600
Cushion 15,000K
Soil Resistance 5
Distribution 2
(B)
(C)

FIGURE 53

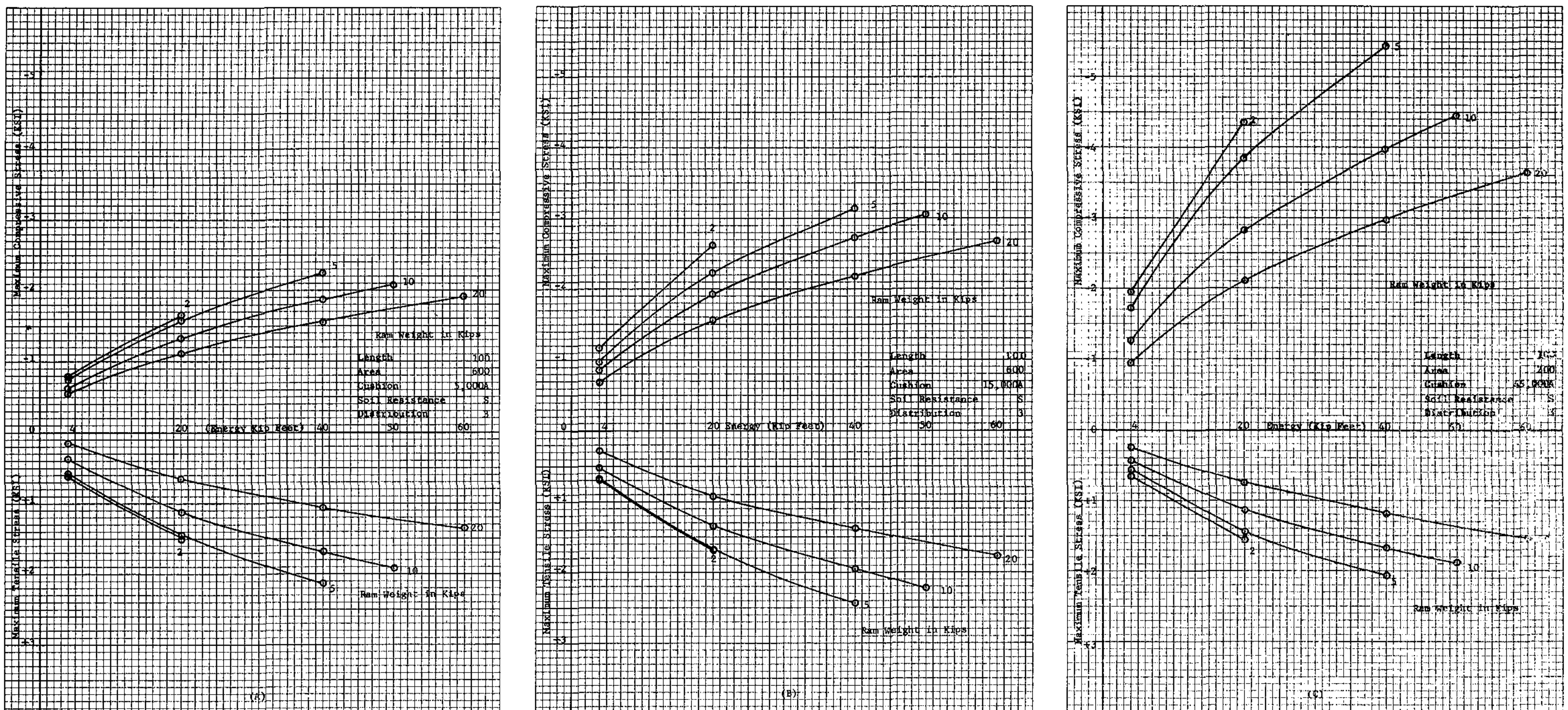

Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Length 100
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Length
Area 200
Soil Resistance S
Distribution 3
(C)

FIGURE 54

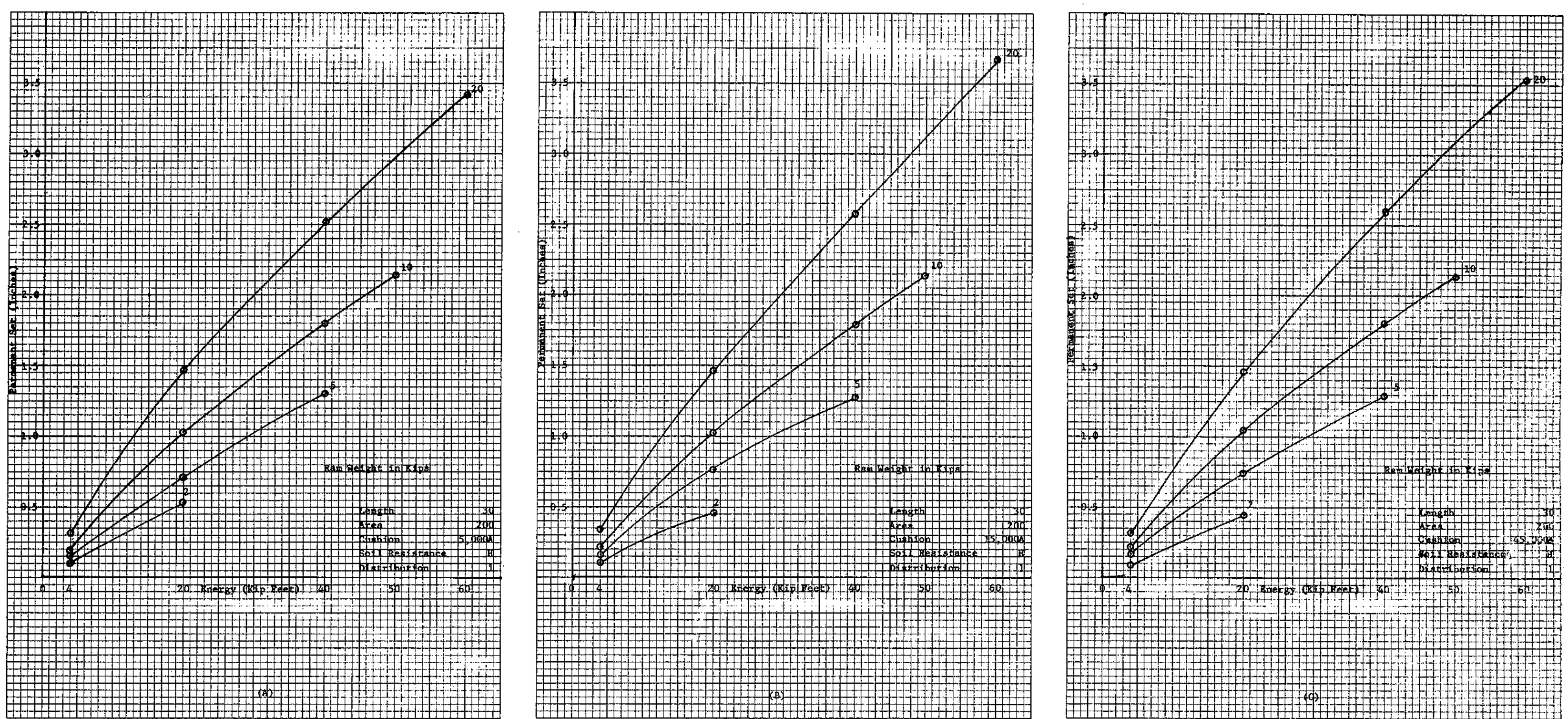
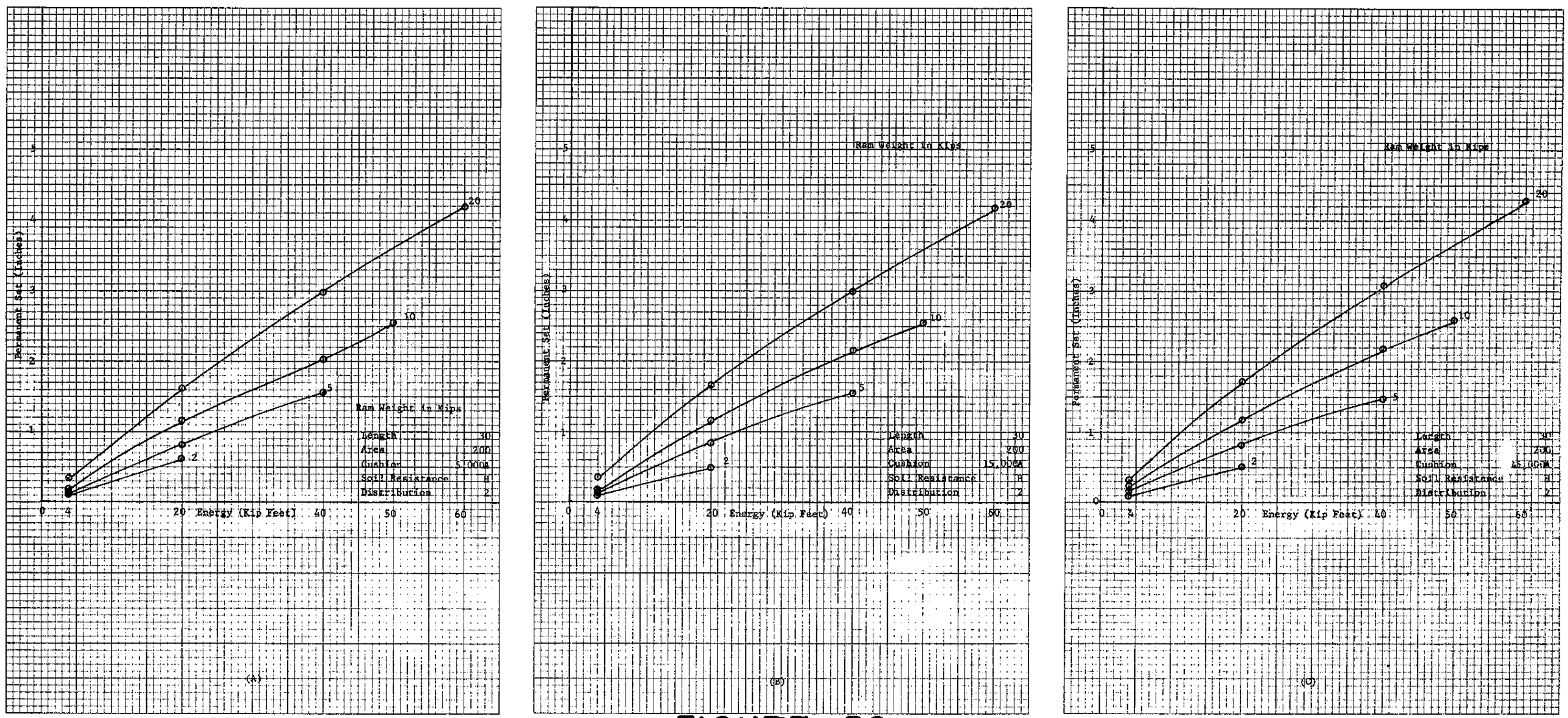

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance B
Distribution 1
(A)
Ram Weight in Kips
Length 30
Area 200
Cushion 15,000A
Soil Resistance B
Distribution 1
(B)
Ram Weight in Kips
Length 30
Soil Resistance B
Distribution 1
(C)

FIGURE 55



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance 8
Distribution 2
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 15,000A
Soil Resistance 8
Distribution 2
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion
Soil Resistance 8
Distribution 2
(C)

FIGURE 56

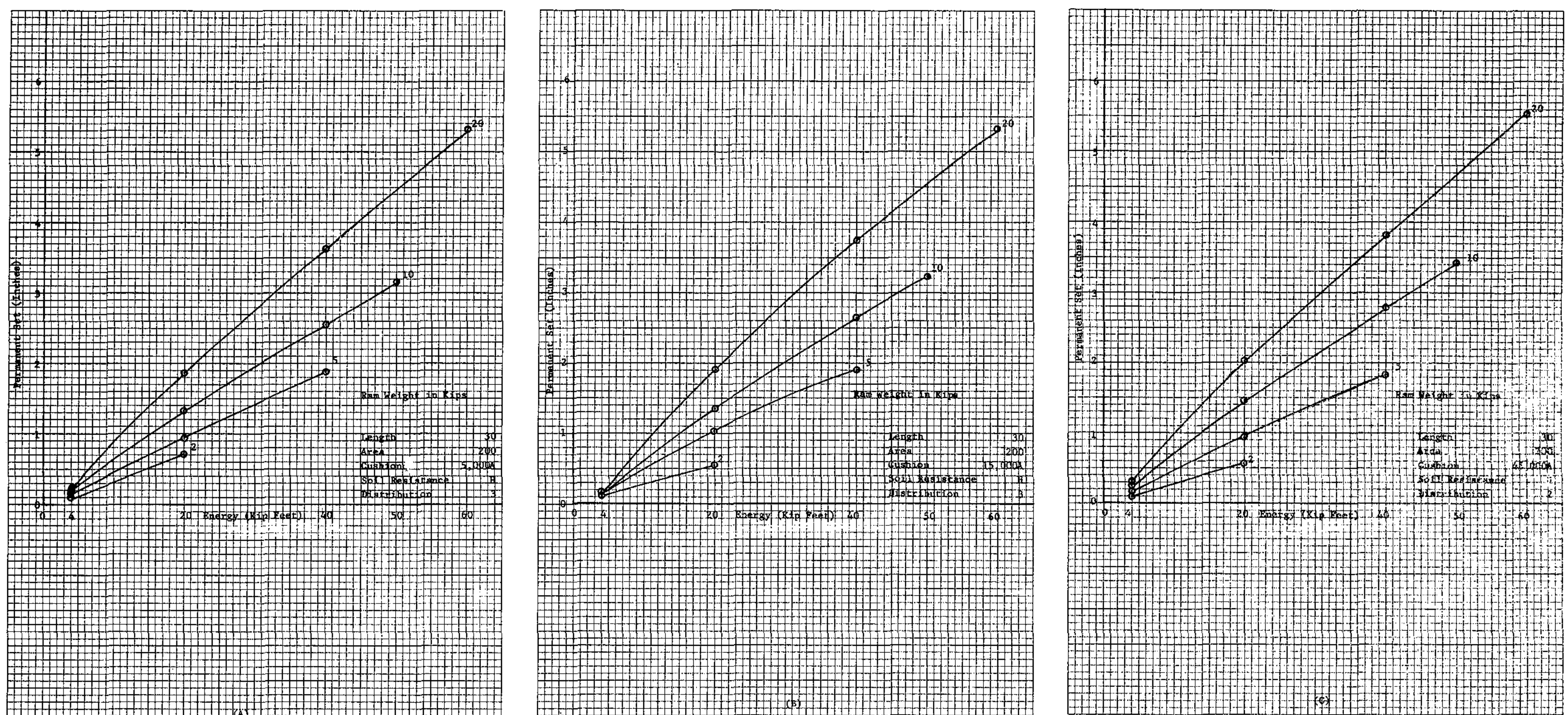

(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance B
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 15,000A
Soil Resistance B
Distribution 3
(C)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area
Cushion
Soil Resistance
Distribution 2

FIGURE 57

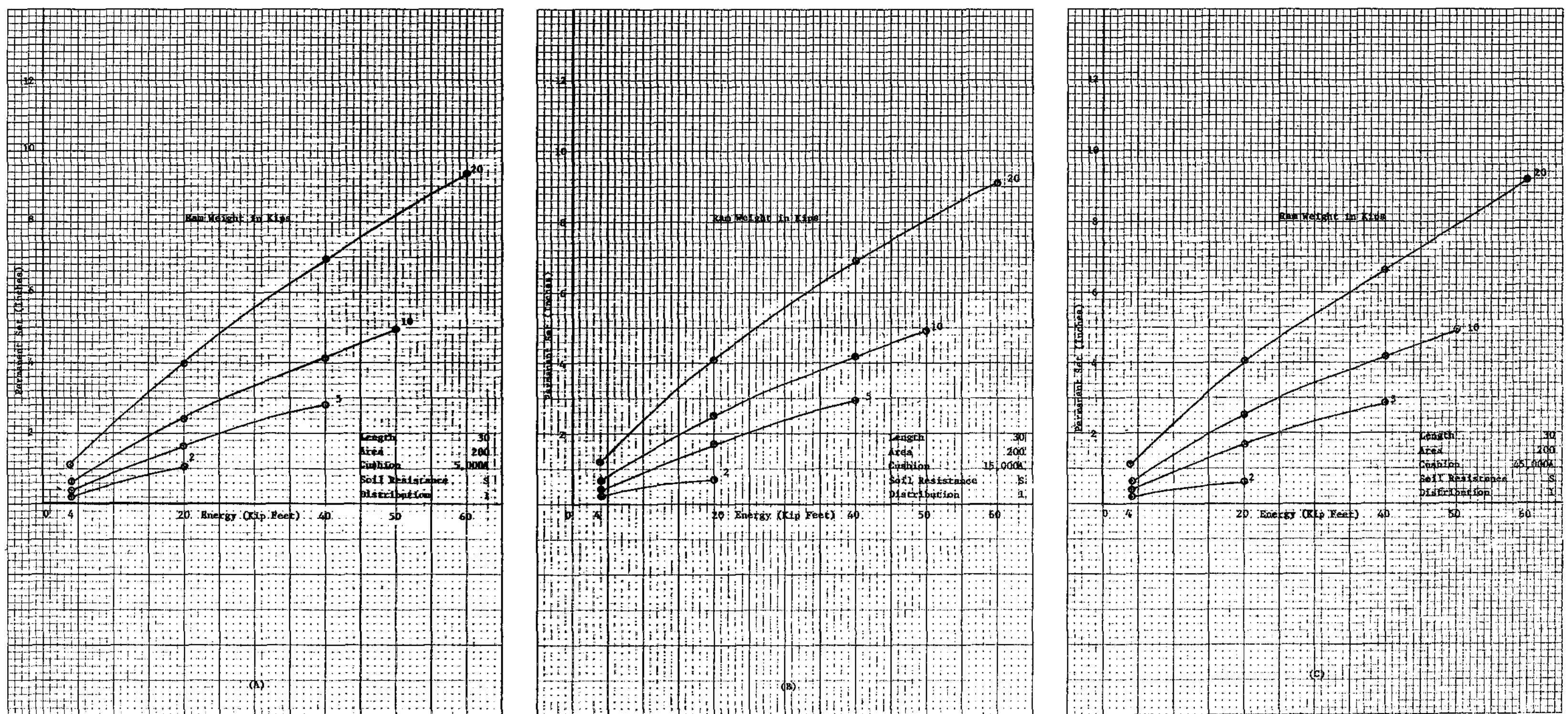

Ram Weight in Kips
Permanent Set (Inches)
Energy (Kip Feet)
Length 30
Area 200
Cushion 5.000Δ
Soil Resistance S
Distribution 1
(A)
Ram Weight in Kips
Permanent Set (Inches)
Energy (Kip Feet)
Length 30
Area 200
Cushion 15.000Δ
Soil Resistance S
Distribution 1
(B)
Ram Weight in Kips
Permanent Set (Inches)
Energy (Kip Feet)
Length 30
Area 200
Cushion 45.000Δ
Soil Resistance S
Distribution 1
(C)

FIGURE 58

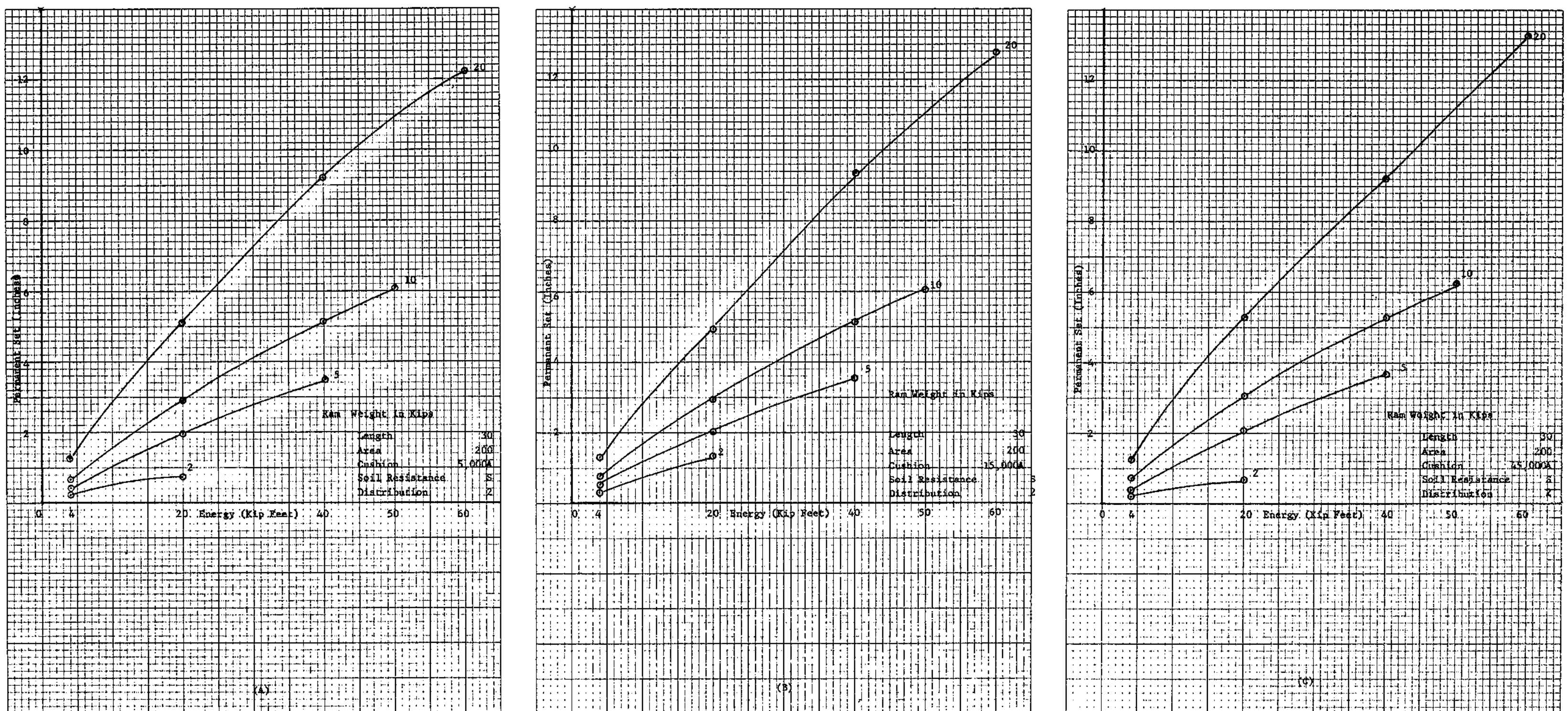

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
(B)
(C)

FIGURE 59

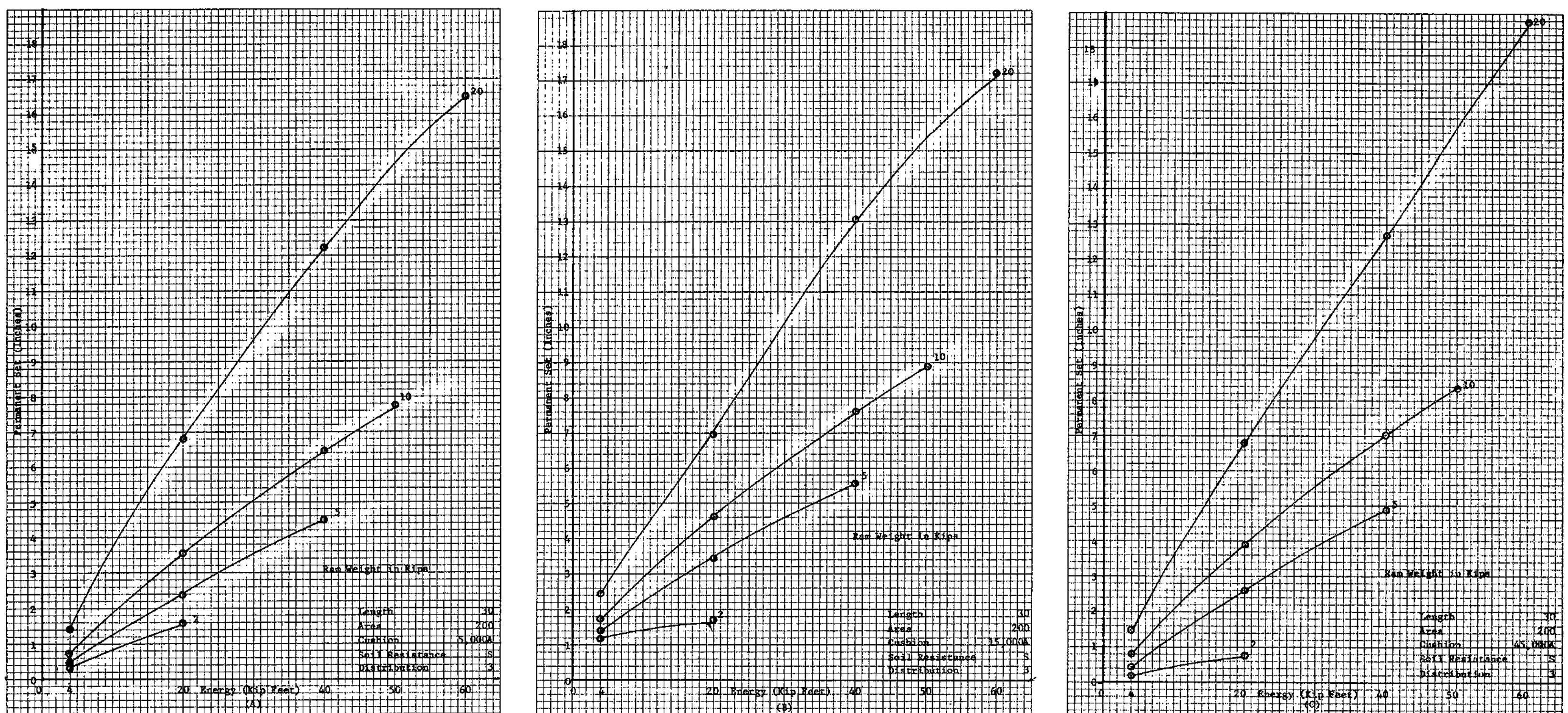

Permanent Set (Inches)
Energy (Kip Feet)
(A)
(B)
(C)
Ram Weight in Kips
Length 30
Area 200
Cushion 5,000A
Cushion 15,000A
Cushion 45,000A
Soil Resistance S
Distribution 3

FIGURE 60

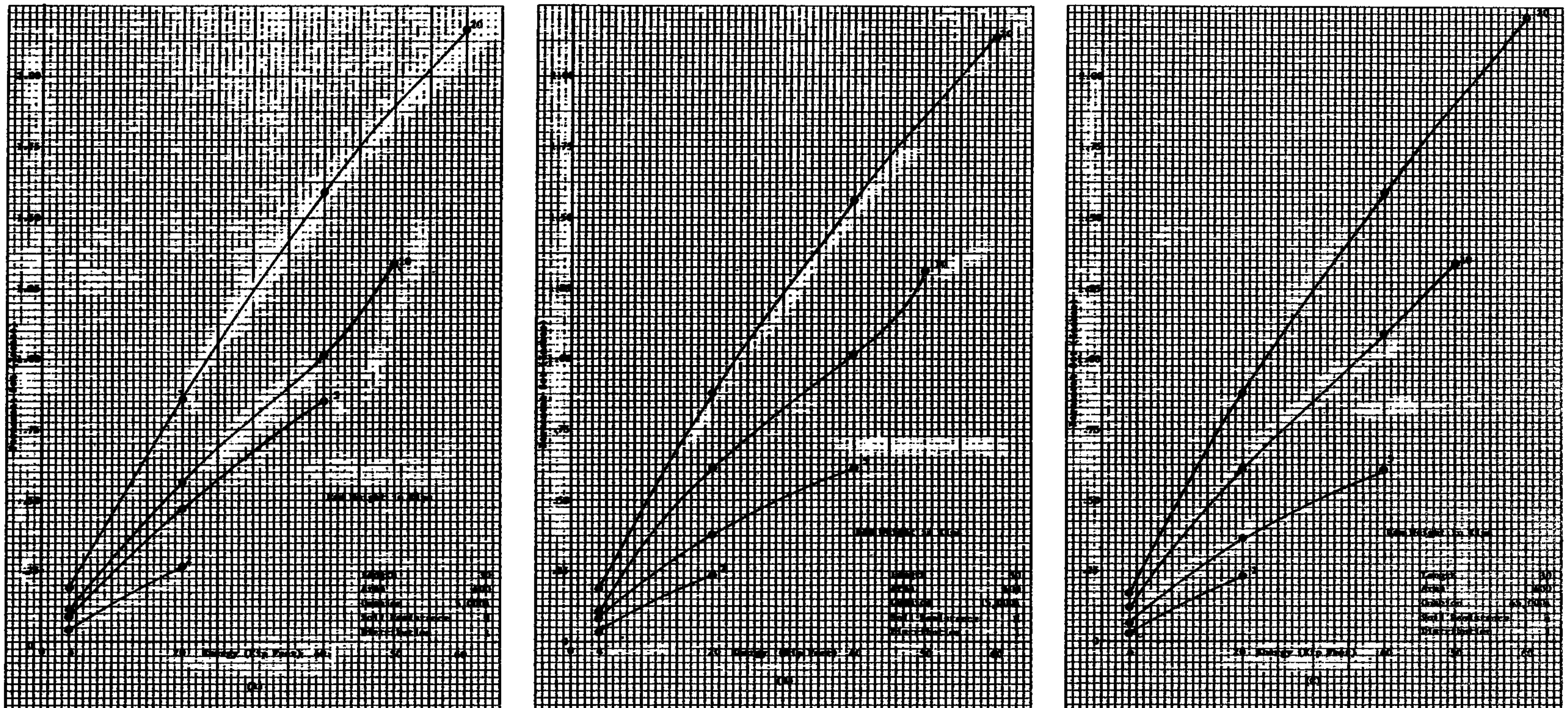
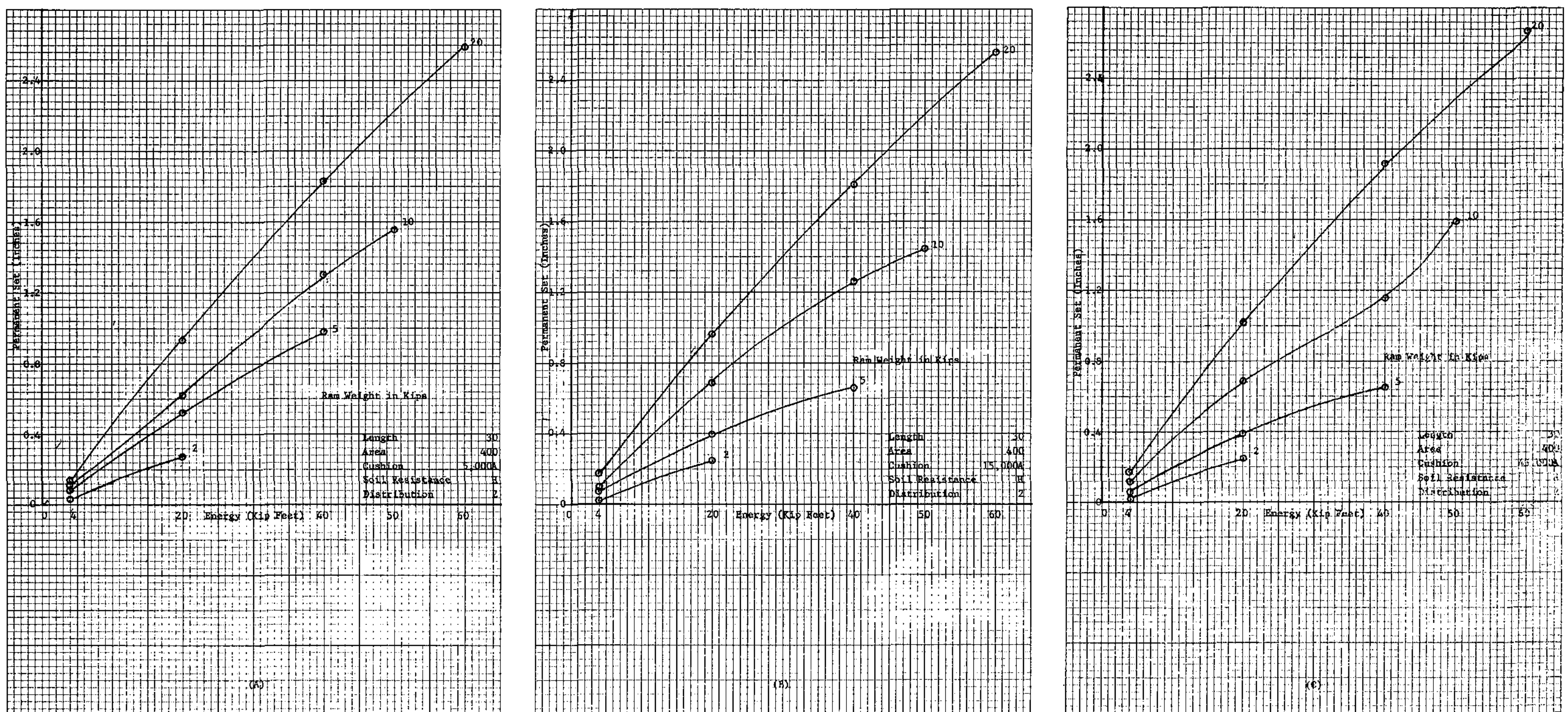
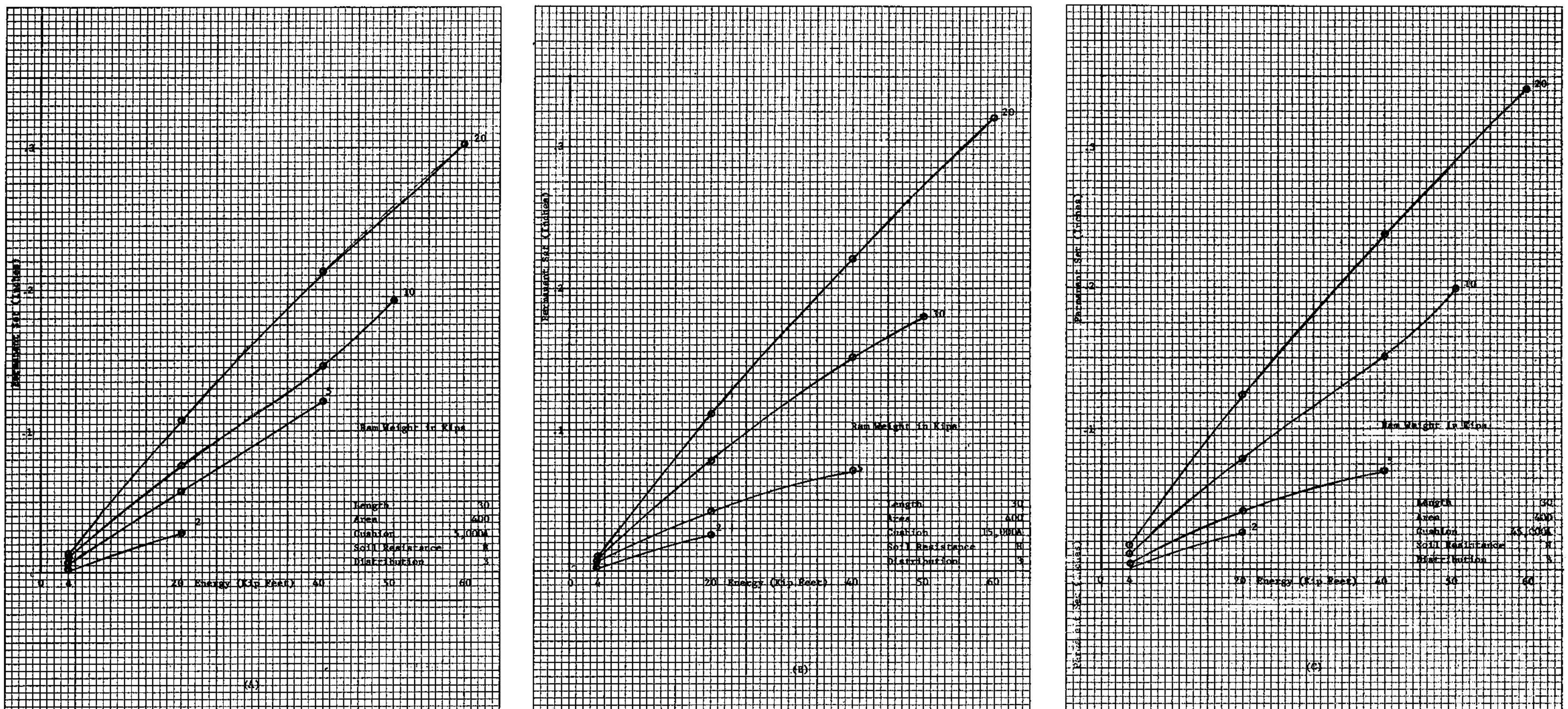


FIGURE 61



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Length 30
Area 400
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
(C)

FIGURE 62



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution

FIGURE 63

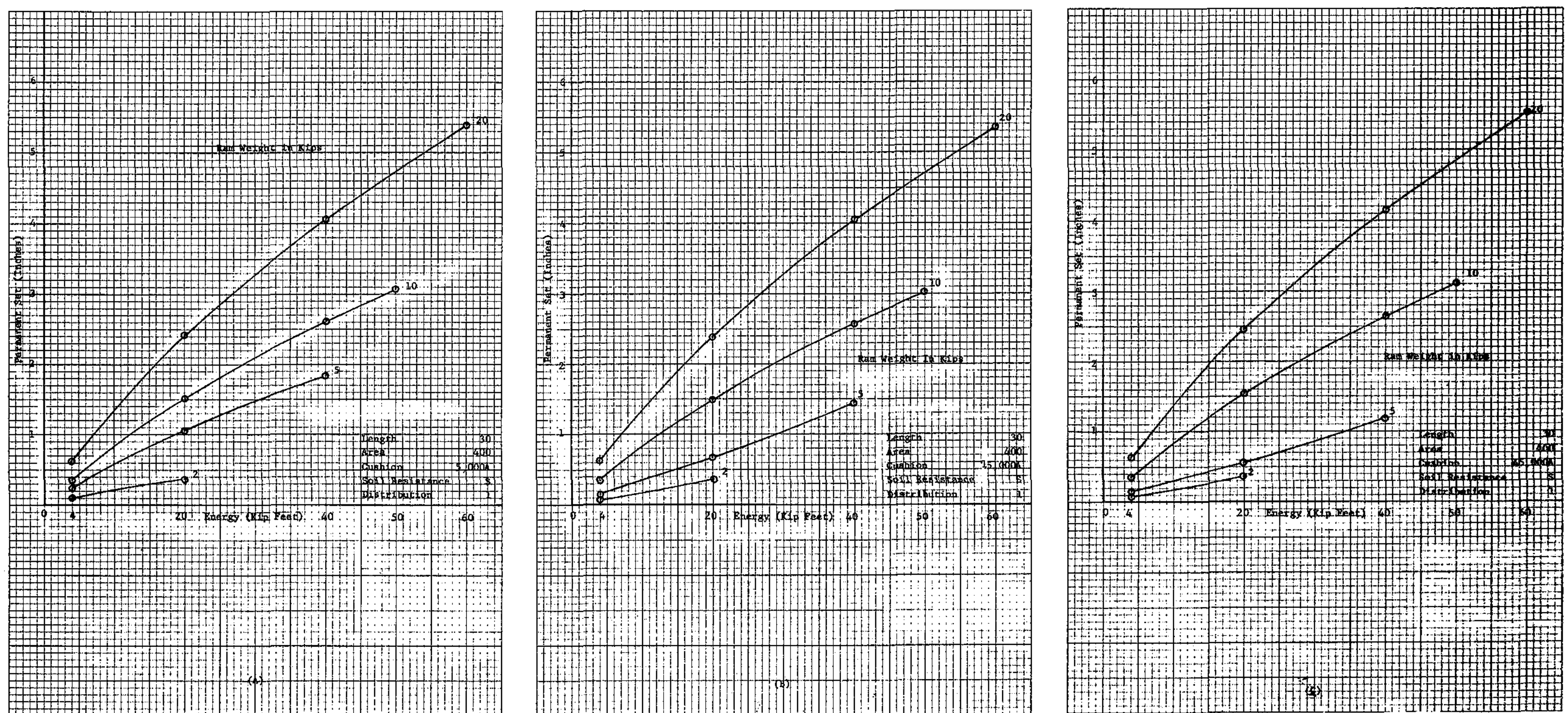

Ram Weight In Kips
Permanent Set (Inches)
Energy (Kip Feet)
Length 30
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 1
Cushion 15,000A
(a)
(b)
(c)

FIGURE 64

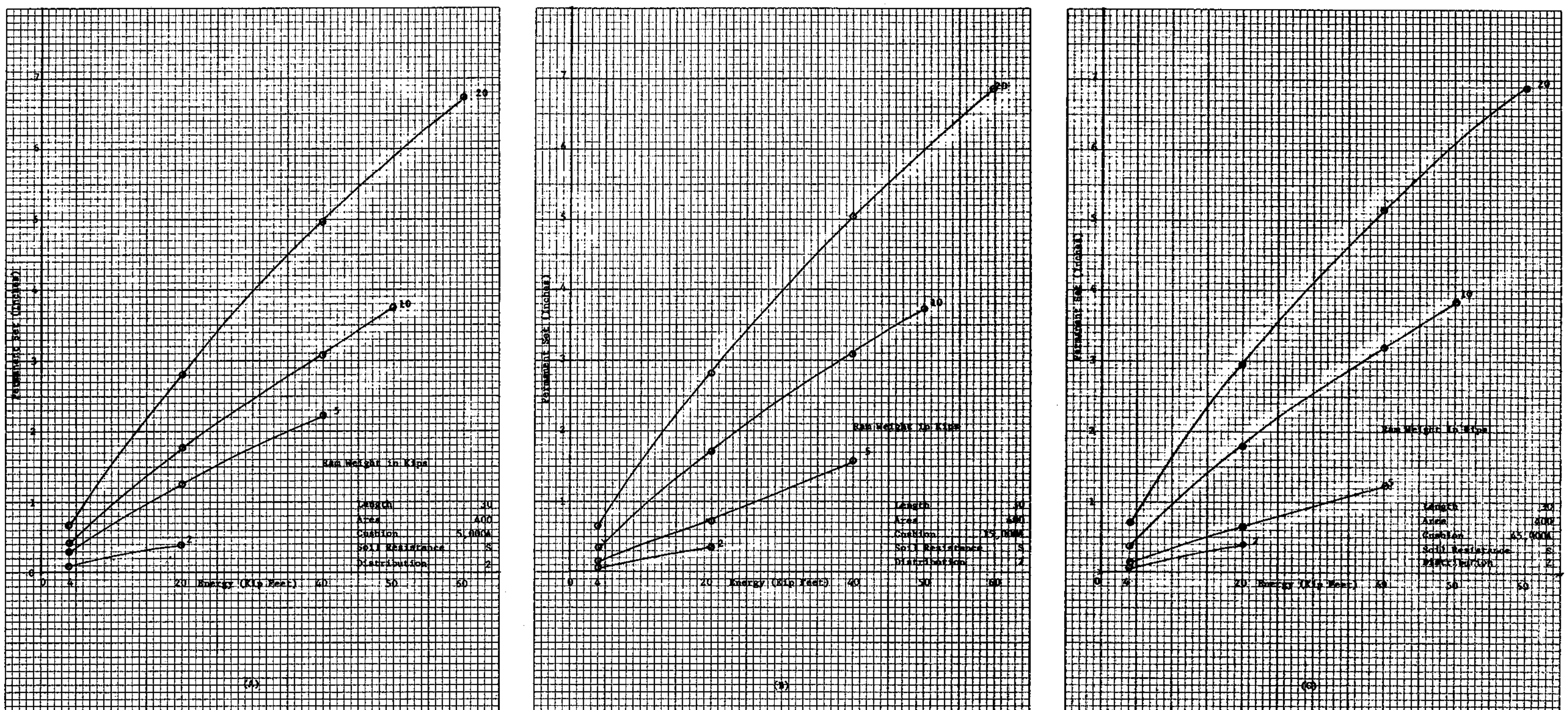

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Soil Resistance
Distribution 2

FIGURE 65

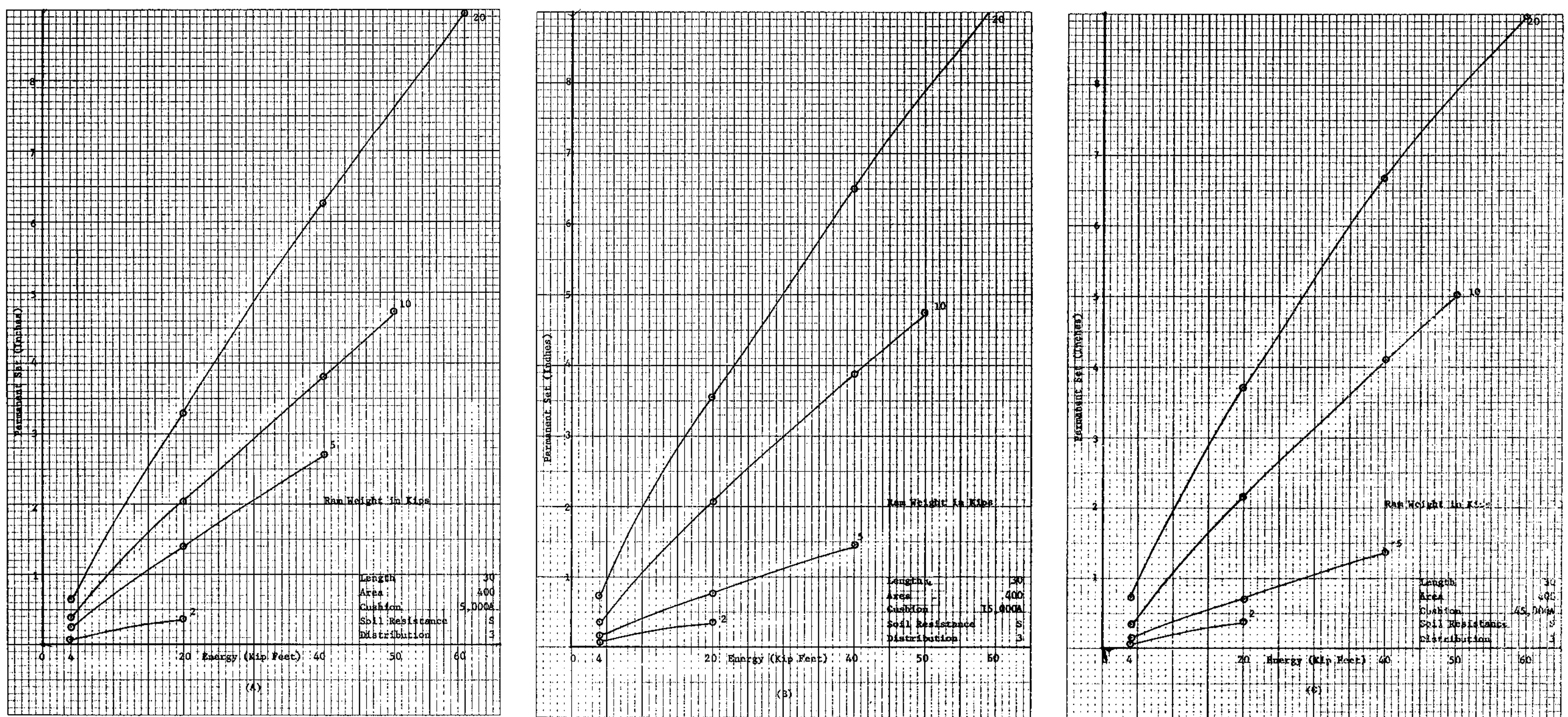

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Length 30
Area 400
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
(C)

FIGURE 66

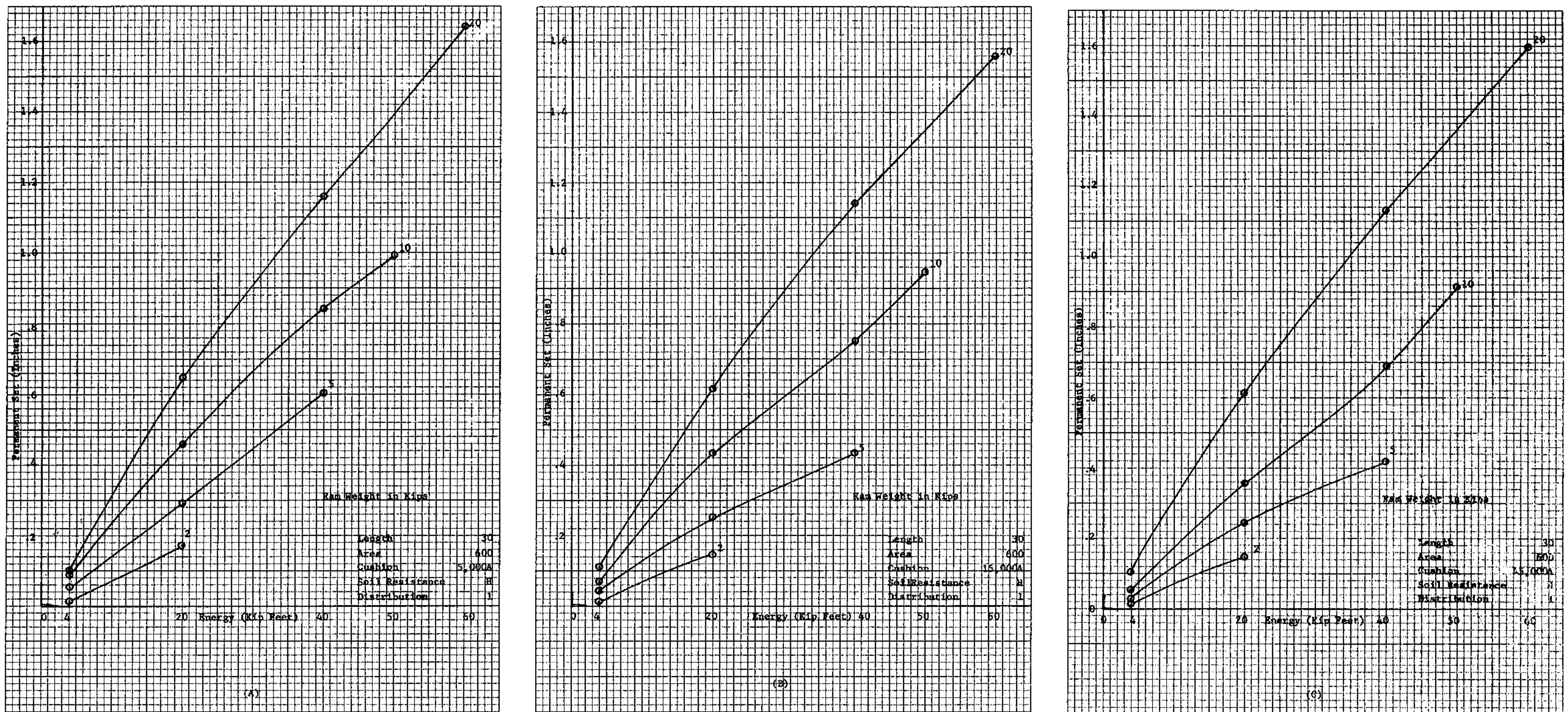
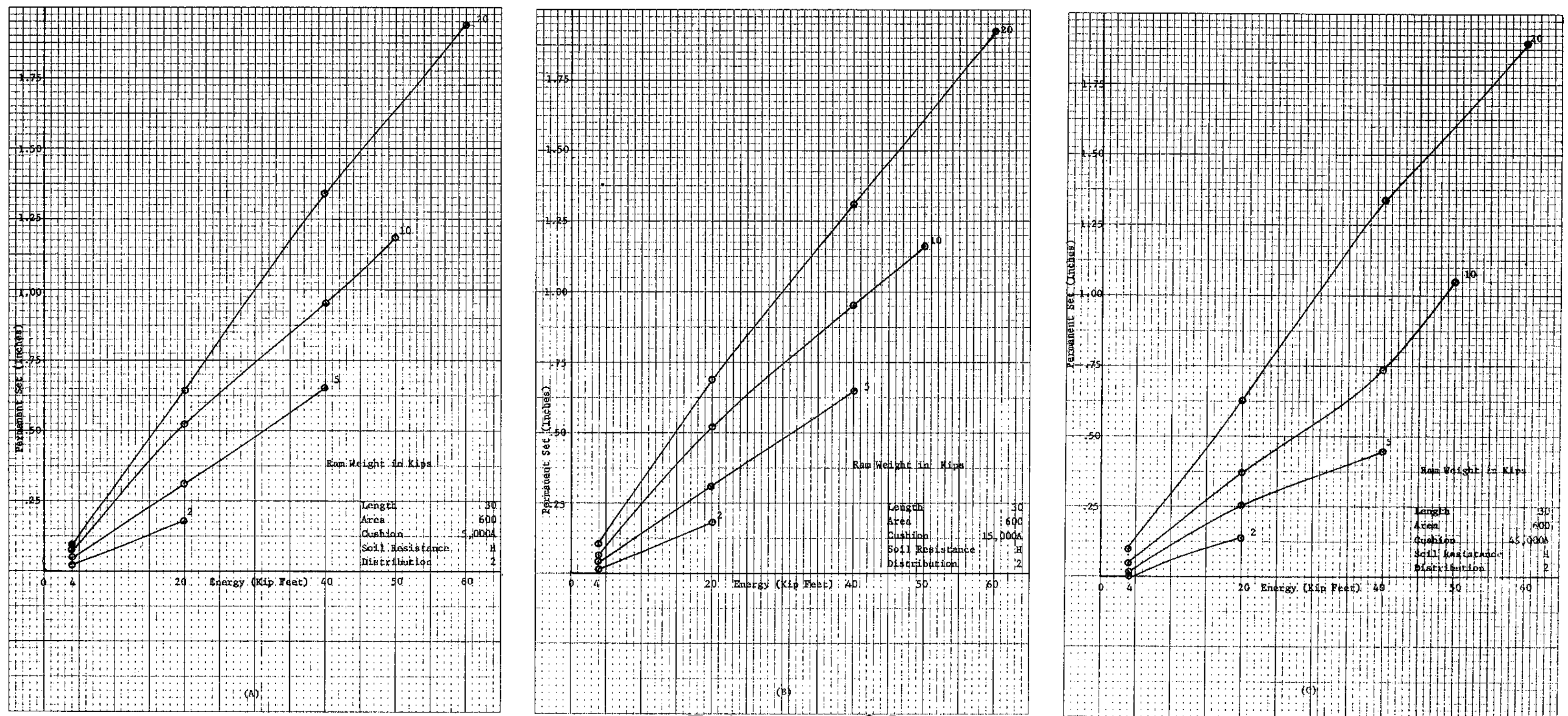

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 1
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 15,000A
Soil Resistance H
Distribution 1
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area
Cushion
Soil Resistance
Distribution 1
(C)

FIGURE 67



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 45,000A
Soil Resistance H
Distribution 2
(C)

FIGURE 68

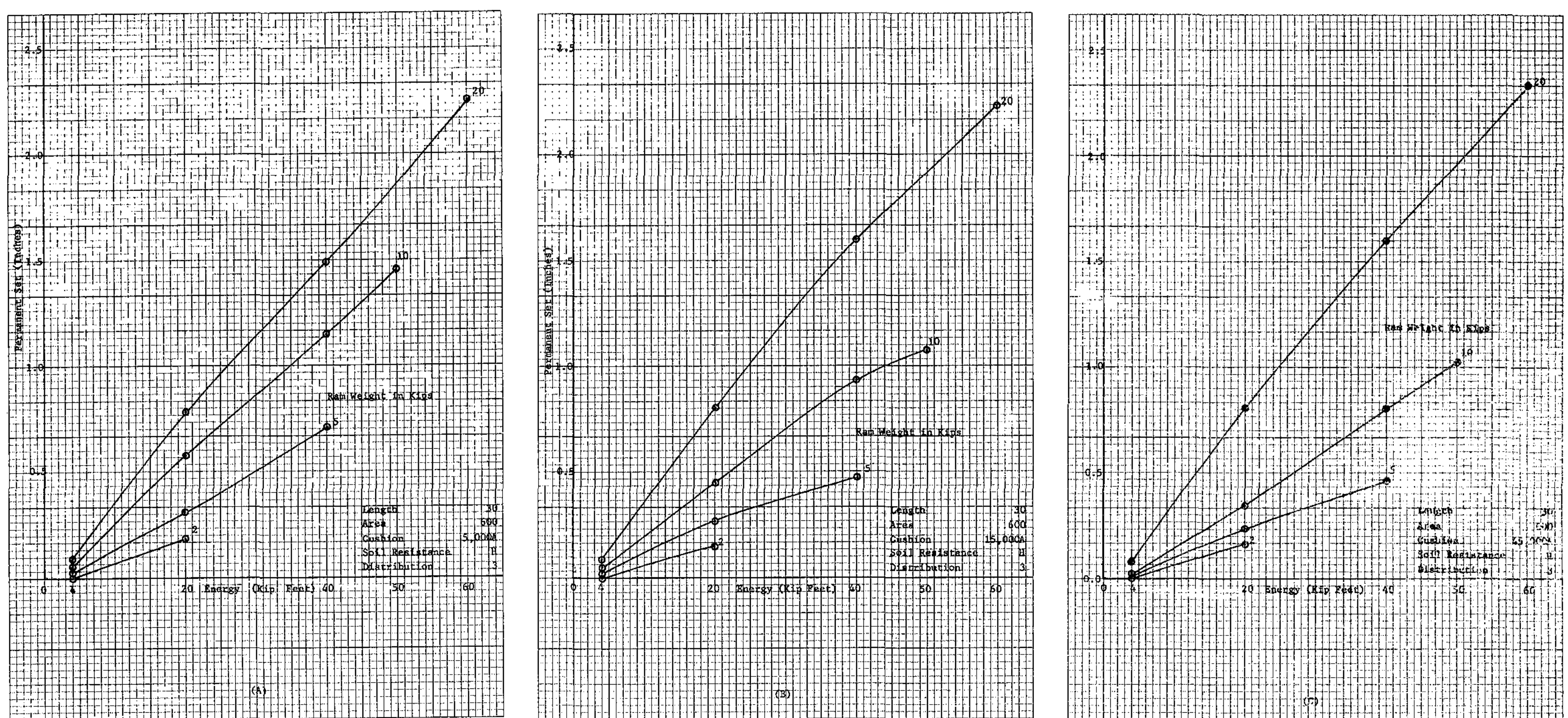

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)

FIGURE 69

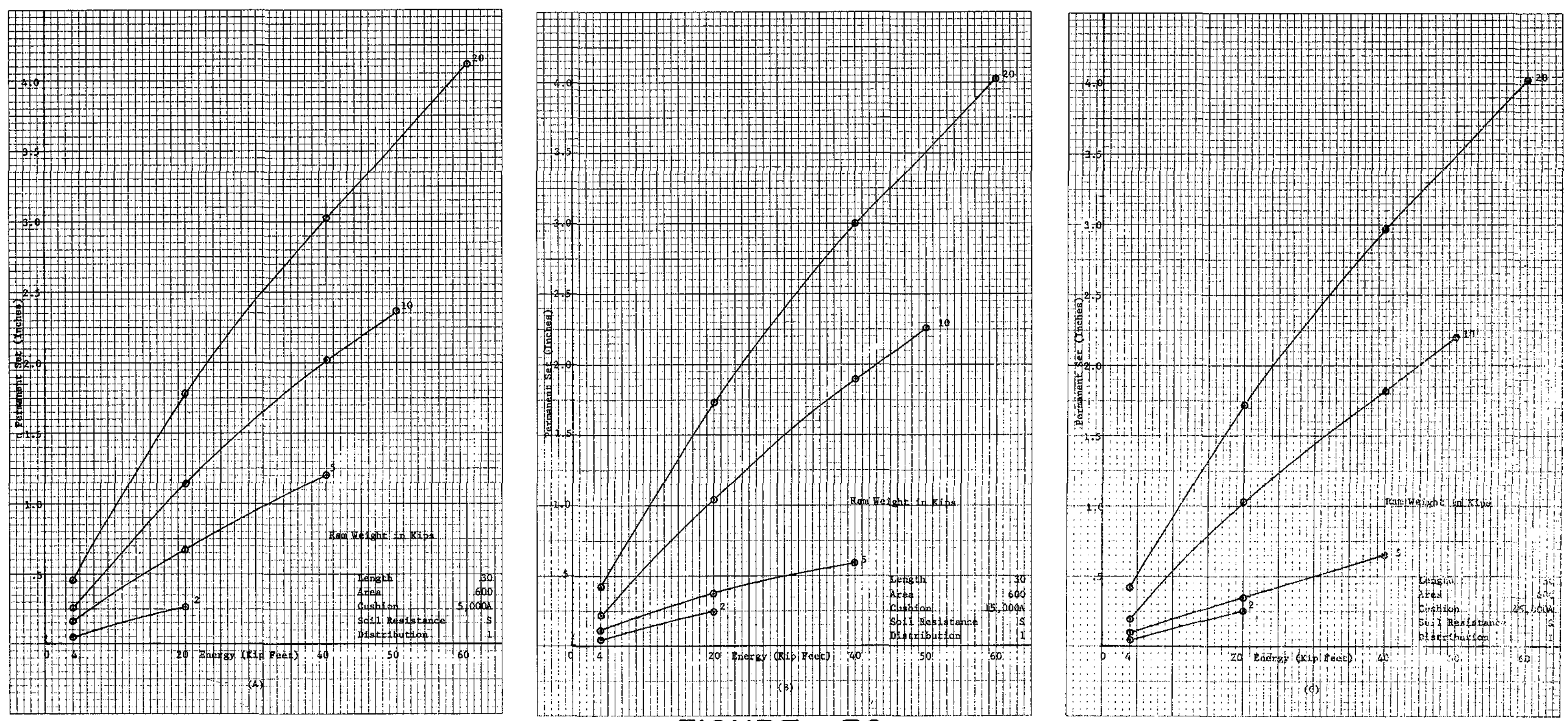
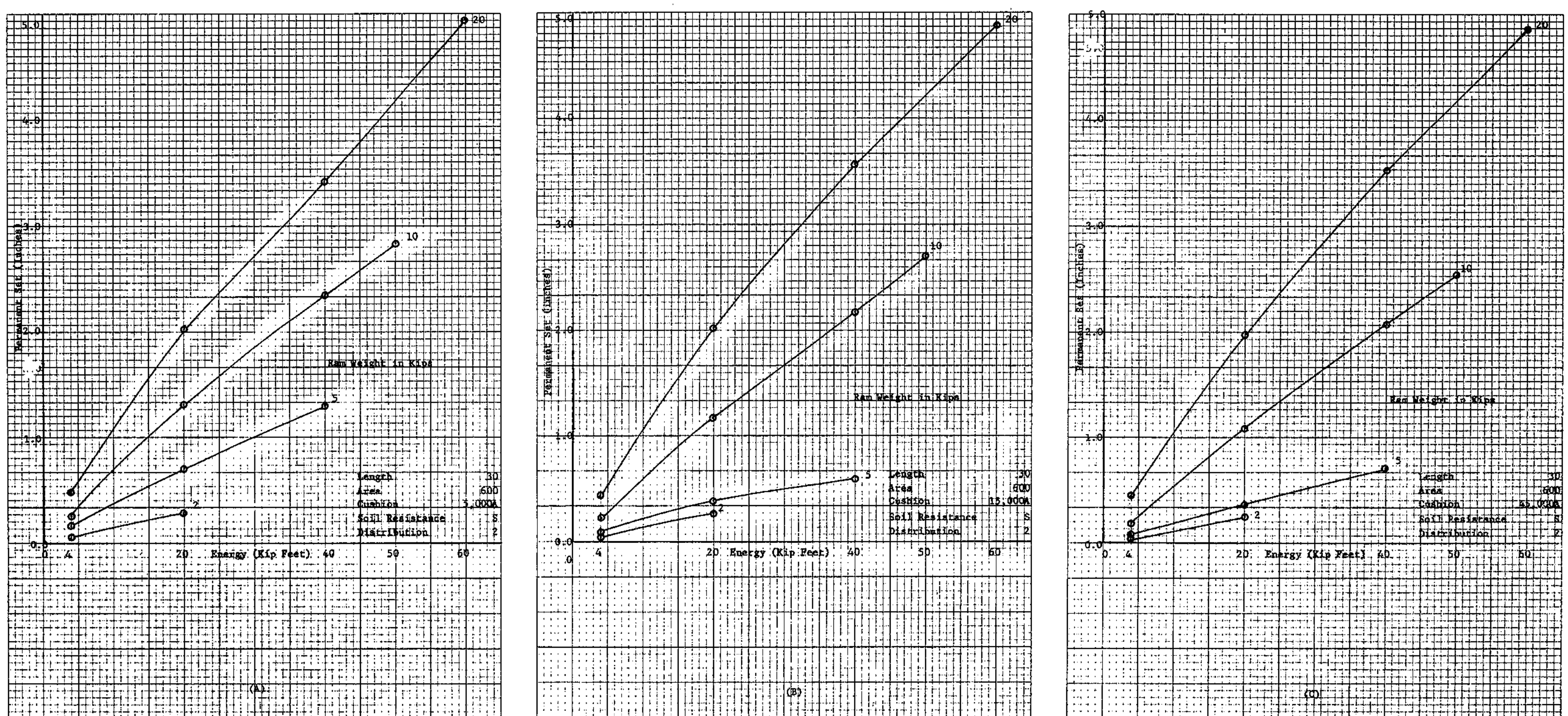

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Length 30
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
(C)

FIGURE 70



Permanent Set (Inches)
0.0
1.0
2.0
3.0
4.0
5.0
Energy (Kip Feet)
0
4
20
40
50
60
Ram Weight in Kips
2
5
10
20
Length 30
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Permanent Set (Inches)
0.0
1.0
2.0
3.0
4.0
5.0
Energy (Kip Feet)
0
4
20
40
50
60
Ram Weight in Kips
2
5
10
20
Length 30
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 2
(B)
Permanent Set (Inches)
0.0
1.0
2.0
3.0
4.0
5.0
Energy (Kip Feet)
0
4
20
40
50
60
Ram Weight in Kips
2
5
10
20
Length 30
Area 600
Cushion 45,000A
Soil Resistance S
Distribution 2
(C)

FIGURE 71

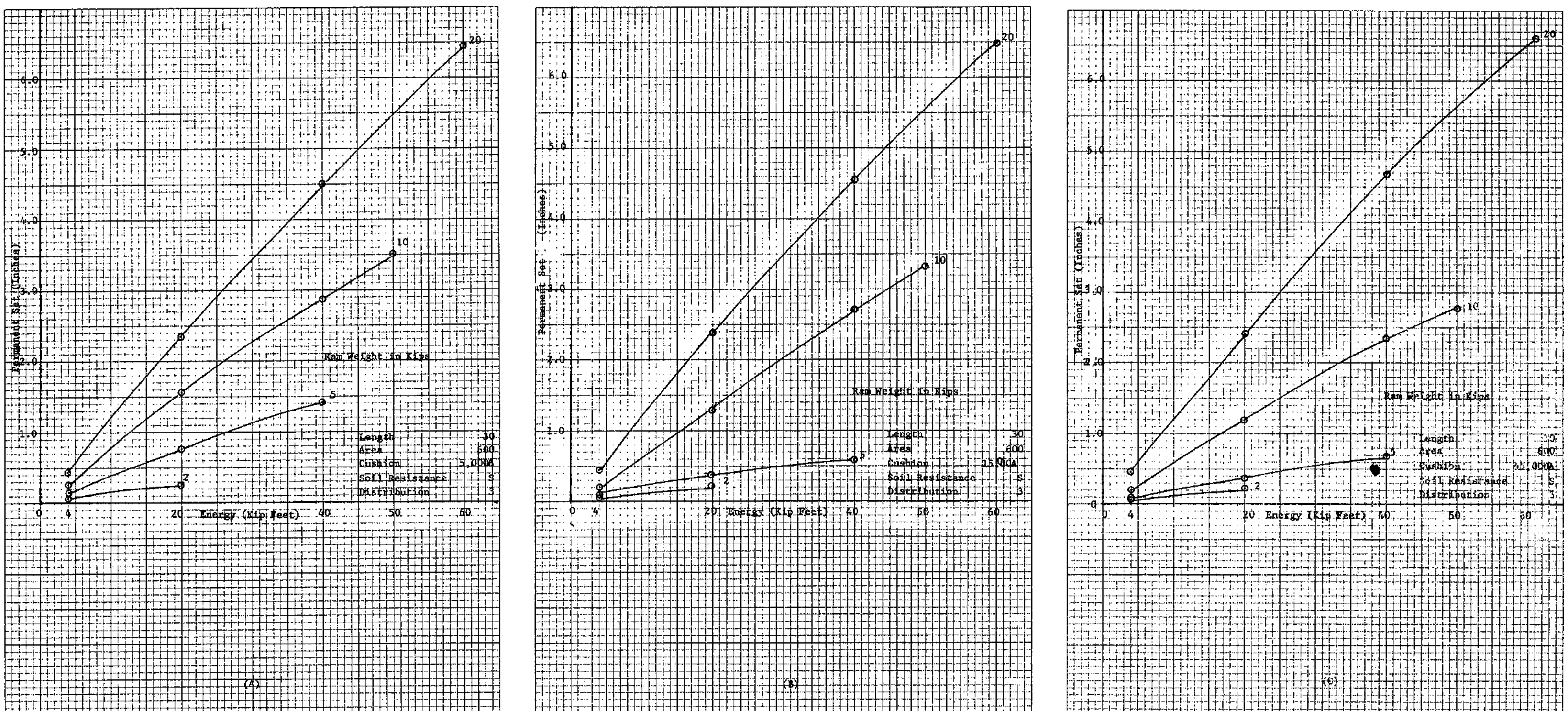

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 30
Area 600
Soil Resistance S
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area 600
Cushion
Soil Resistance S
Distribution
(C)

FIGURE 72

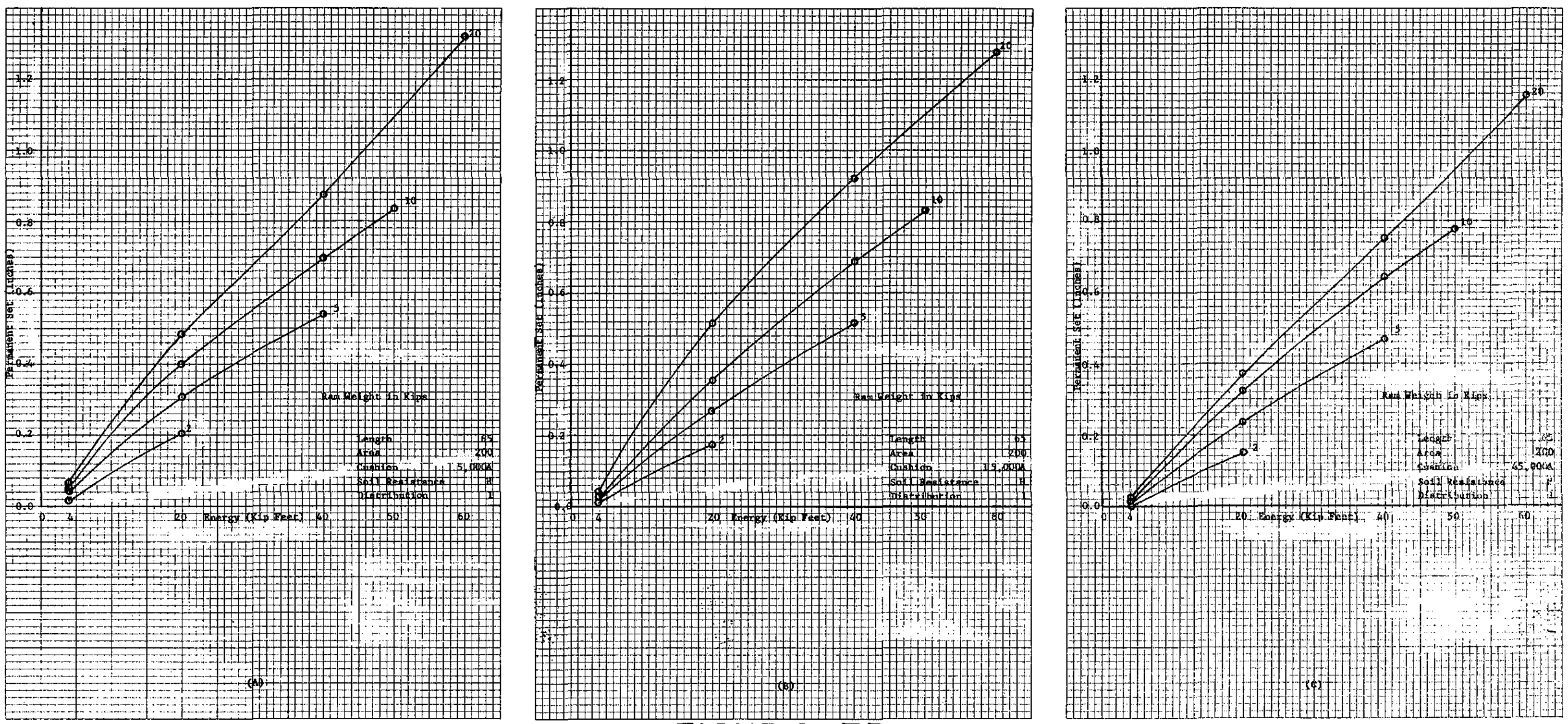

Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance B
Distribution 1
(A)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 15,000A
Soil Resistance B
Distribution 1
(B)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area 200
Cushion 45,000A
Soil Resistance
Distribution 1
(C)

FIGURE 73

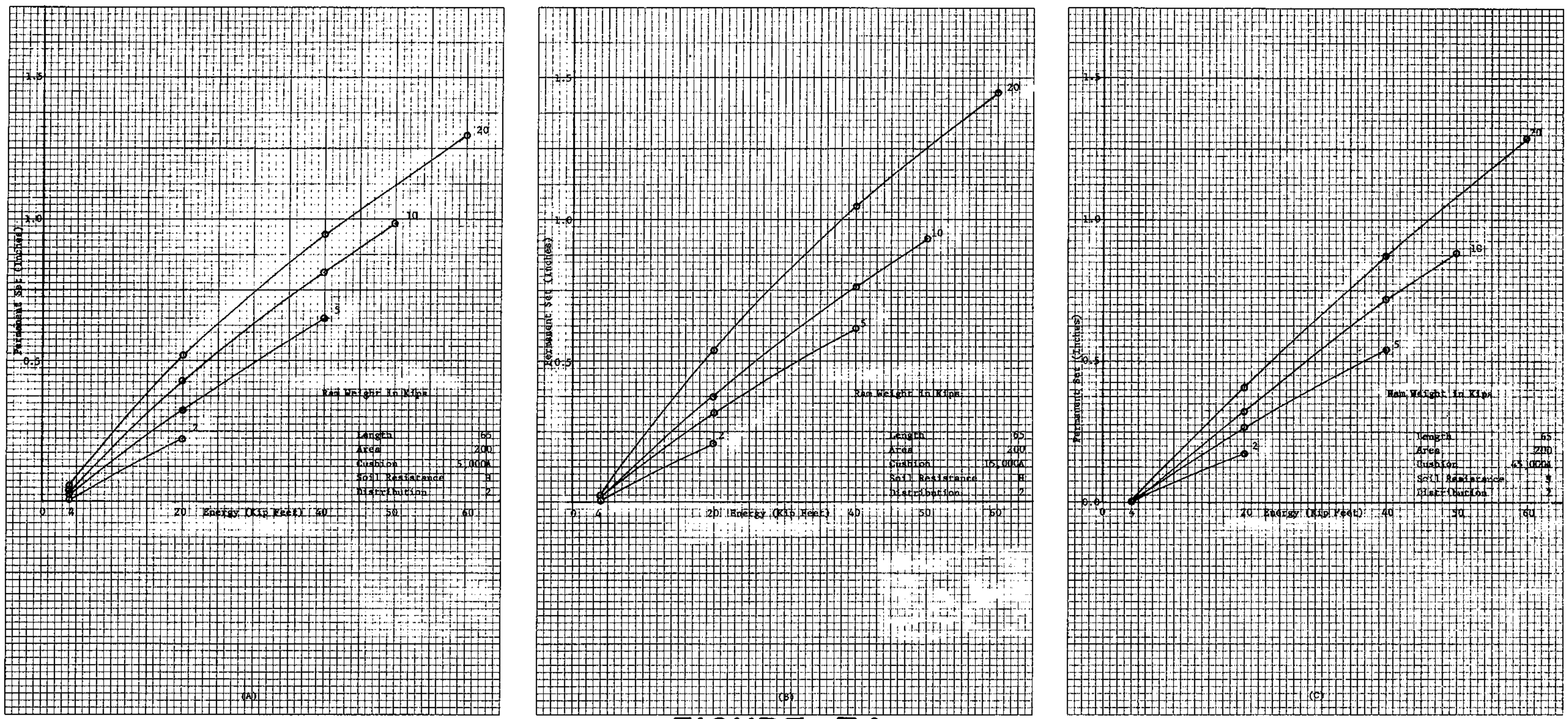

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 74

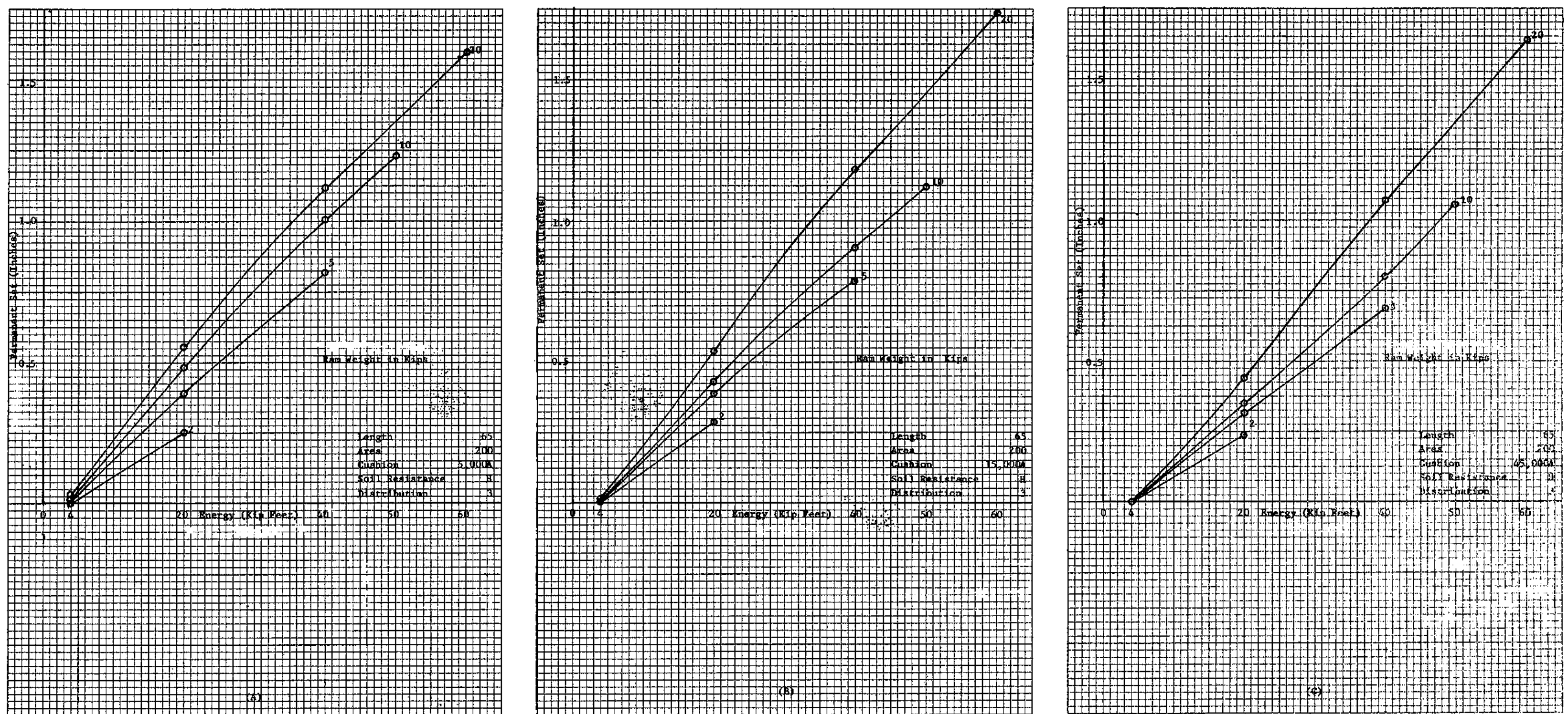

(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 15,000A
Soil Resistance H
Distribution 3
(C)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 45,000A
Soil Resistance H
Distribution 3

FIGURE 75

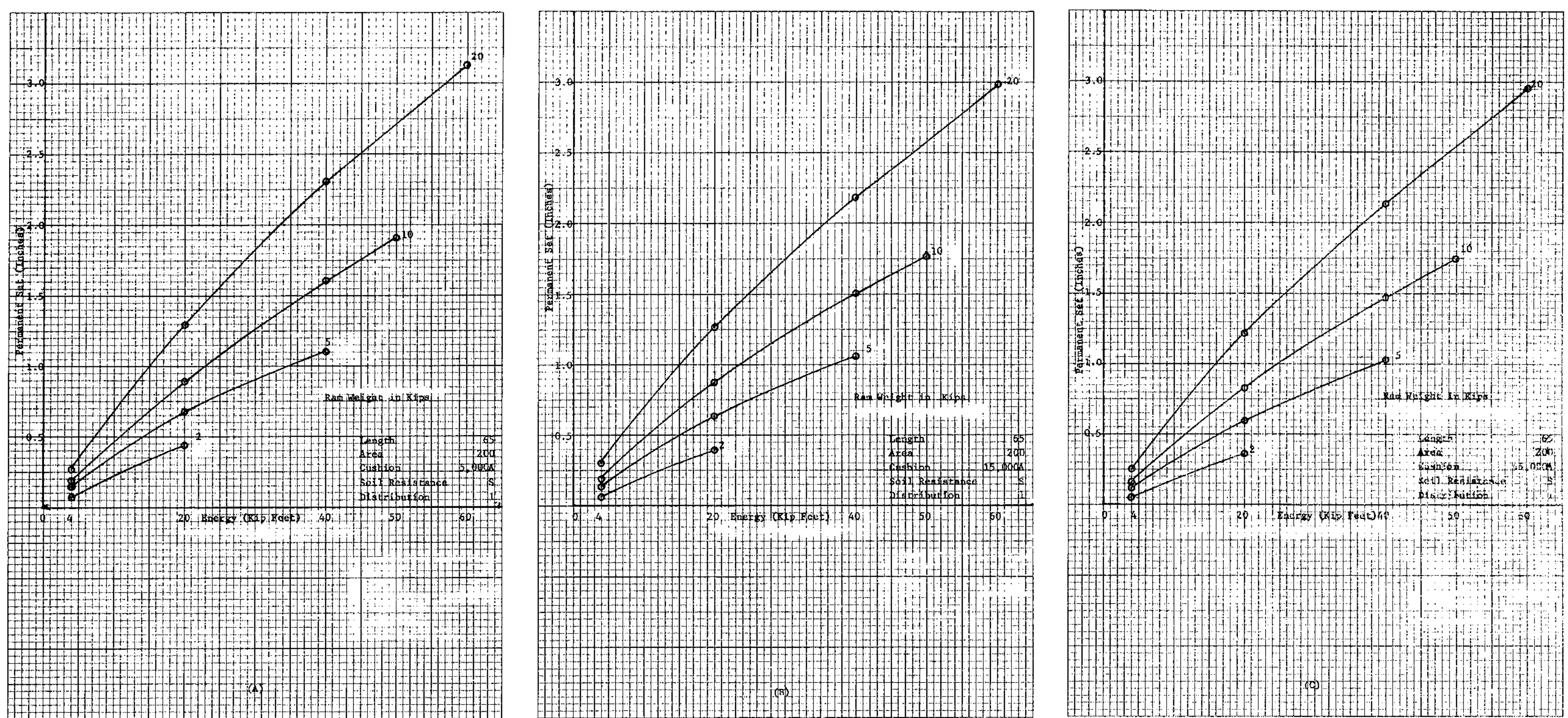

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Length 65
Area 200
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
(C)

FIGURE 76

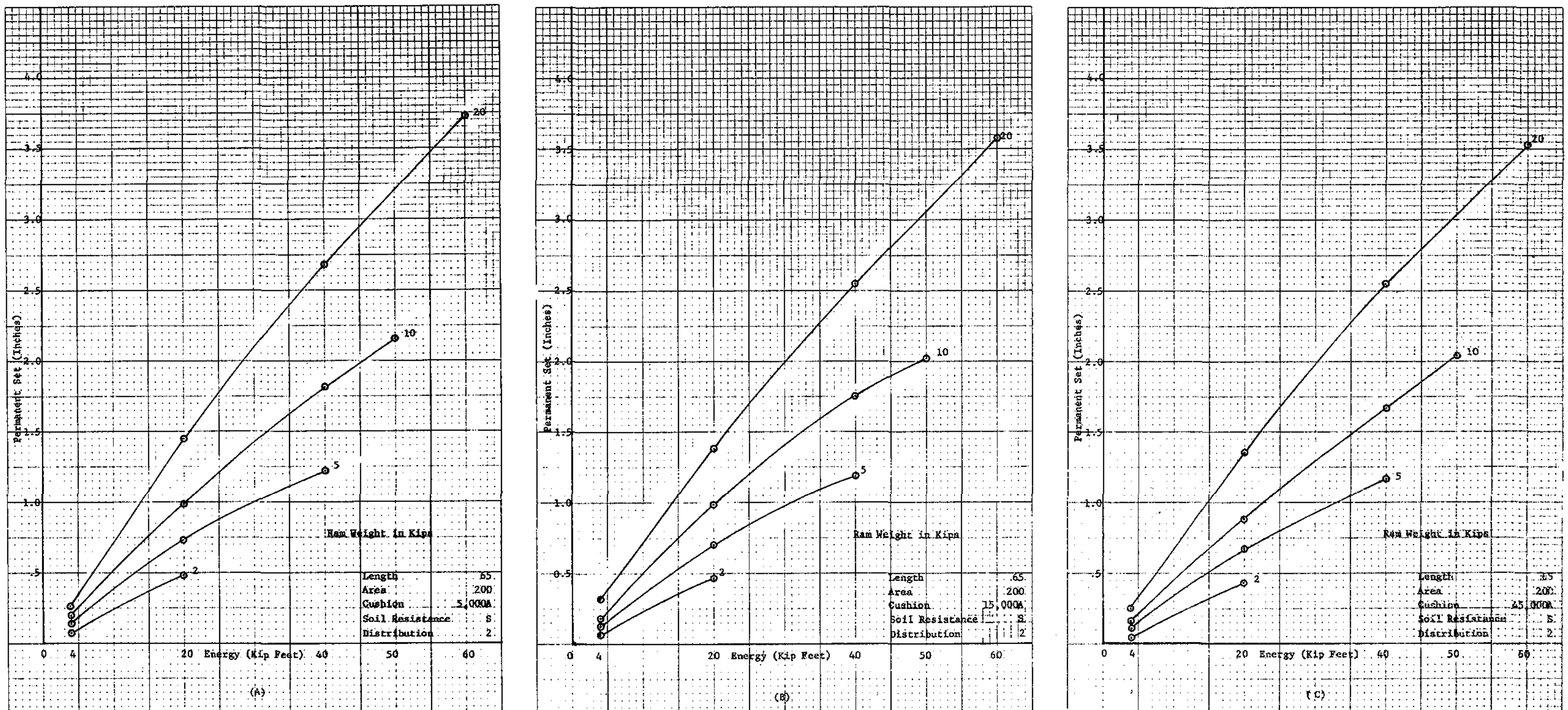

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 15,000A
Soil Resistance S
Distribution 2
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance S
Distribution 2
(C)

FIGURE 77

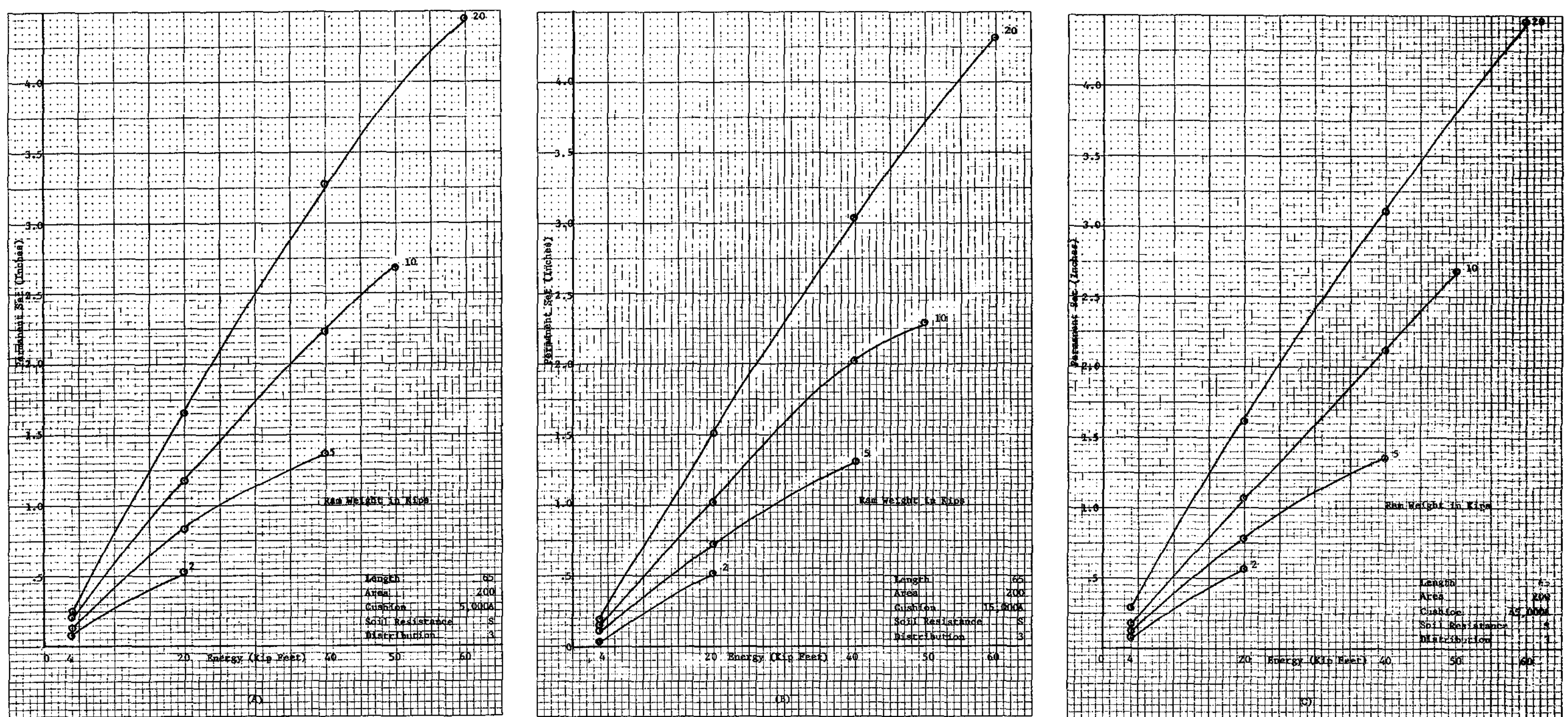

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Length 65
Area 200
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Length 65
Area 200
Cushion 15,000A
Soil Resistance 4
Distribution 1
(C)

FIGURE 78

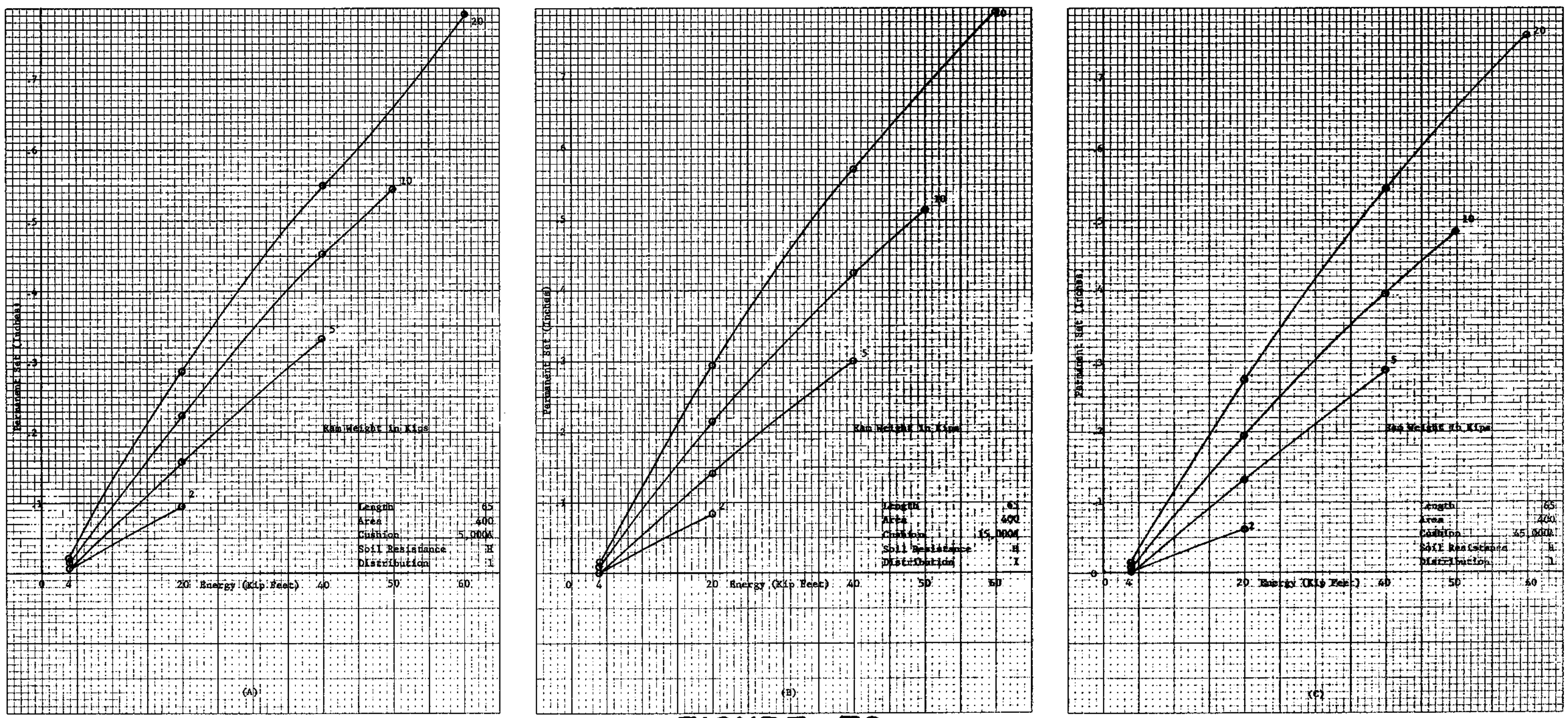
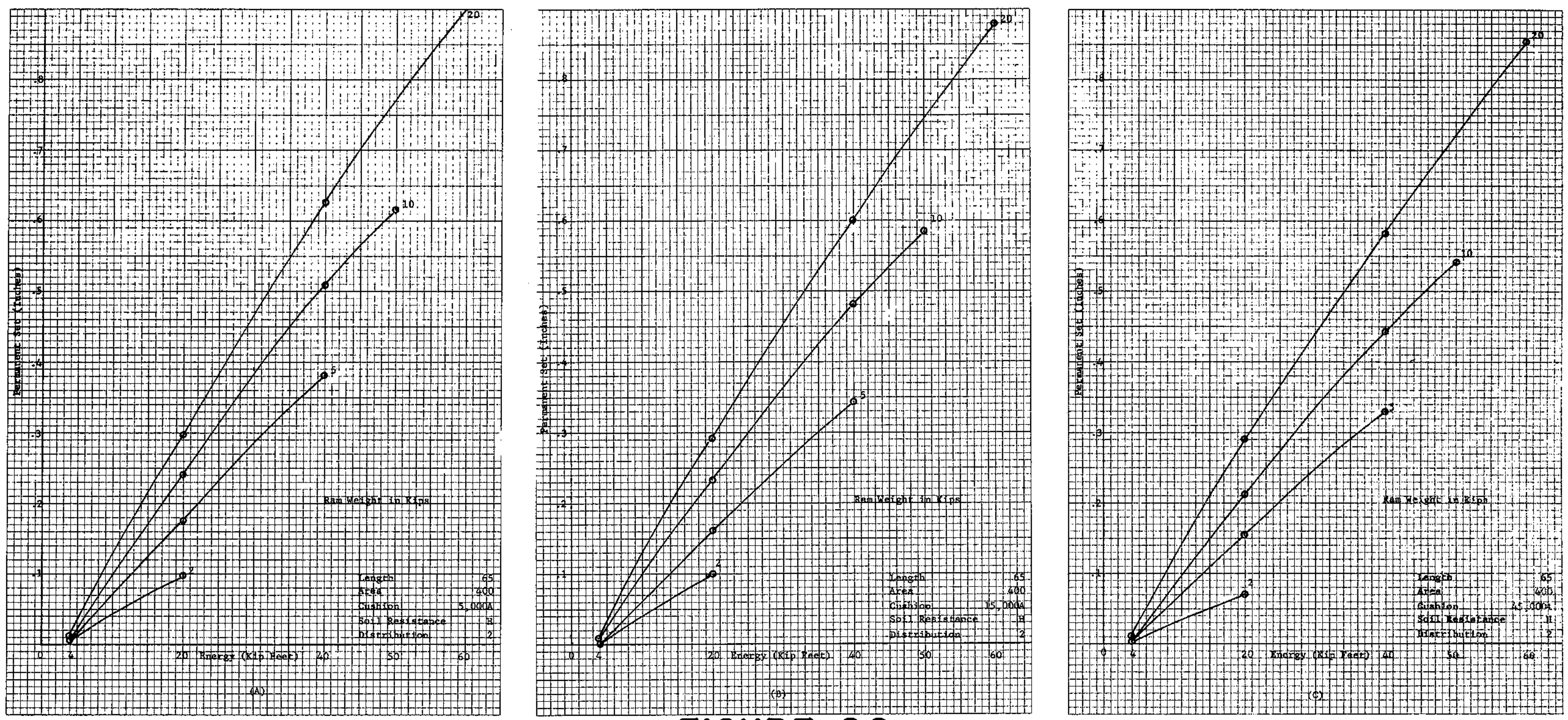

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000K
Soil Resistance H
Distribution 1
(A)
(B)
(C)

FIGURE 79



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion
Soil Resistance H
Distribution 2
(C)

FIGURE 80

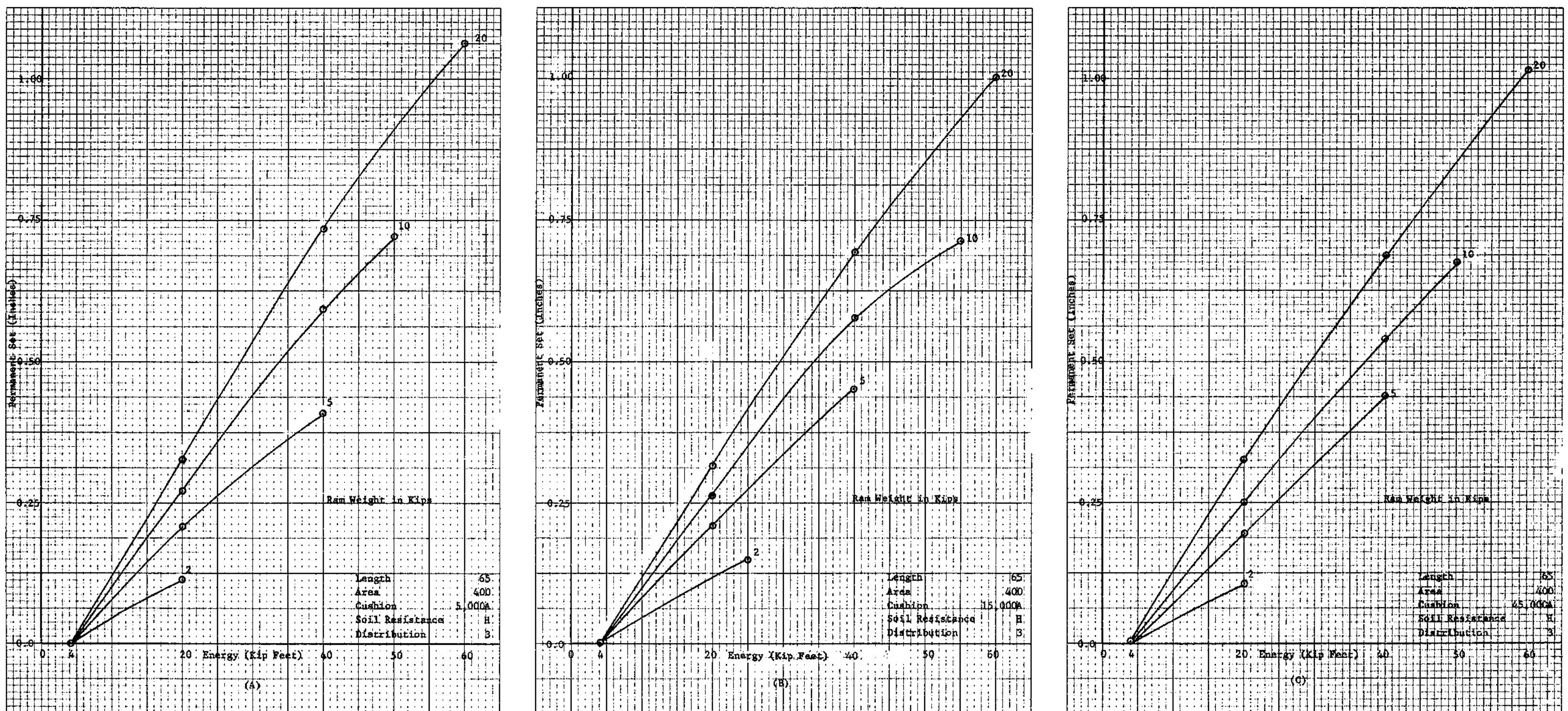
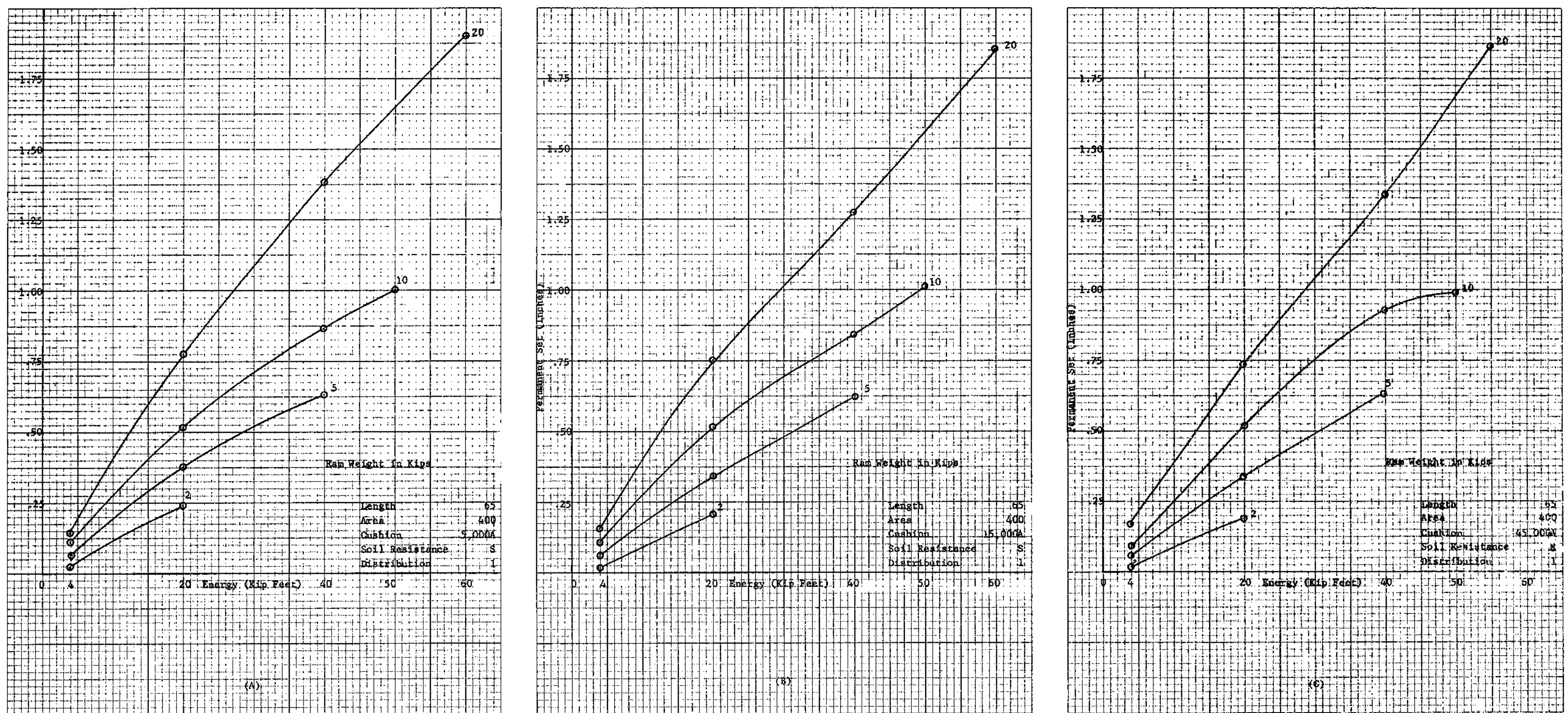
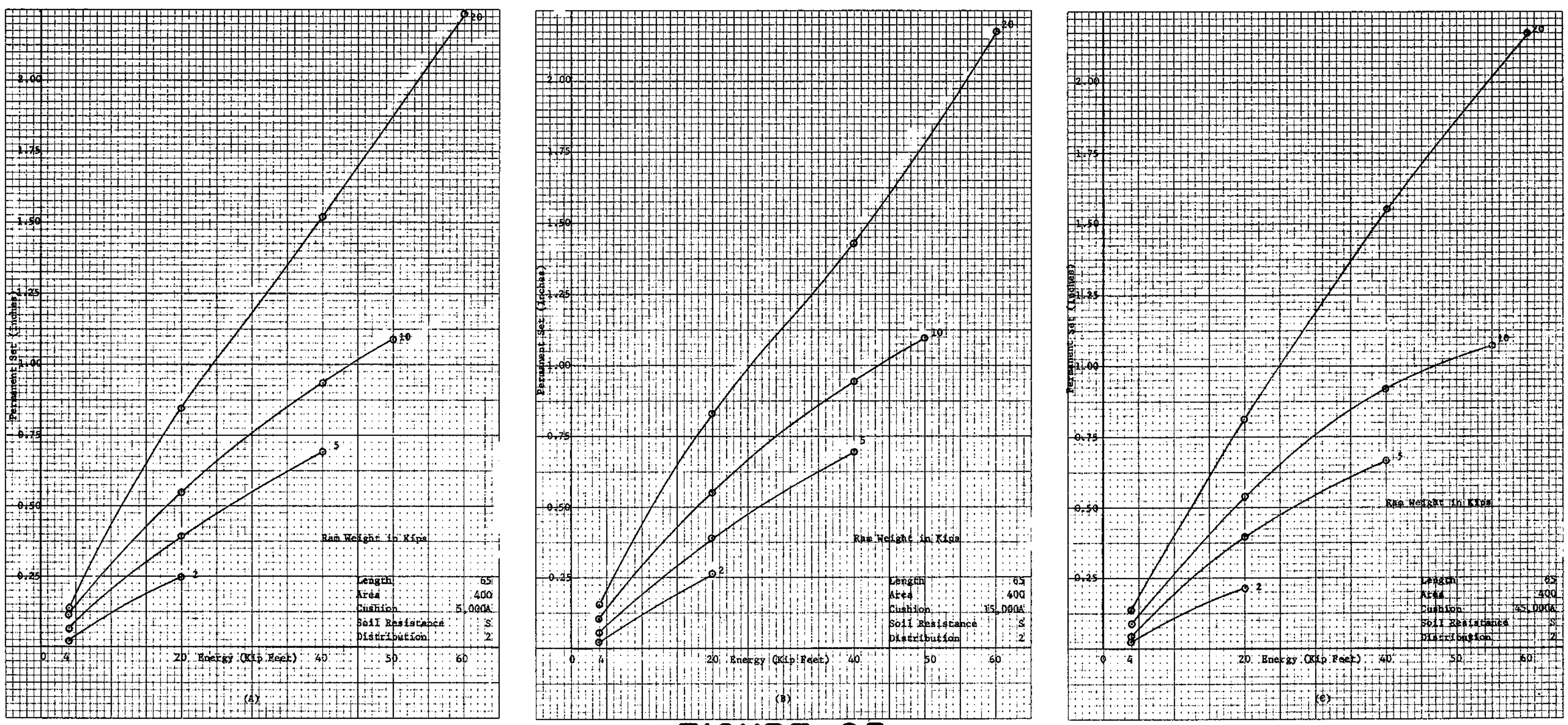

Permanent Set (Inches)
1.00
0.75
0.50
0.25
0.0
0
4
20
40
50
60
Energy (Kip Feet)
Ram Weight in Kips
20
10
5
2
Length 65
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)
Cushion 45,000A
(C)

FIGURE 81



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Length 65
Area 400
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
Length 65
Area 400
Cushion 45,000A
Soil Resistance M
Distribution 1
(C)

FIGURE 82



(A)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 2
(B)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 15,000A
Soil Resistance S
Distribution 2
(C)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 45,000A
Soil Resistance S
Distribution 2

FIGURE 83

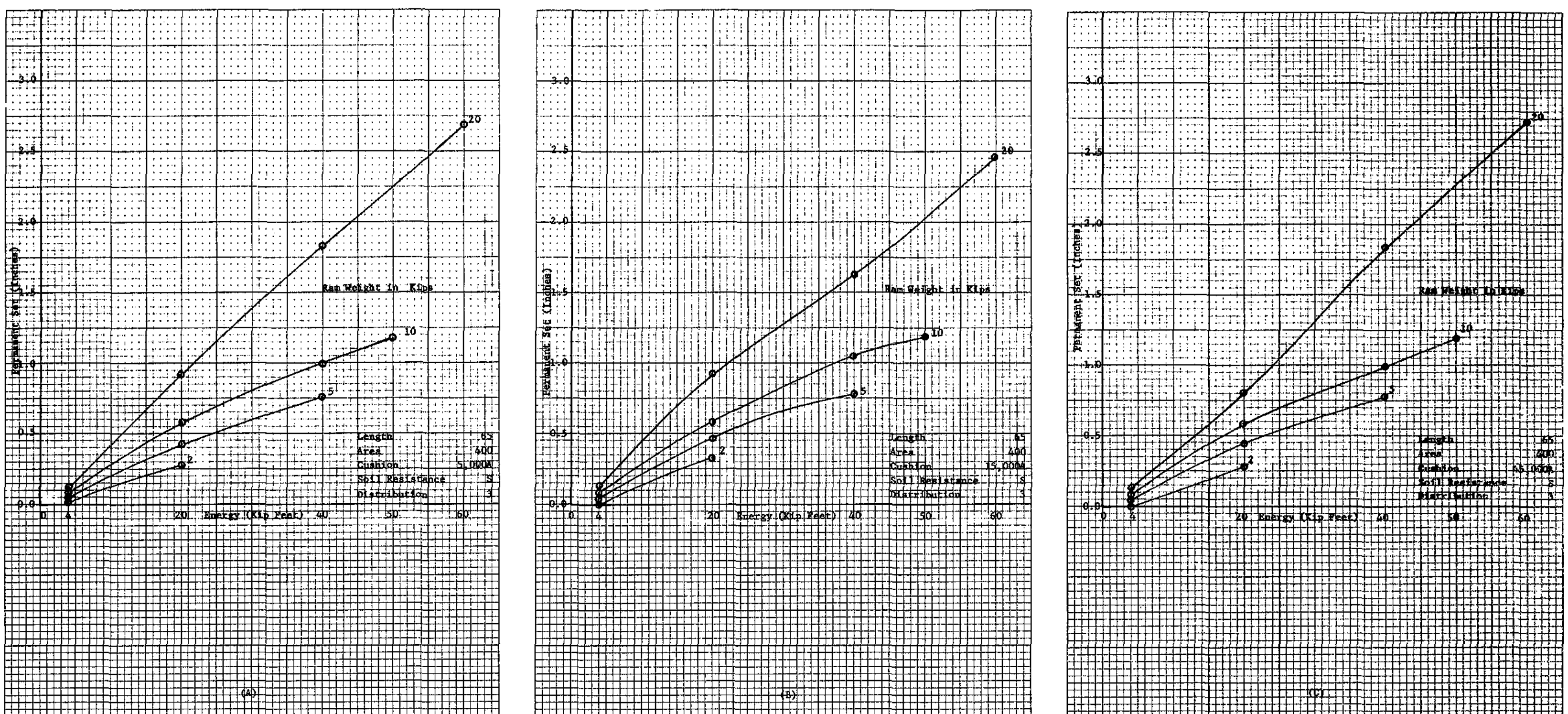

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 400
Cushion
Soil Resistance S
Distribution
(C)

FIGURE 84

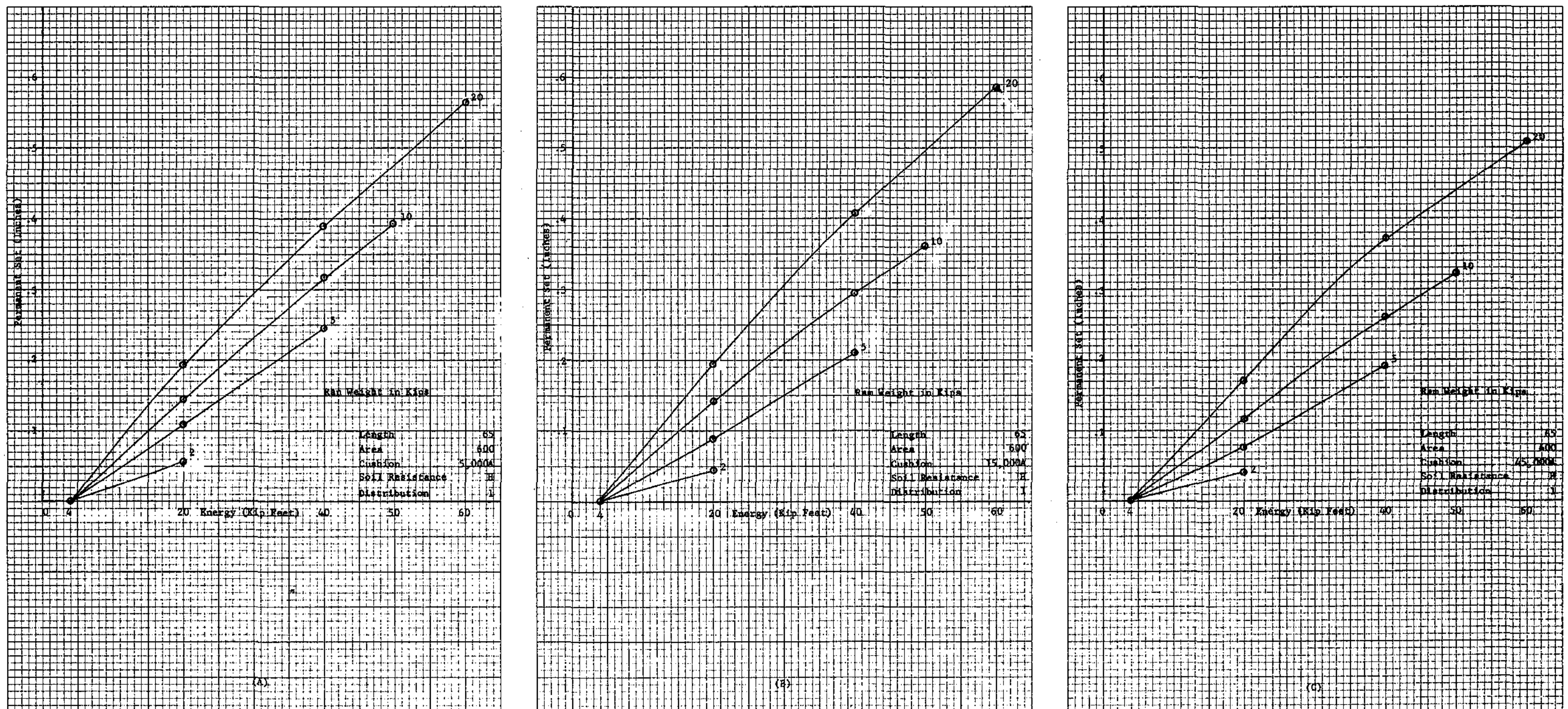
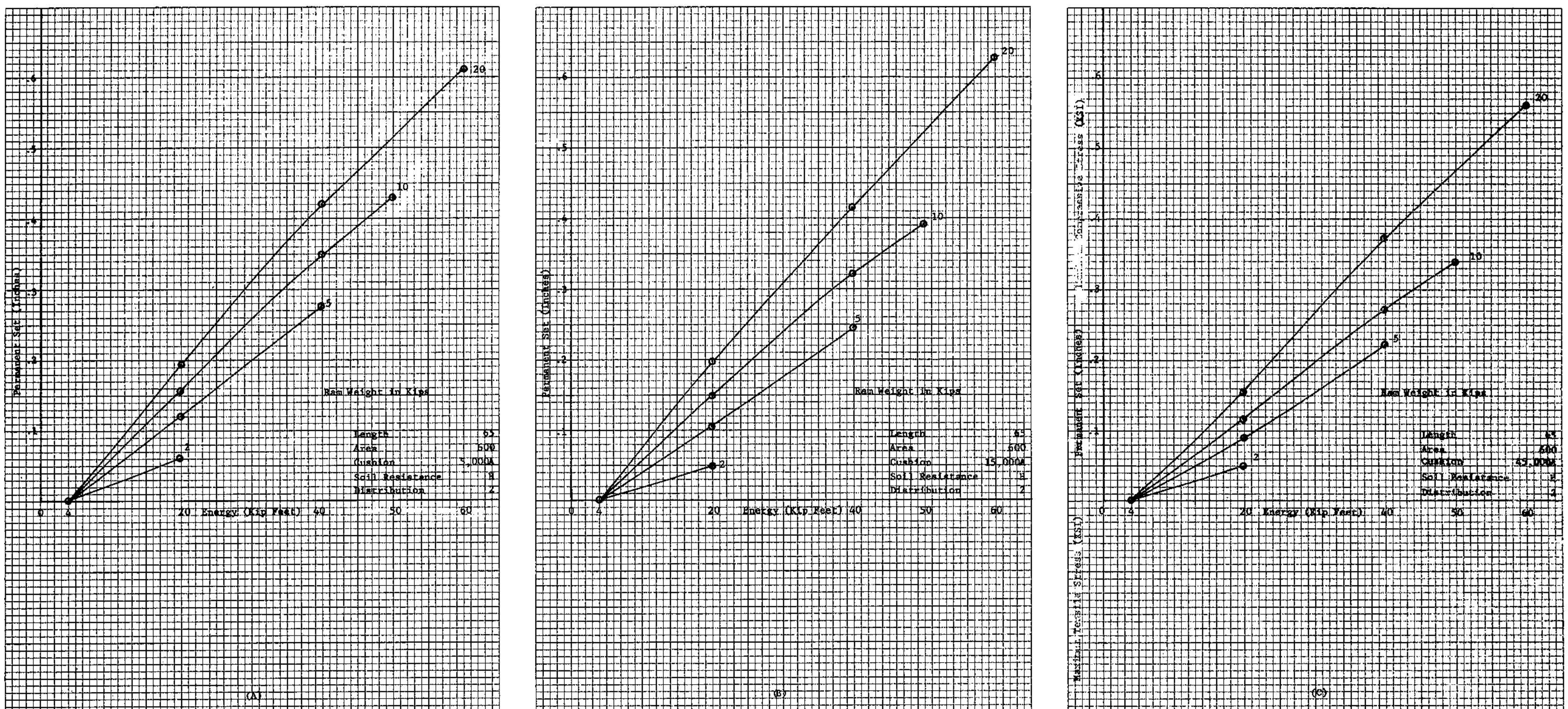

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000K
Soil Resistance H
Distribution 1
(A)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000K
Soil Resistance H
Distribution 1
(B)
Ram Weight in Kips
Length 65
Area 600
Cushion 45,000K
Soil Resistance H
Distribution 1
(C)

FIGURE 85



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance
Distribution 2
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000A
Soil Resistance
Distribution 2
(B)
Permanent Set (Inches)
Maximum Compressive Stress (KSI)
Maximum Tensile Stress (KSI)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(C)

FIGURE 86

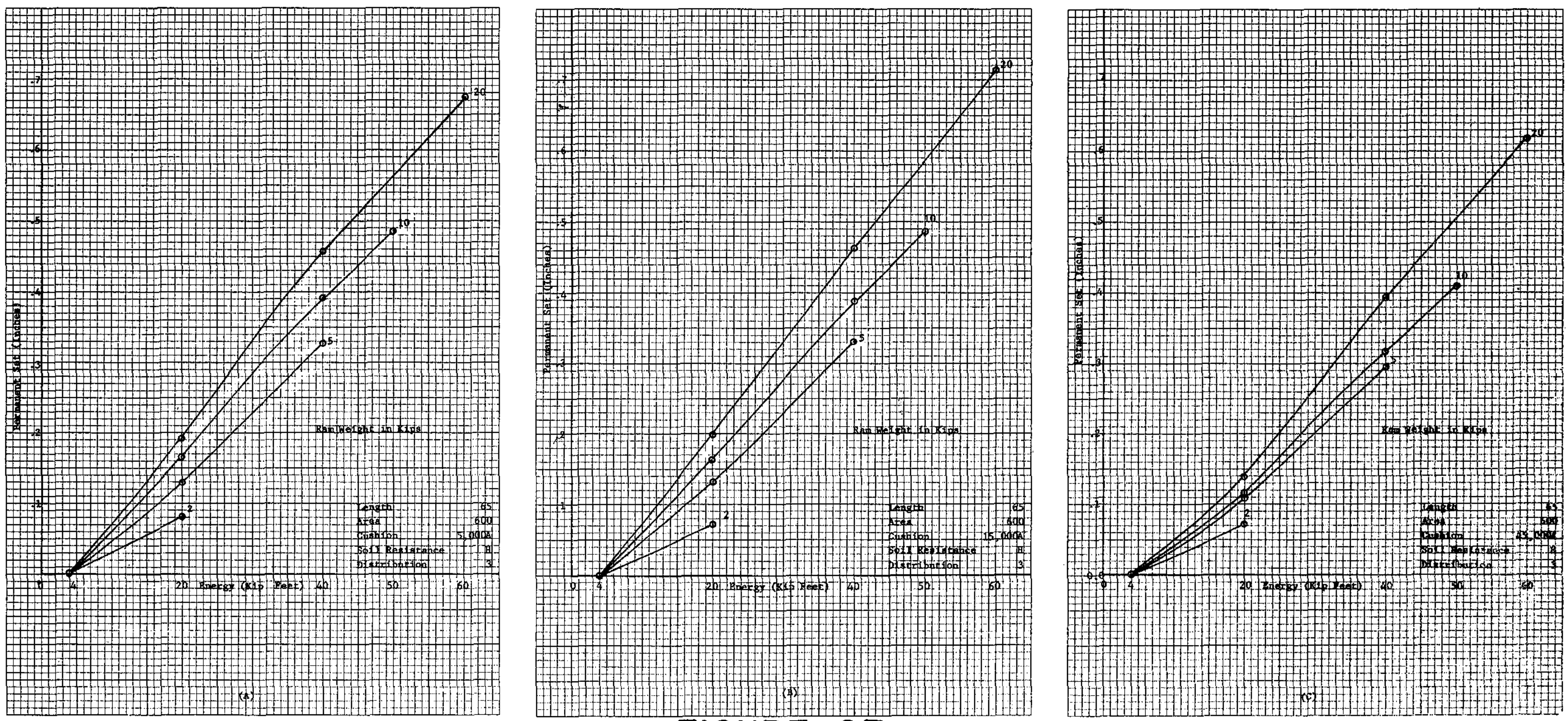

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance B
Distribution 3
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000A
Soil Resistance B
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
(C)

FIGURE 87

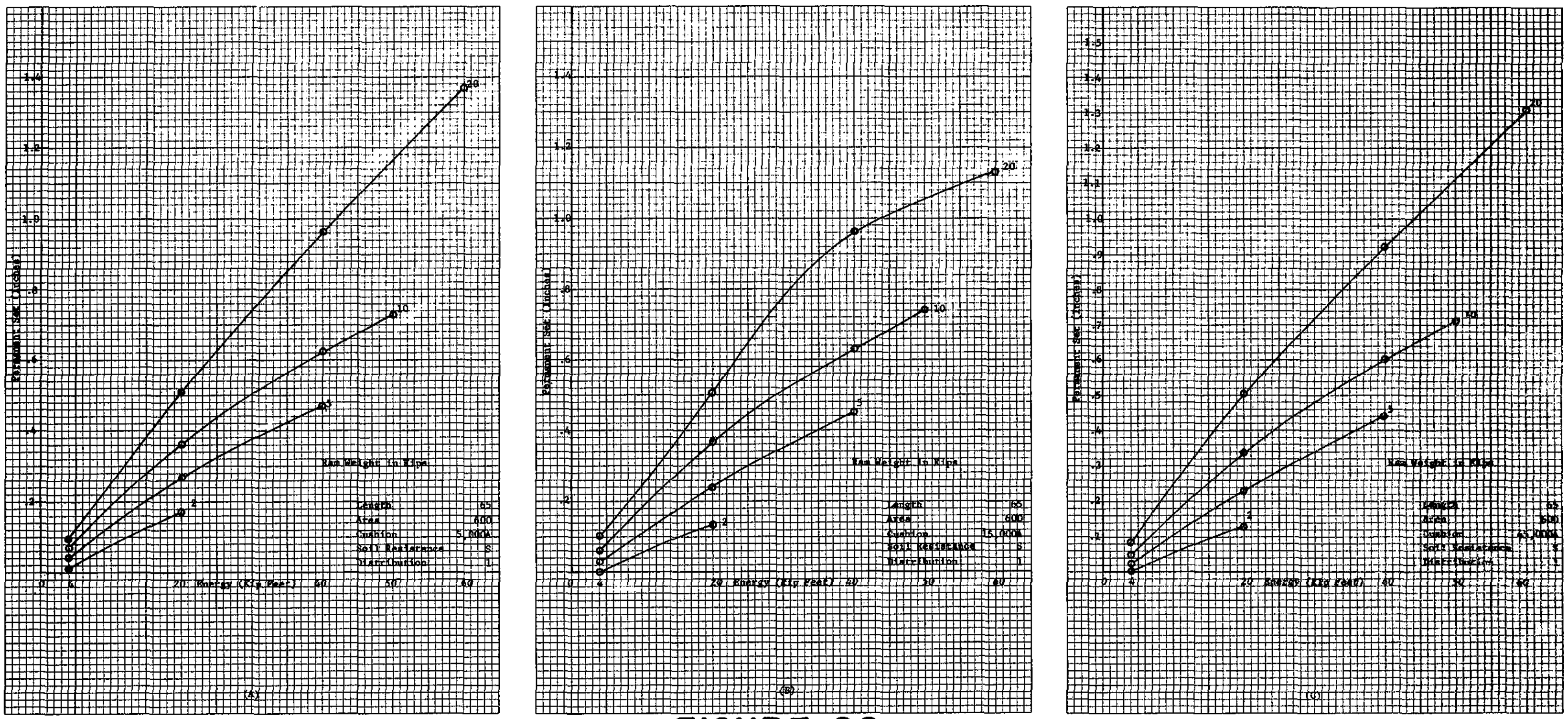

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 1
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Soil Resistance S
Distribution 1
(C)

FIGURE 88

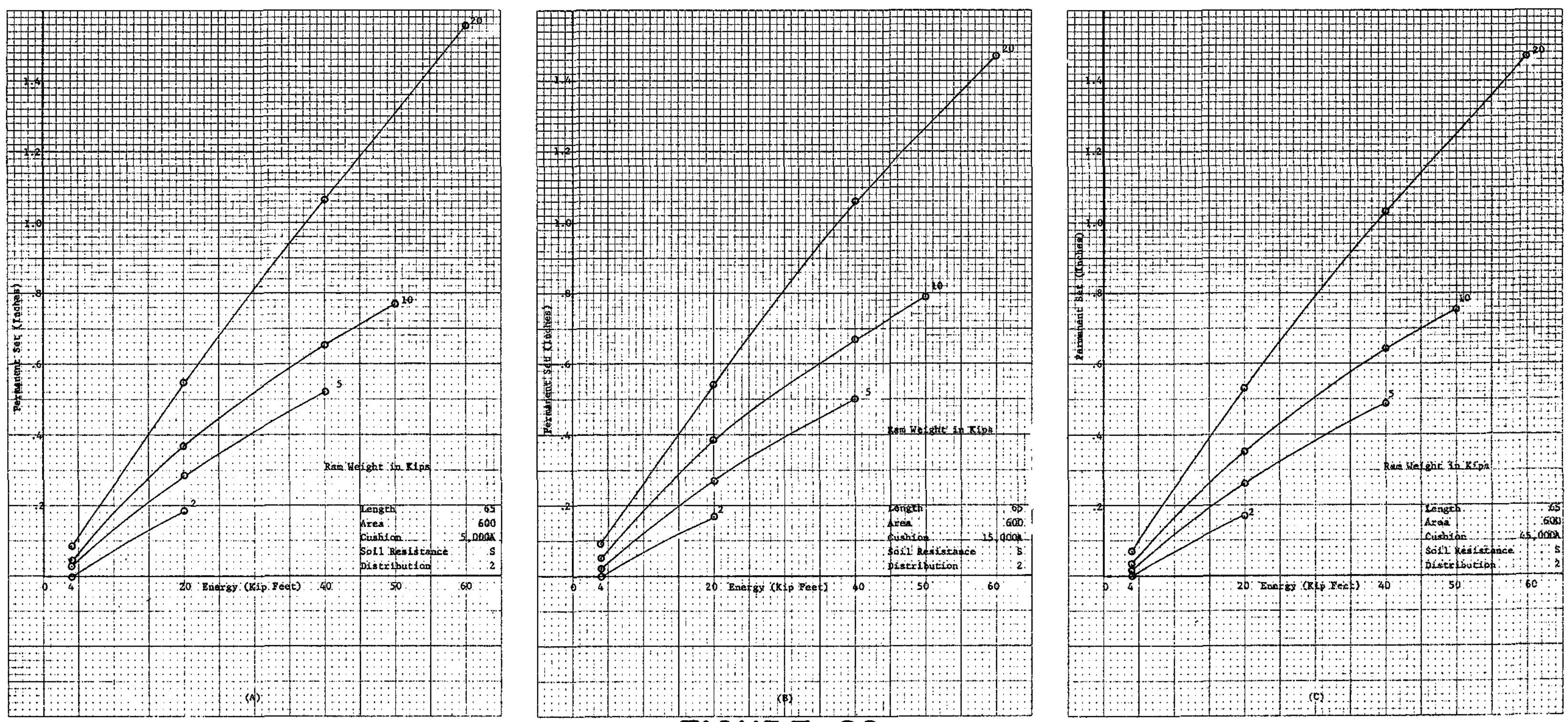
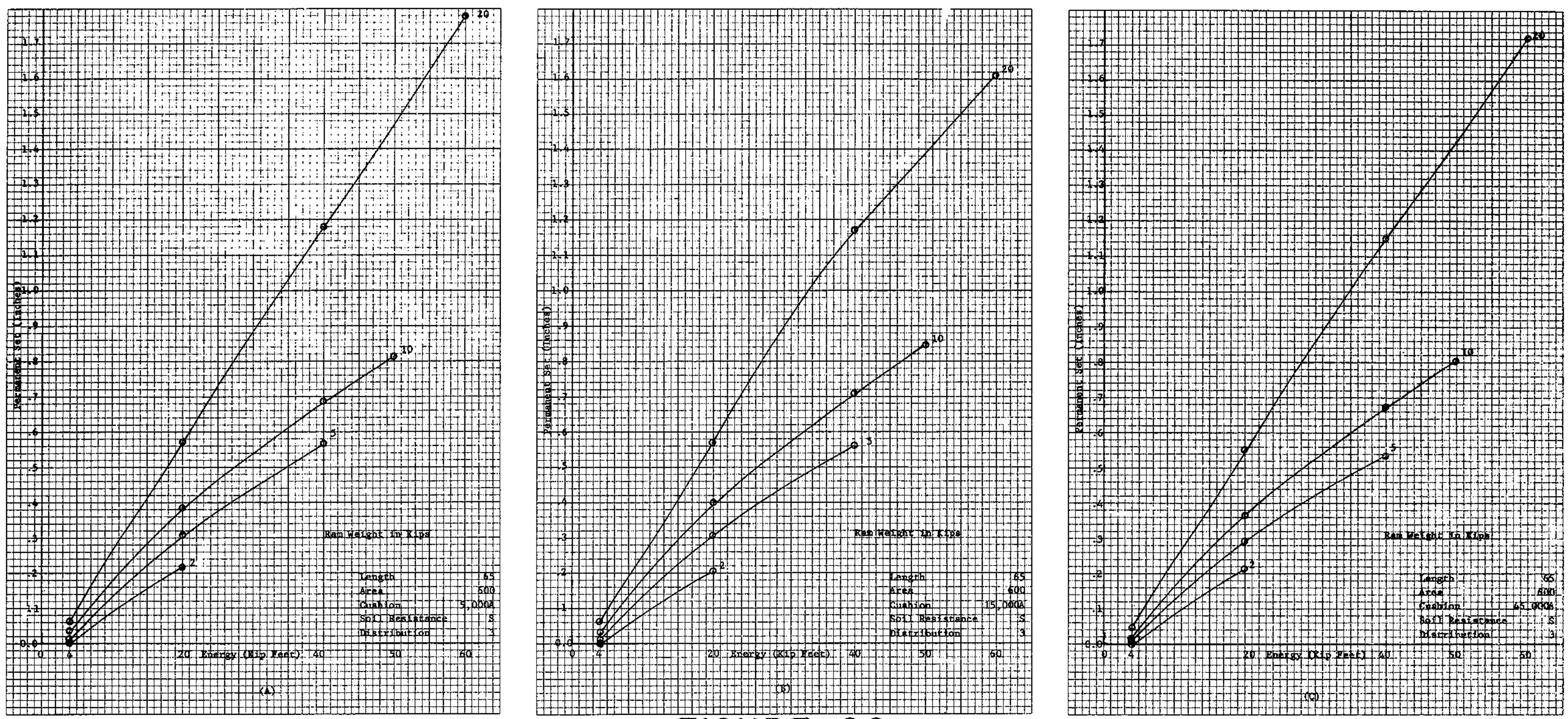

(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 2
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 2
(C)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 600
Cushion 45,000A
Soil Resistance S
Distribution 2

FIGURE 89



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 65
Area 500
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Length 65
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Length 65
Area 600
Cushion 45,000A
Soil Resistance S
Distribution 3
(C)

FIGURE 90

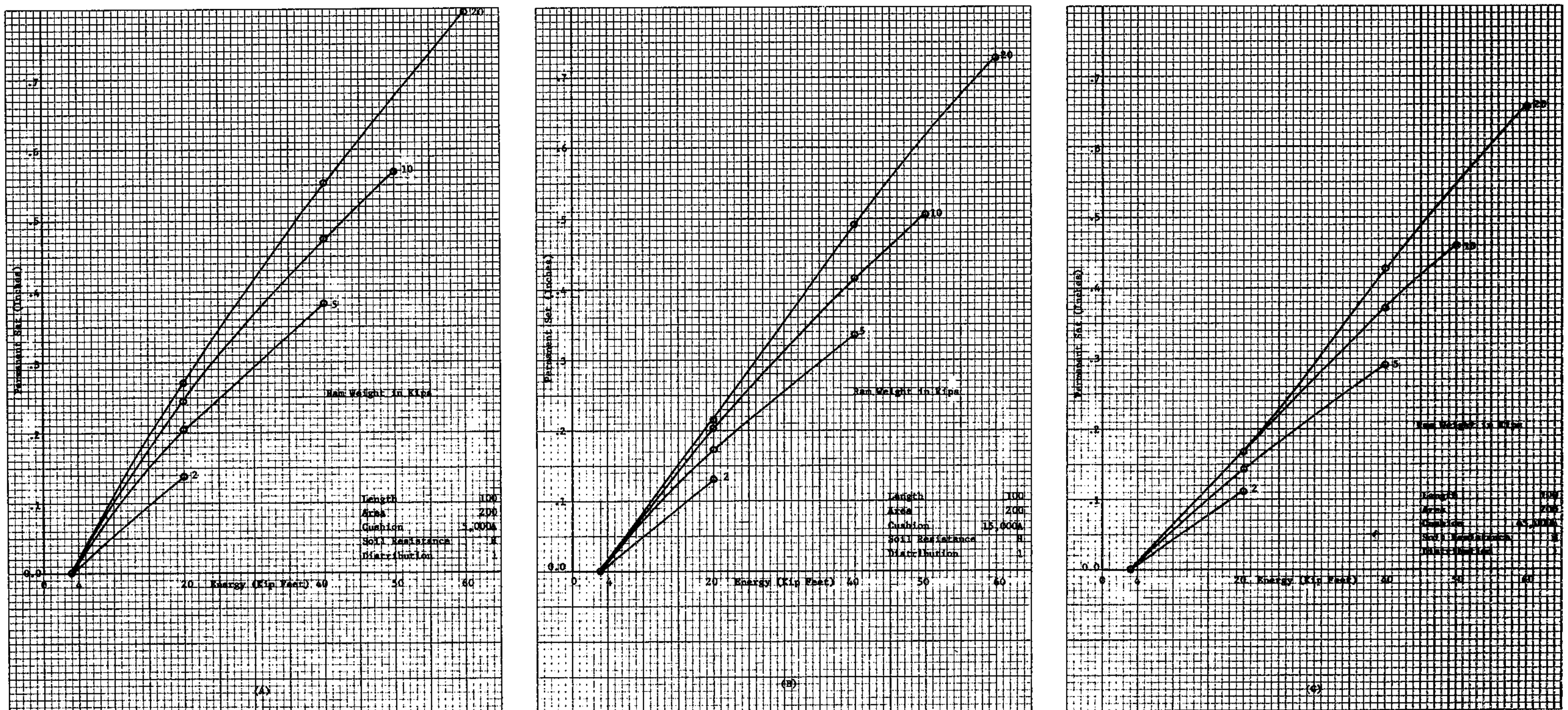


FIGURE 91

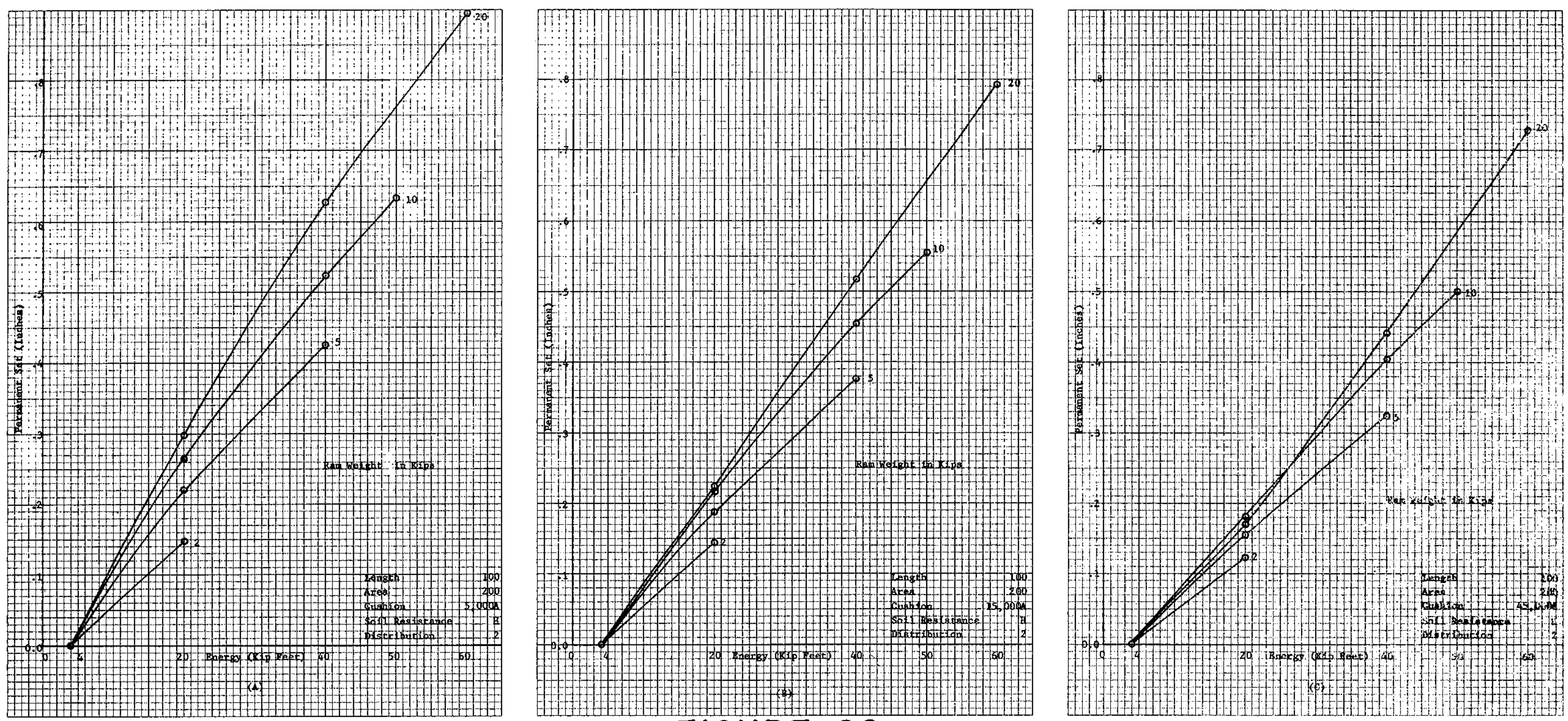

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Length 100
Area 200
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
Length 100
Soil Resistance L
Distribution 2
(C)

FIGURE 92

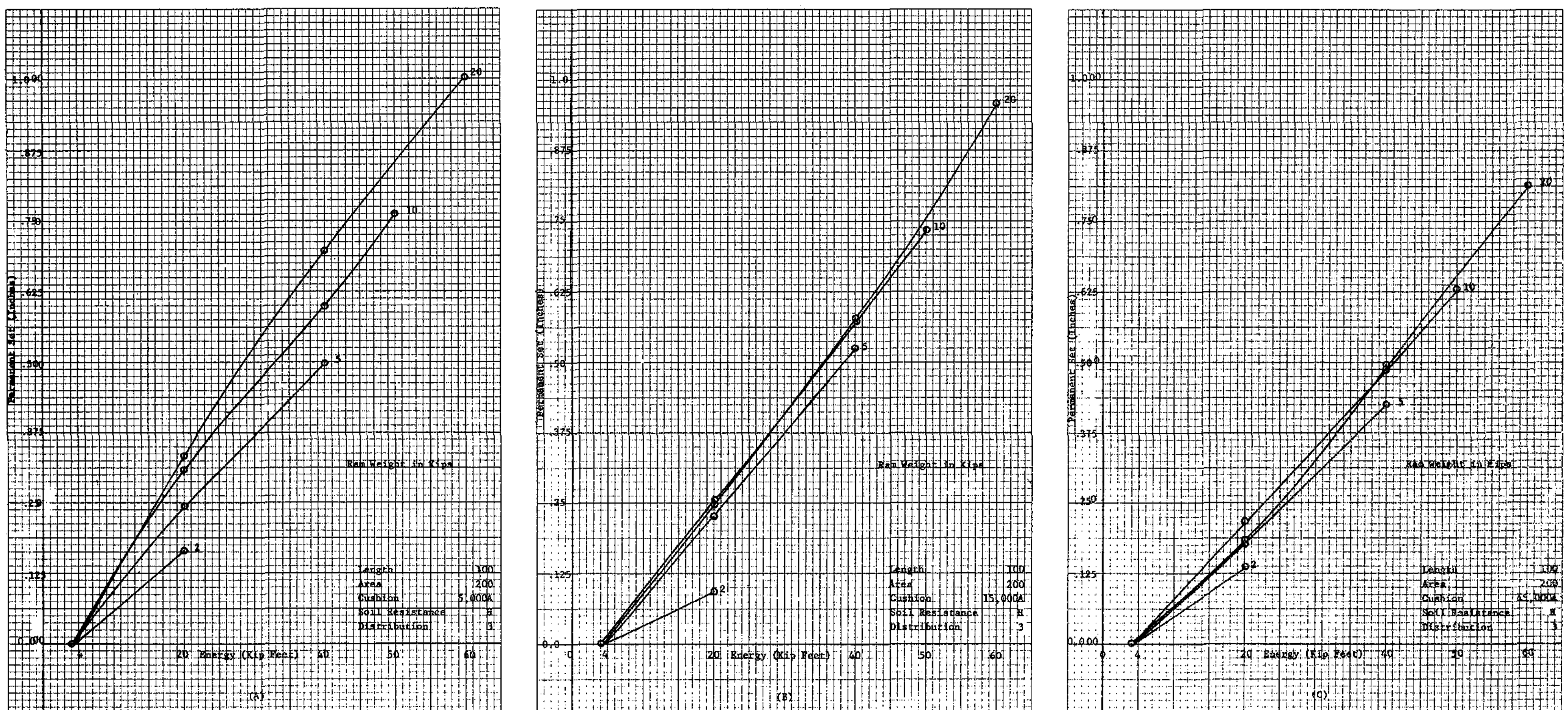
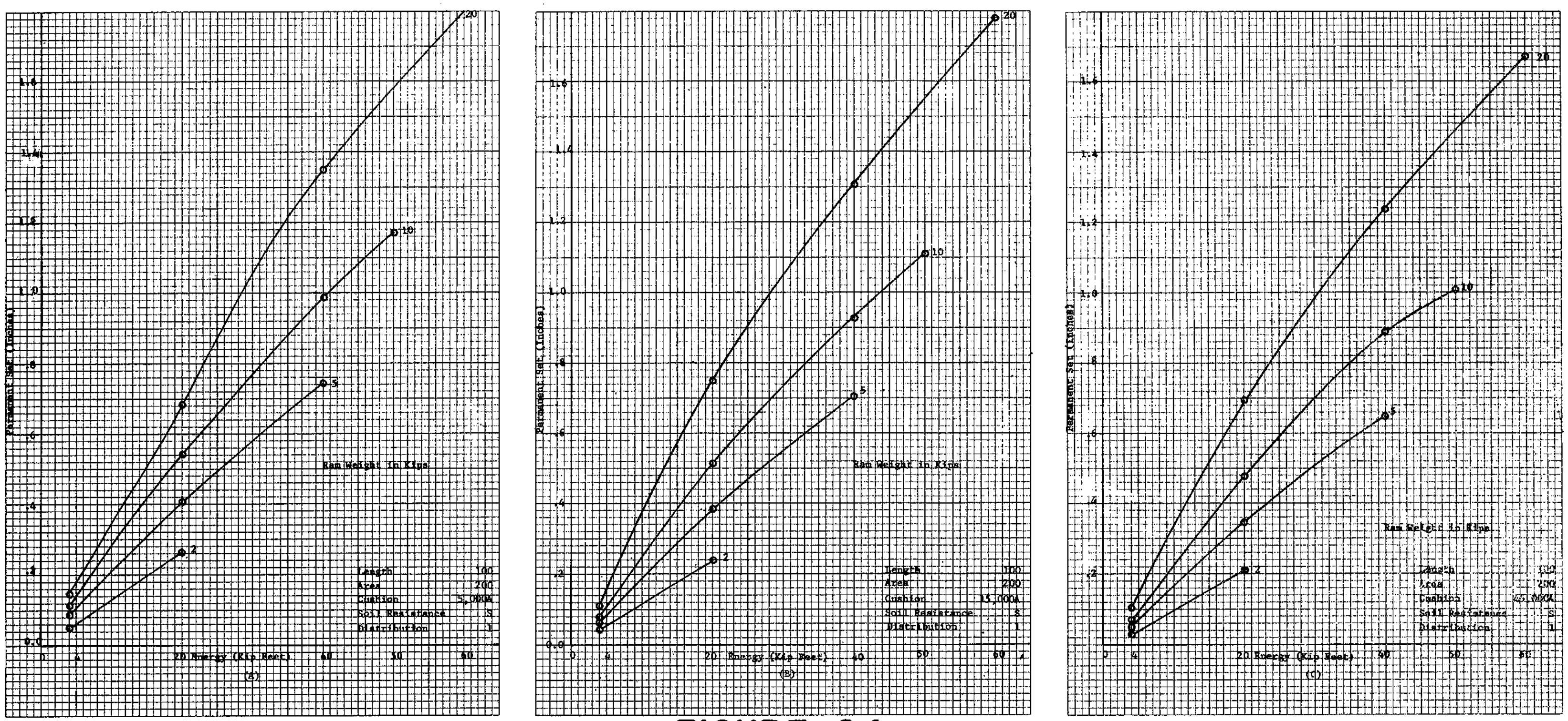

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Cushion 15,000A
(B)
(C)

FIGURE 93



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Soil Resistance 8
Distribution 1
(A)
(B)
(C)

FIGURE 94

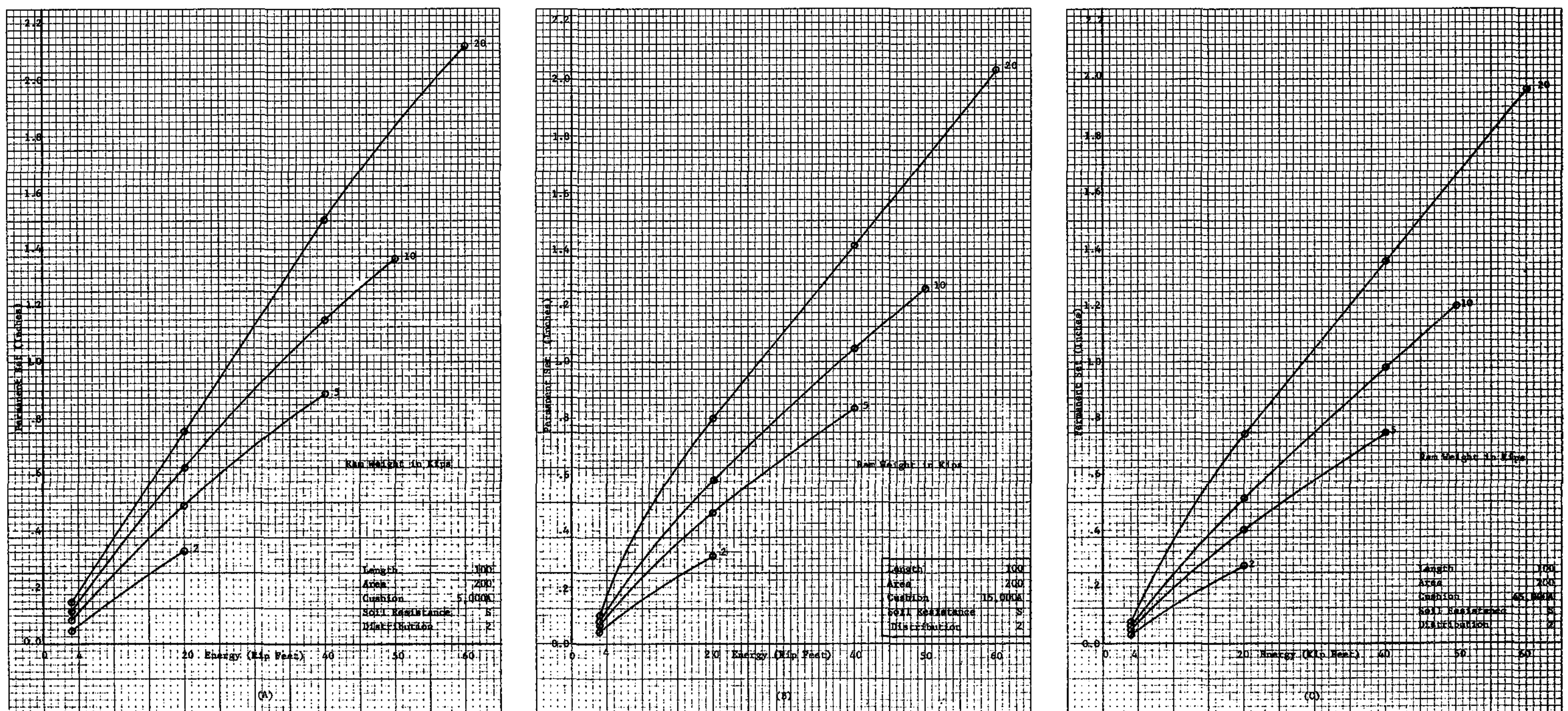
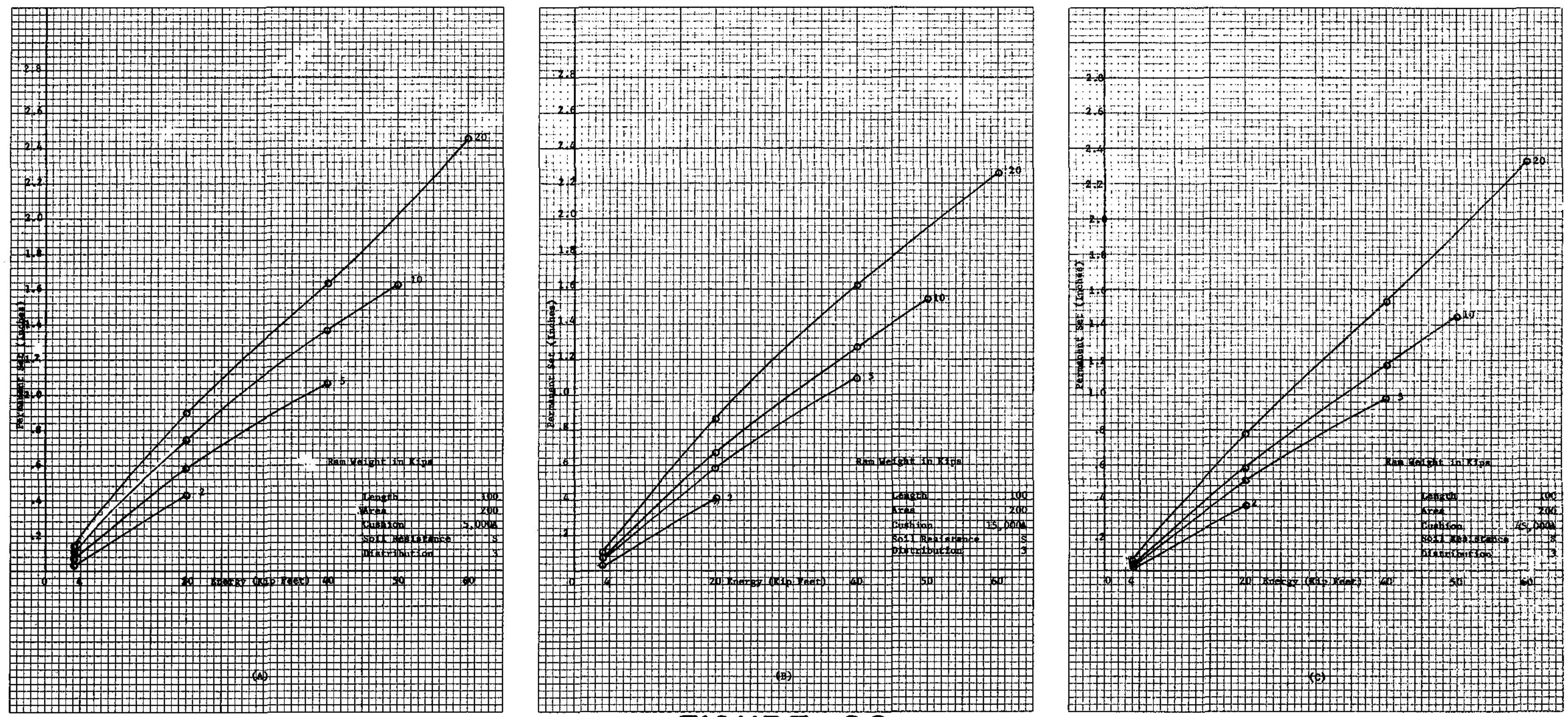

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
(A)
Length 100
Area 200
Cushion 5,000A
Soil Resistance S
Distribution 2
(B)
Length 100
Area 200
Cushion 15,000A
Soil Resistance S
Distribution 2
(C)

FIGURE 95



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 200
Cushion 15,000
Soil Resistance S
Distribution 3
(A)
(B)
(C)

FIGURE 96

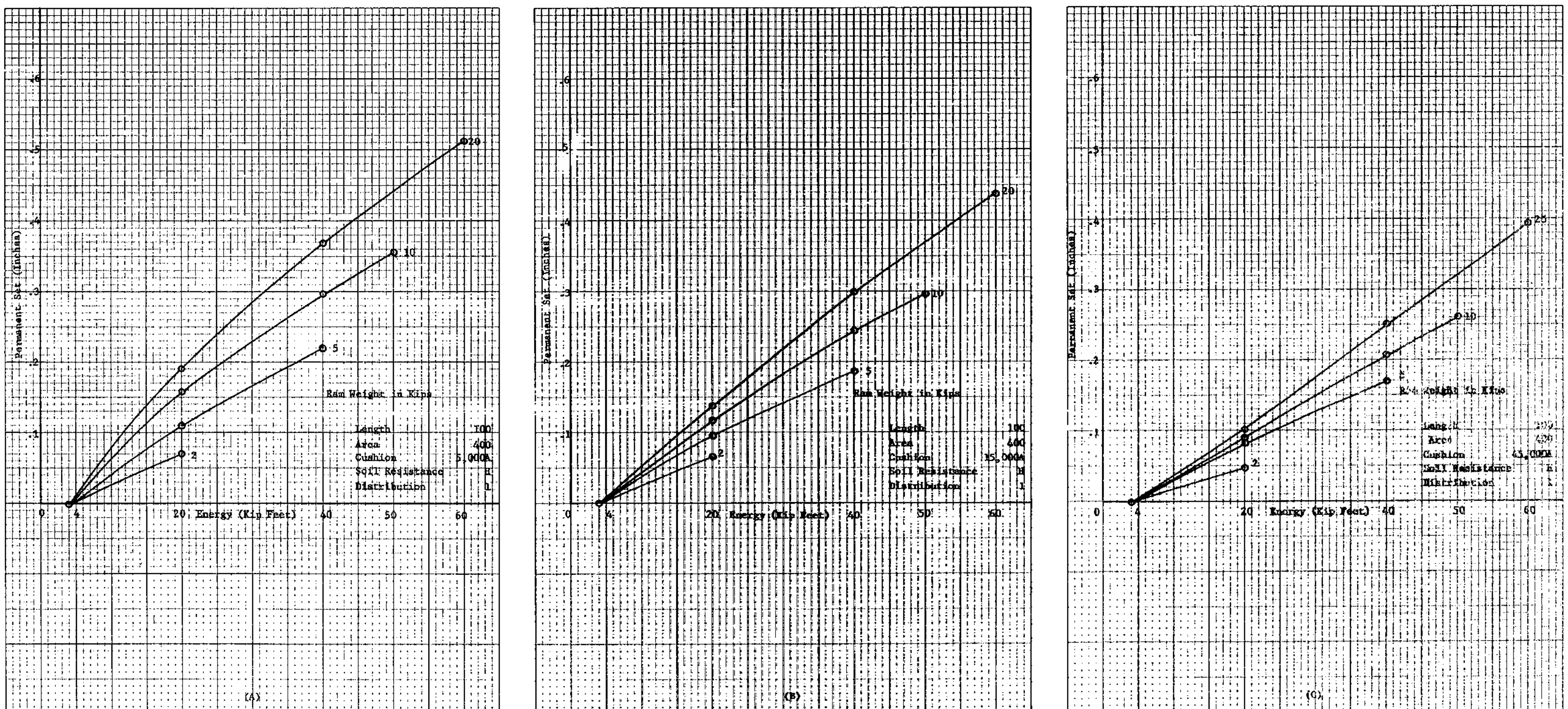

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 1
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 15,000A
Soil Resistance H
Distribution 1
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Soil Resistance
Distribution
(C)

FIGURE 97

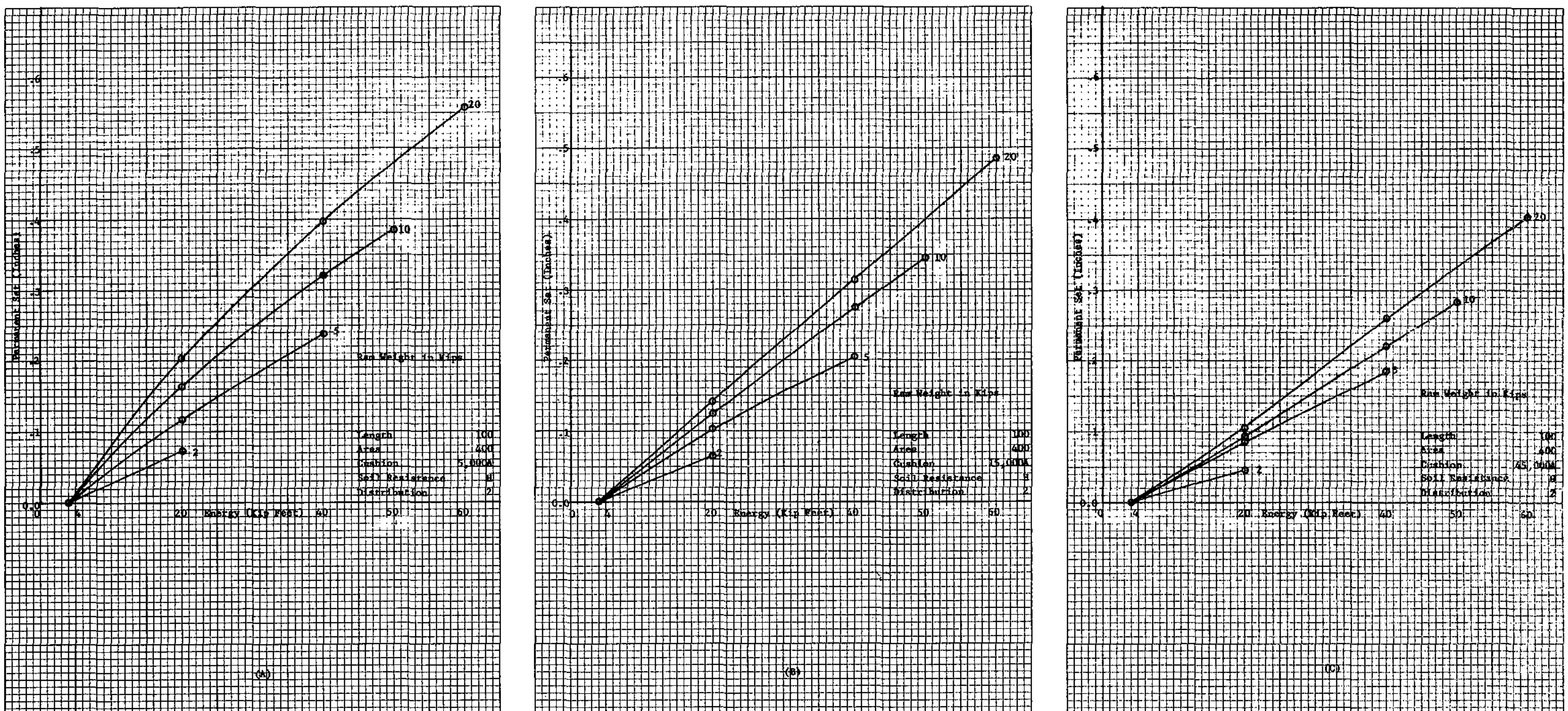

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 2
(A)
Length 100
Area 400
Cushion 15,000A
Soil Resistance H
Distribution 2
(B)
Length 100
Area 400
Cushion 45,000A
Soil Resistance H
Distribution 2
(C)

FIGURE 98

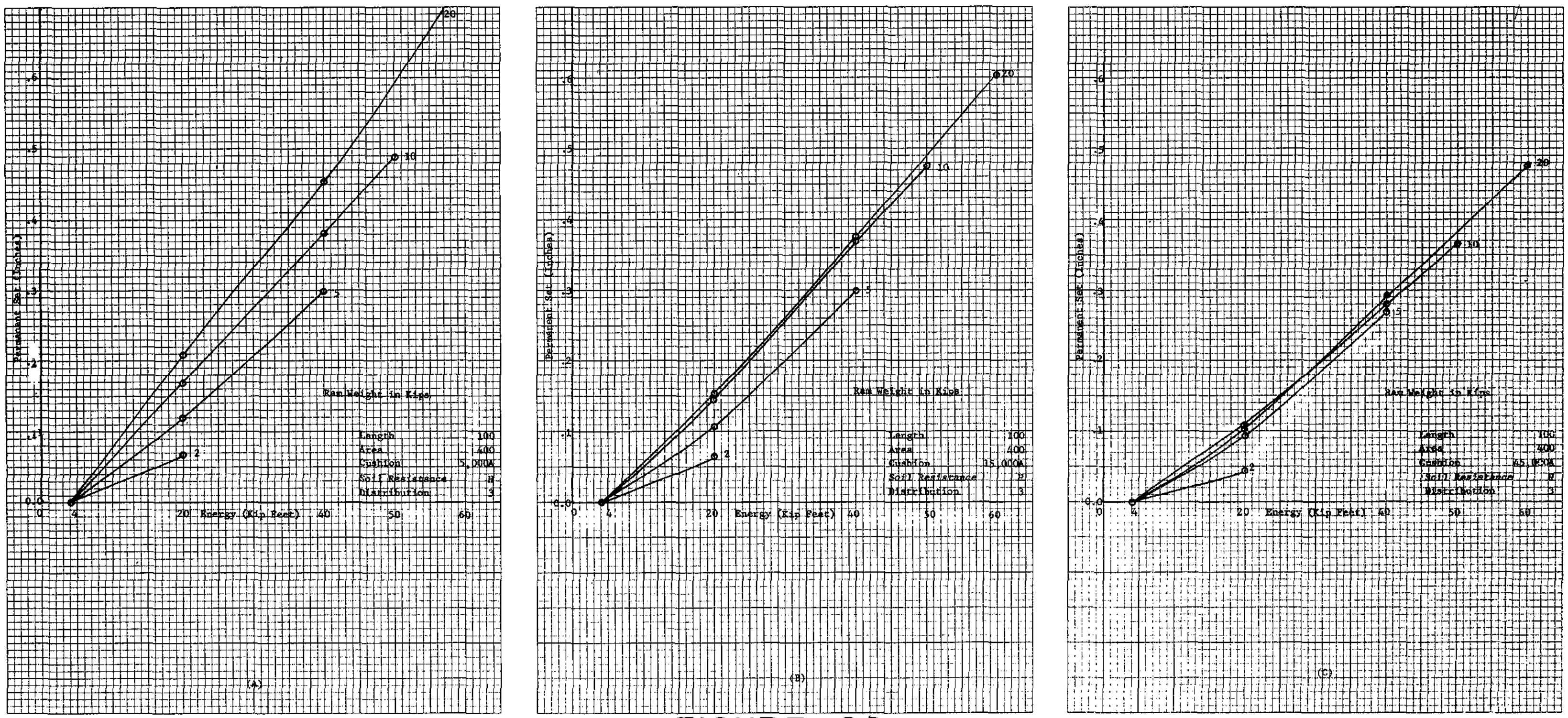

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Ram Weight in Kips
Length 100
Area 400
Cushion 15,000A
Soil Resistance H
Distribution 3
(B)
Ram Weight in Kips
Length 100
Area 400
Soil Resistance H
Distribution 3
(C)

FIGURE 99

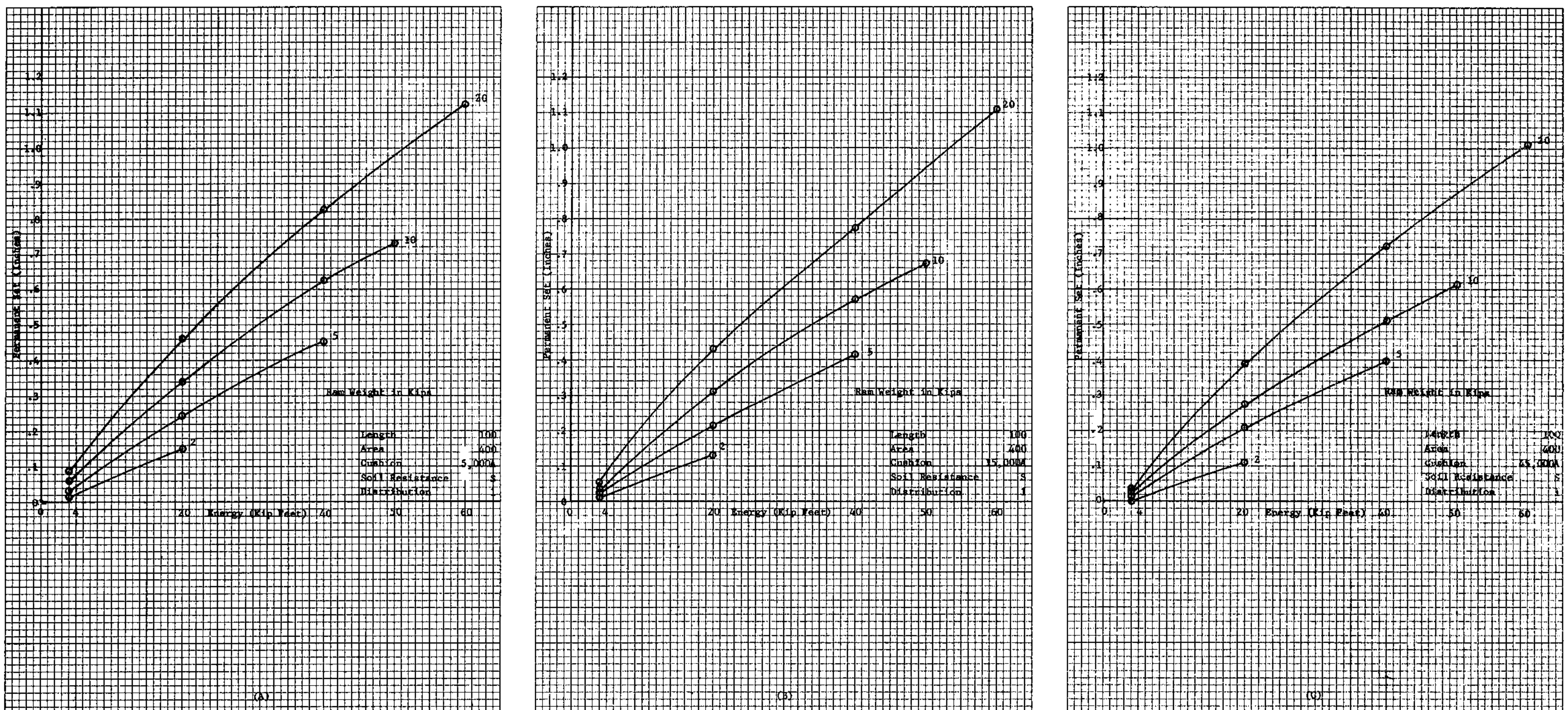

Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000
Soil Resistance 5
Distribution
(A)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 15,000
Soil Resistance 5
Distribution 1
(B)
Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
(C)

FIGURE 100

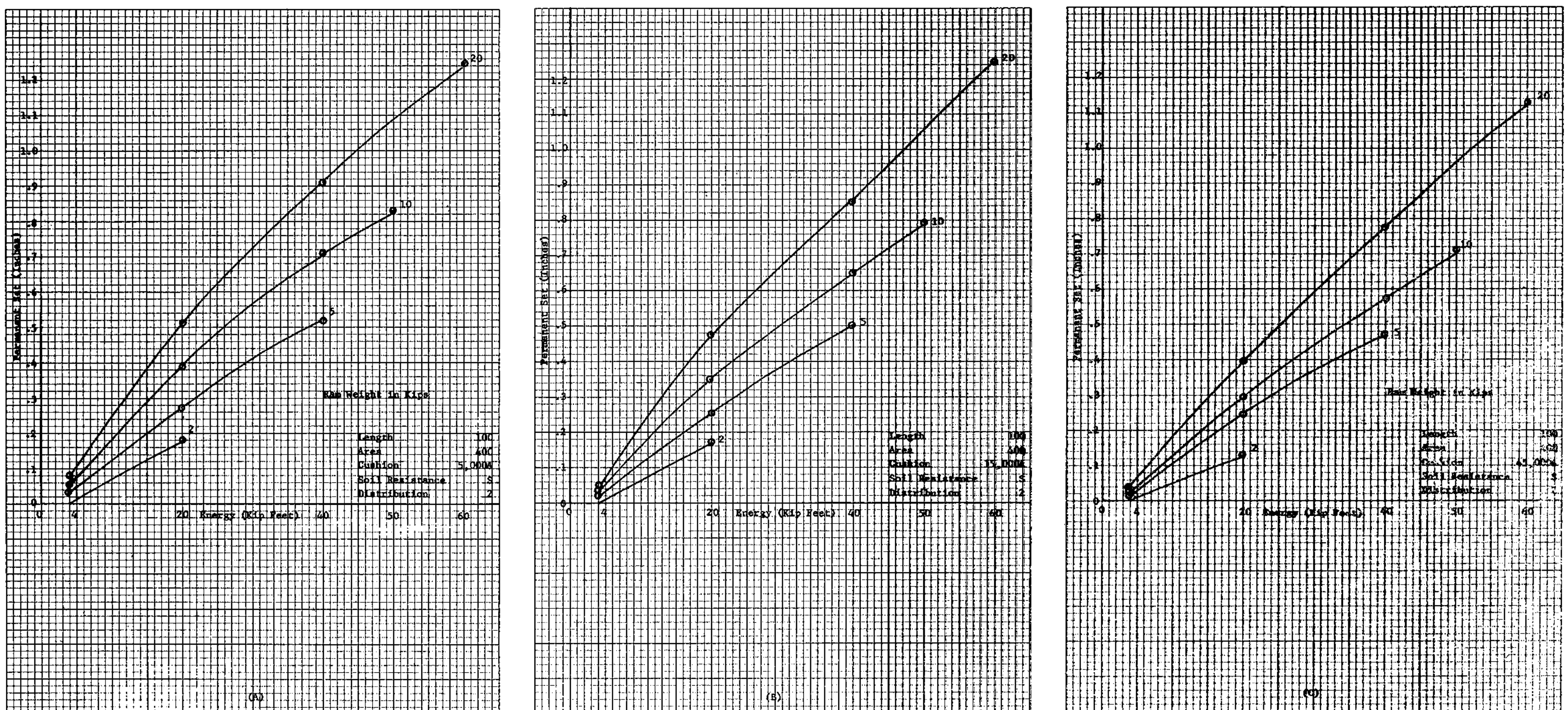
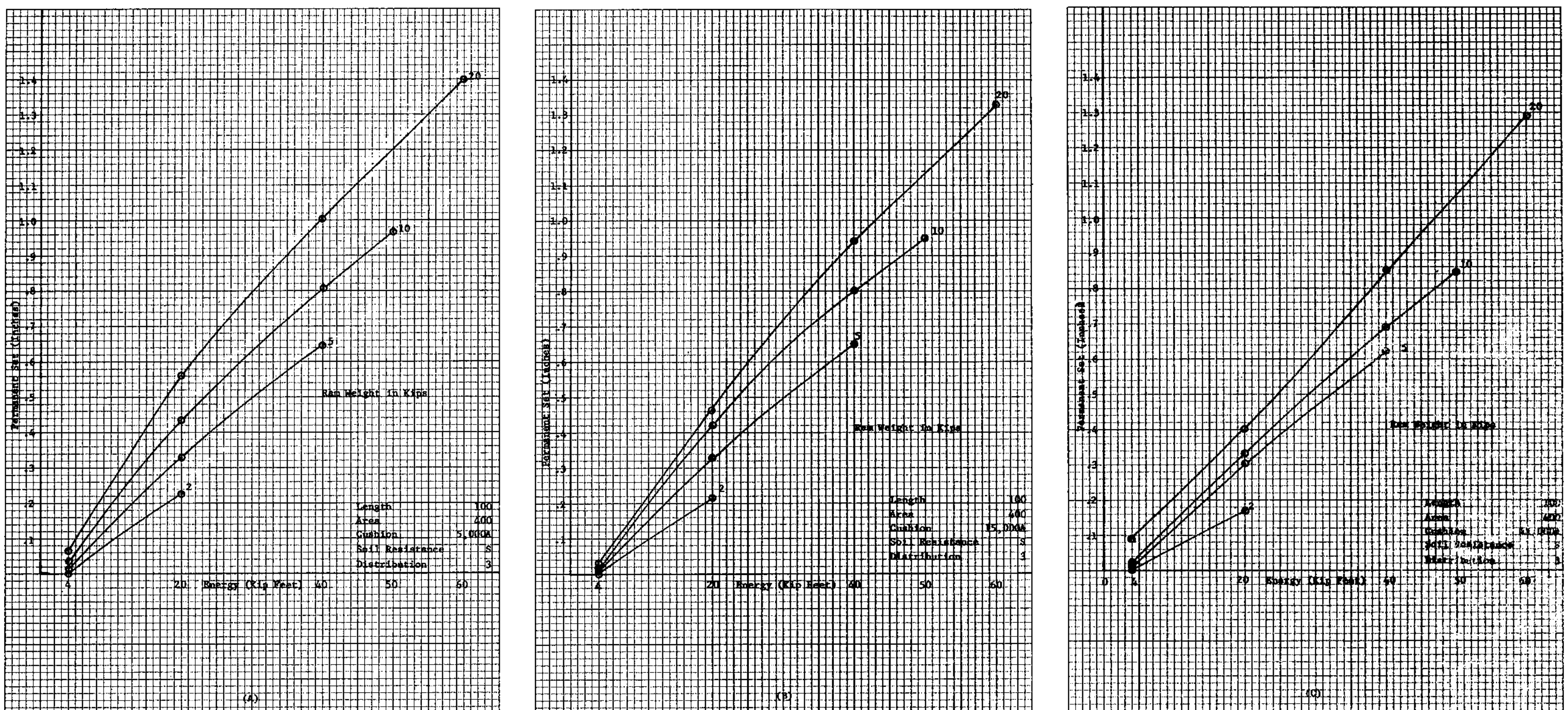

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length
Area
Cushion
Soil Resistance
Distribution
(A)
(B)
(C)

FIGURE 101



Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 5,000A
Soil Resistance S
Distribution 3
(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 400
Cushion 15,000A
Soil Resistance S
Distribution 3
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
(C)

FIGURE 102

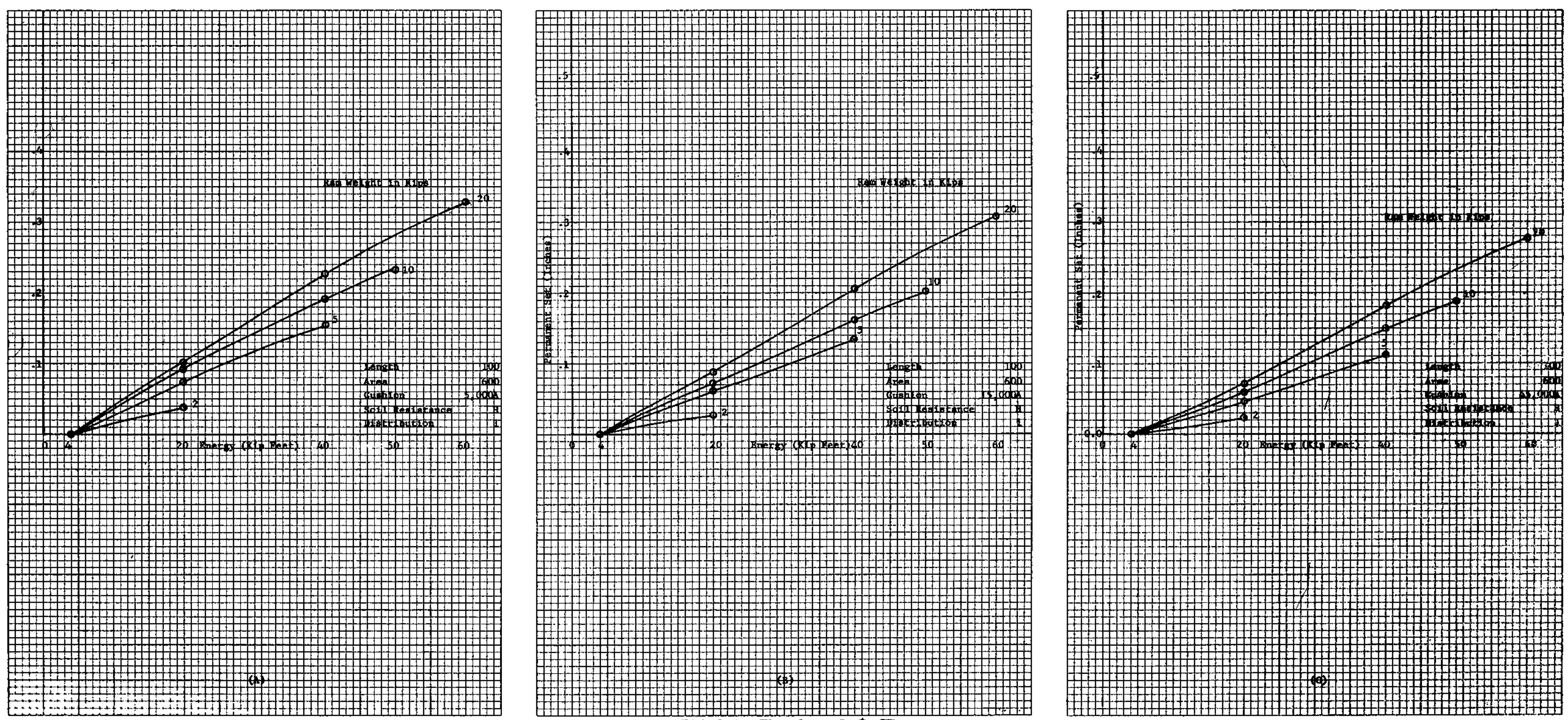
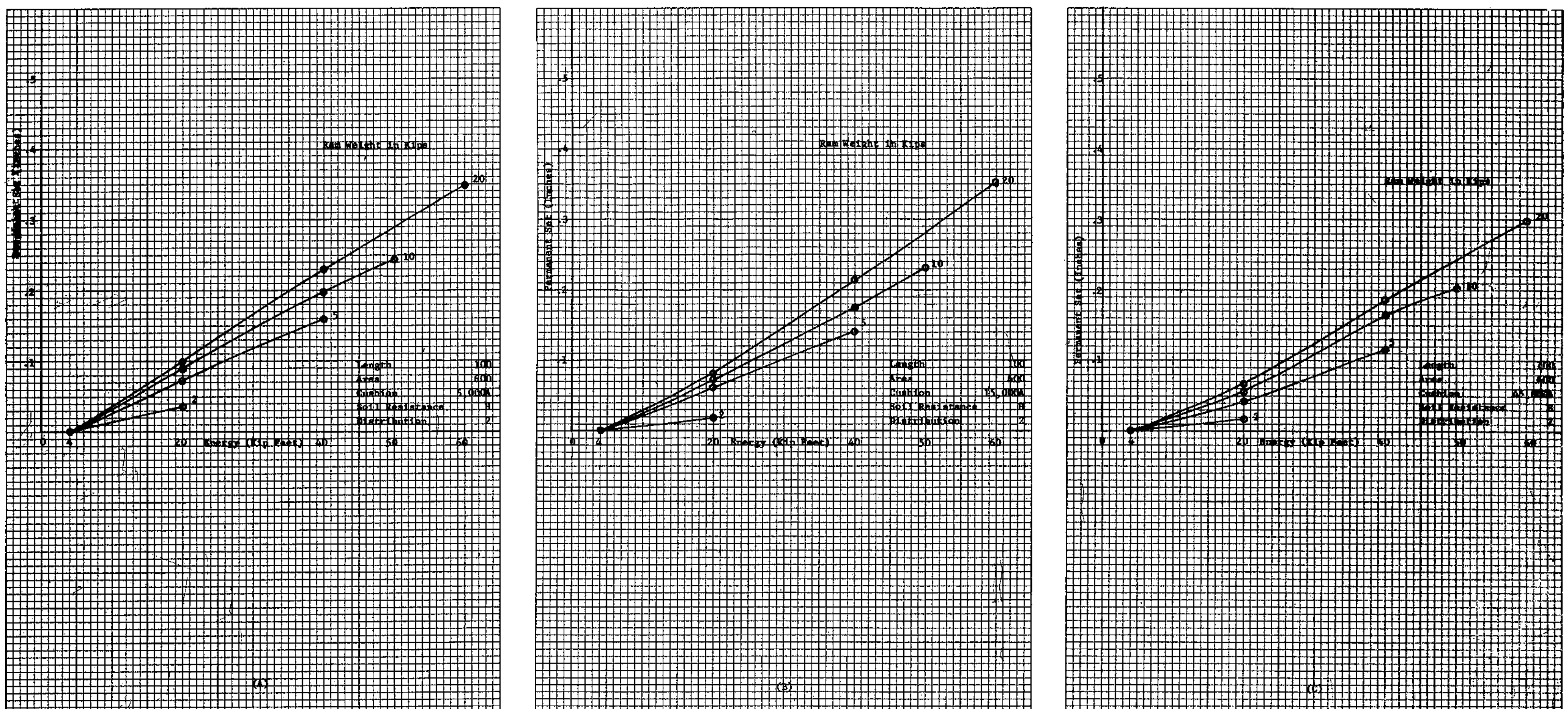
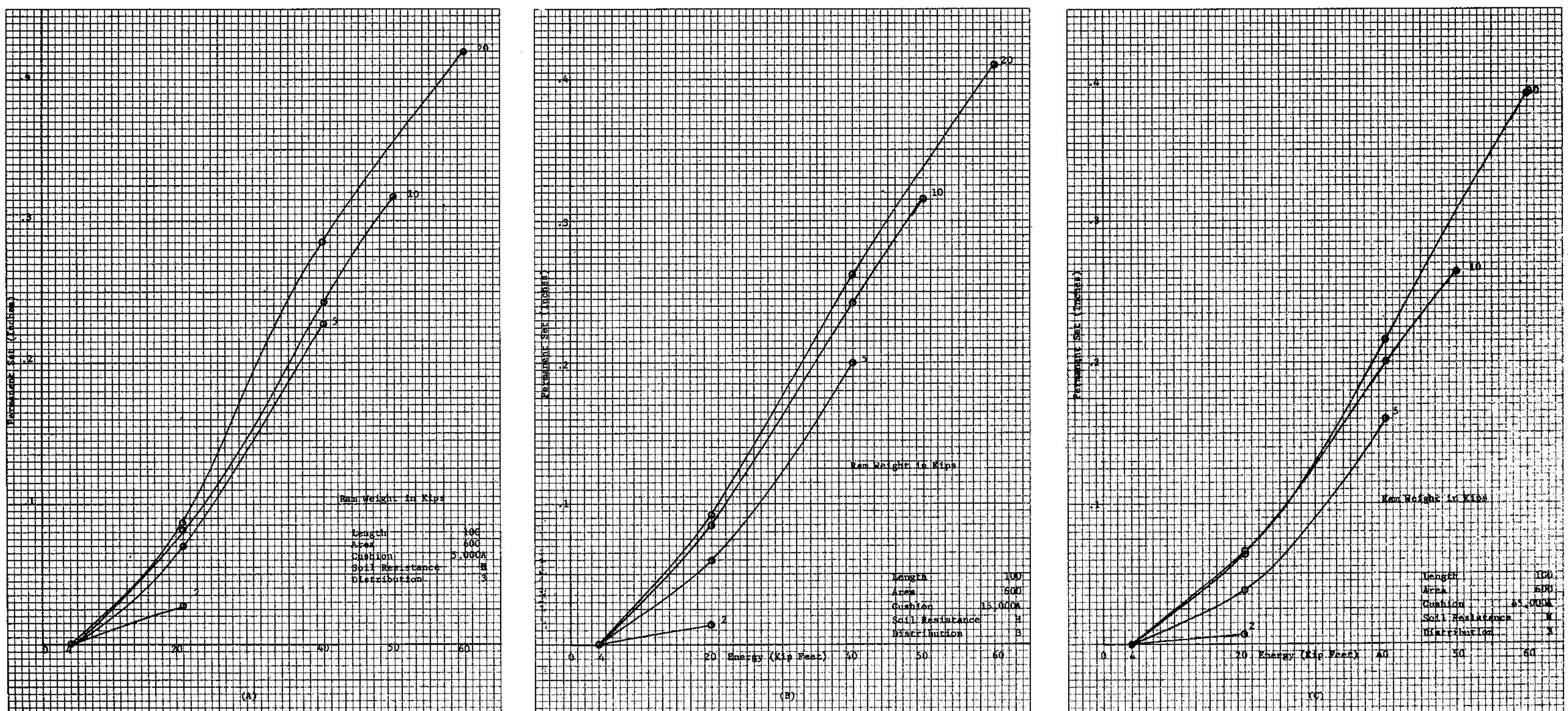

Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance N
Distribution 1
Energy (Kip Feet)
(A)
Permanent Set (Inches)
Ram Weight in Kips
Length 100
Area 600
Cushion 15,000A
Soil Resistance N
Distribution 1
Energy (Kip Feet)
(B)
Permanent Set (Inches)
Ram Weight in Kips
Energy (Kip Feet)

FIGURE 103



Ram Weight in Kips
Energy (Kip Feet)
Permanent Set (Inches)
Length 100
Area 600
Cushion 5,000K
Soil Resistance 8
Distribution 2
(A)
Ram Weight in Kips
Energy (Kip Feet)
Permanent Set (Inches)
Length 100
Area 600
Cushion 15,000K
Soil Resistance 8
Distribution 2
(B)
Ram Weight in Kips
Energy (Kip Feet)
Permanent Set (Inches)
(C)

FIGURE 104



Permanent Set (inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance H
Distribution 3
(A)
Length 100
Area 600
Cushion 15,000A
Soil Resistance H
Distribution 3
(B)
(C)

FIGURE 105

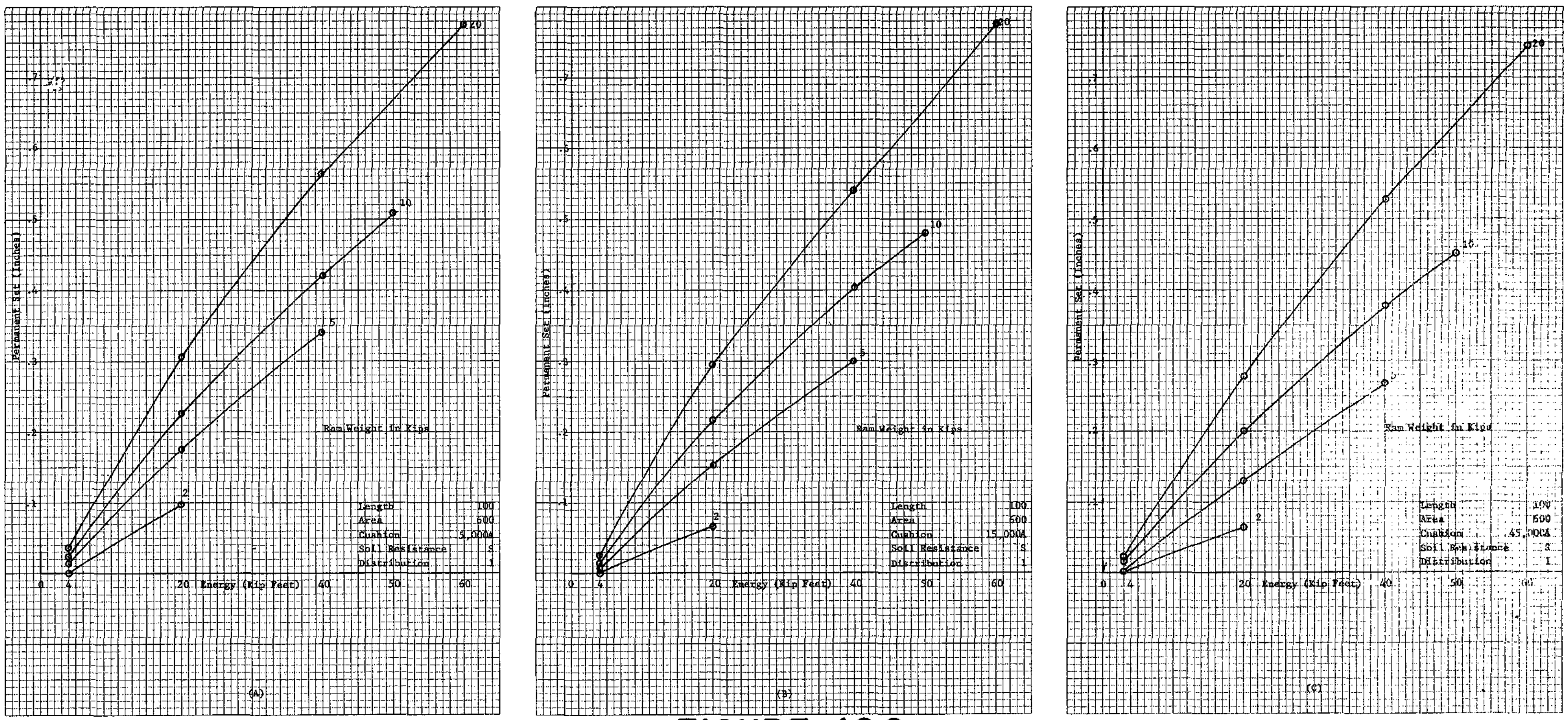

(A)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 1
(B)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 1
(C)
Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 45,000A
Soil Resistance S
Distribution 1

FIGURE 106

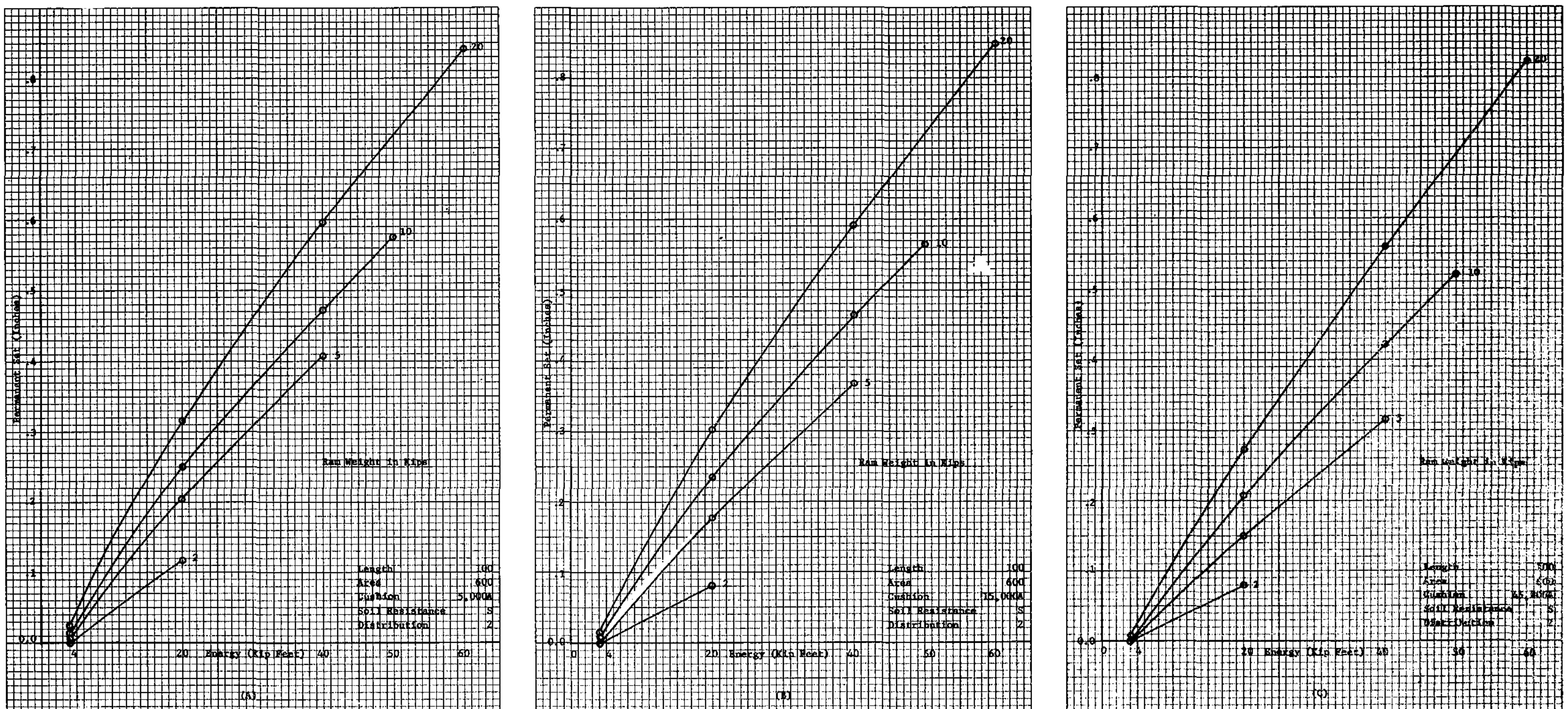

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 5,000A
Soil Resistance S
Distribution 2
(A)
Length 100
Area 600
Cushion 15,000A
Soil Resistance S
Distribution 2
(B)
(C)

FIGURE 107

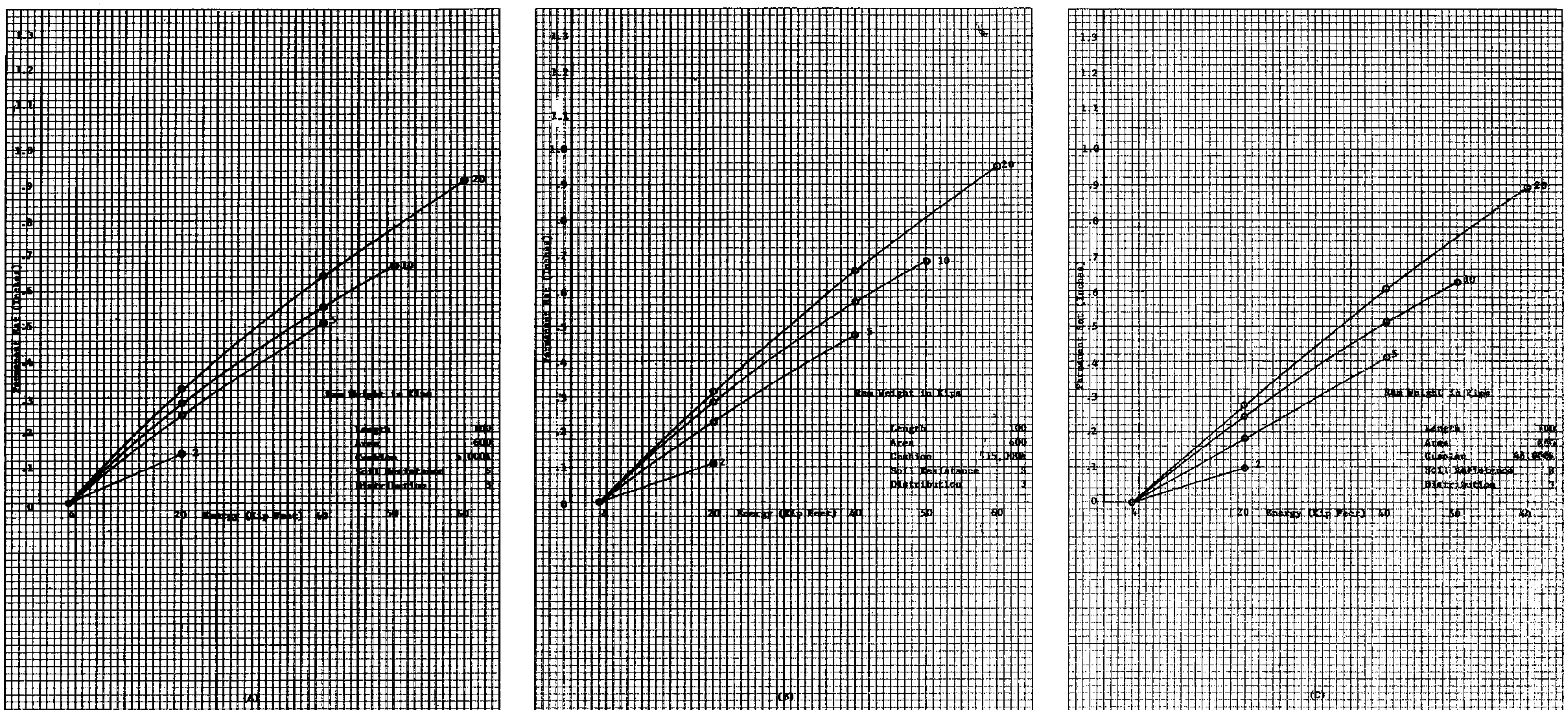

Permanent Set (Inches)
Energy (Kip Feet)
Ram Weight in Kips
Length 100
Area 600
Cushion 15,000
Soil Resistance S
Distribution 2

FIGURE 108