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**SMALL-SCALE MODEL STUDY TO
DETERMINE THE EFFECTS OF SAWKERFS
AND BORED RECESSES ON LOAD-CARRYING
CAPACITY OF RIGID PAVEMENT**

by

R. M. BEHRMANN



AUGUST 1966

**DEPARTMENT OF THE ARMY
OHIO RIVER DIVISION LABORATORIES , CORPS OF ENGINEERS
CINCINNATI, OHIO 45227**

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SUMMARY

This study was made to determine the effects of sawkerfs and bored recesses on the load-carrying capacity of rigid pavement. Information of this nature is needed to evaluate the effect of boring recesses in rigid airfield pavement to accommodate inset light fixtures and of making sawkerfs in the same pavement to carry power lines to the fixtures. In the study, the change in critical stress in the slab due to change in recess diameter, recess depth, distance of the recess from the edge of the slab, sawkerf location and sawkerf depth was observed. The effect of sawkerfs and recesses was expressed by relating the difference between the critical stress developed with a sawkerf and/or a recess and the critical stress developed in a plain slab by comparable loads.

Full-scale pavement was simulated in the model by Hydrostone slabs 0.200 inch thick by 16-3/4 inches square supported by a natural rubber subgrade. Circular recesses of varying depth were drilled in the slabs to simulate the holes bored in the full-scale pavement to accommodate the light fixtures. The sawkerfs in the prototype were represented in the model by narrow grooves cut to varying depths. Static loads were applied to the model slabs through single circular footprints. The strains in the slab resulting from the static loads were observed by means of SR-4 electrical strain gages mounted on the bottom of the slab.

A detailed description of the construction, instrumentation and testing of the model is included in this report. Information pertaining to the physical properties of the materials of the model is given also. The data obtained from the tests are presented, followed by an analysis and discussion of the test results.

The testing schedule was to have included eighteen prototype conditions so that the effects of three recess diameters, three slab thicknesses and two types of fixture would be investigated. Only thirteen of the scheduled tests were performed. A number of tests of an exploratory nature were performed in conjunction with the scheduled tests.

For the range of prototype conditions represented by the model, the test results indicated the following:

- a. A recess of any depth tends to lower the load-carrying capacity of a slab. Depending on the type of fixture, the load-carrying capacity could be reduced as much as 39% by extending the recess completely through the slab.

b. Sawkerfs perpendicular to the edge tend to reduce the load-carrying capacity of a slab, the amount of reduction being dependent on the depth of the sawkerfs.

c. In a slab containing a recess, a sawkerf, or both, the stress per pound of load is constant throughout the elastic range of the slab and subgrade.

d. Crack patterns associated with the initial failure of a plain slab and a slab containing a recess are practically identical.

e. Cracking associated with the complete failure of a slab containing a recess is more extensive than that associated with a plain slab.

f. With a recess near the edge and completely through a slab, critical stresses may develop at the edge of the recess rather than at the edge of the slab.

PREFACE

This report describes and presents the results of a small-scale static load model study made to determine the effects of sawkerfs and bored recesses on the load-carrying capacity of rigid pavement. The study was made by the Research Analysis Branch, Construction Engineering Laboratory, Ohio River Division Laboratories, in accordance with the authorization contained in "Instructions and Outline, Engineering Investigations for Rigid Pavements, Air Force, Fiscal Year 1964." This investigational program is directed and coordinated by the Civil Engineering Branch, Engineering Division, Military Construction, Office of the Chief of Engineers.

Professors Gerald Pickett and C. P. Sless, consultants for the Engineering Investigations for the Rigid Pavement program, were particularly helpful in providing guidance for this study and in interpreting and analyzing the data obtained.

This report was prepared by Mrs. R. M. Behrmann, Research Mathematician, under the supervision of Mr. R. L. Hutchinson and Mr. E. A. Lotz, Chief and Assistant Chief, respectively, of the Construction Engineering Laboratory. Mr. F. M. Mellinger was Director of the Ohio River Division Laboratories during the conduct of this investigation.

The Office of the Chief of Engineers and the consultants have reviewed this report in draft and their comments have been incorporated in this final form.

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SMALL-SCALE MODEL STUDY TO DETERMINE THE EFFECTS OF
SAWKERFS AND BORED RECESSES ON LOAD-CARRYING CAPACITY
OF RIGID PAVEMENT

PART I: INTRODUCTION

Purpose of the Study

1. In the installation of runway centerline and narrow-gauge inset light fixtures in airfield pavement, it is required that recesses be bored to accommodate the fixtures and sawkerfs be made to carry power lines to the fixtures. Since the amount of information suitable for evaluating the effect of recesses and sawkerfs on the load-carrying capacity of rigid pavement was extremely meager, it was proposed that a small-scale model study be made to provide some insight into the behavior of slabs subjected to treatment of this kind.

Scope of the Study

2. The model used to obtain the desired information consisted of a Hydrostone slab 16-3/4 inches square and 0.200 inch thick supported continuously on an elastic subgrade and subjected to static loads. Vertical dimensions in the model and prototype slabs were scaled in proportion to the thickness of the slab. Horizontal dimensions in the model and prototype slabs were scaled in proportion to the radius of relative stiffness* of the slab. The slabs were instrumented on the bottom with SR-4 electrical

* The notation l , radius of relative stiffness, was introduced by Westergaard to express the relationship between the stiffness of the slab and the resistance of the subgrade to vertical displacement.

$$l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$$

where

- E = modulus of elasticity of the slab,
- h = thickness of the slab,
- μ = Poisson's ratio of the slab,
- k = modulus of subgrade reaction.

strain gages. The testing involved observing the change in strain for a particular load resulting from various modifications to the test slab to determine the following:

a. The effect of scaling the horizontal dimensions of the model to those of the prototype by means of their respective thicknesses instead of by means of their respective radii of relative stiffness.

b. The effect of simulated centerline inset light fixtures on the load-carrying capacity of a slab.

c. The effect of simulated narrow-gauge inset light fixtures on the load-carrying capacity of a slab.

d. The effect of a recess at the interior of a slab on the load-carrying capacity of the slab.

e. The effect of a sawkerf deepened at the edge of the slab on the load-carrying capacity of a slab.

f. The effect of recesses on failure loads and crack patterns.

3. The effects of the various modifications on the load-carrying capacity of a slab were based on critical stresses determined from the stresses computed from the observed strains.

PART II: DEVELOPMENT OF THE MODEL

General Description of the Model

4. Full-scale rigid pavement was simulated in the model by Hydrostone gypsum cement slabs approximately 16-3/4 inches square and 0.200 inch thick. Circular recesses of varying depths were drilled in the slabs to simulate the discontinuities introduced in the prototype slabs by the installation of different sizes of inset light fixtures. The sawkerfs required to carry the power lines in the full-scale pavement were represented in the model by narrow grooves cut in the surface of the slabs.

5. The subgrade was simulated in the model by a 24-inch square by 12-inch thick block of natural rubber resting on a concrete pedestal. The four vertical sides of the rubber block were restrained by a rigid casing. The slabs were placed directly on the rubber block for testing. In order to increase the effective mass of the slab to insure intimate and continuous contact at the interface between the slab and the rubber subgrade during testing, lead cubes 3/4 inch on an edge were distributed uniformly over the surface of the slab.

6. Loads simulating aircraft wheel loads were applied to the model slab by a reaction beam acting on a single circular footprint. Each footprint consisted of a rigid circular die having the contact area faced with a 1/8-inch thick layer of foam rubber. By facing the footprint with rubber, a more uniform distribution of the load over the contact area was achieved and the loading of pneumatic-tired aircraft wheels was simulated.

7. SR-4 electrical strain gages cemented to the bottom surface of the slab were used to measure strains in the slab.

8. A general view of the model and associated equipment is shown in Figure 1.

Physical Properties of the Model Materials

9. Since models of the type described herein had been used extensively prior to this study, it was assumed that the values determined for the physical properties of the materials comprising the earlier models would be valid for this particular model. The values assumed were as follows:

$$\begin{aligned} E &= \text{modulus of elasticity of the slab} = 3.0 \times 10^6 \text{ psi,} \\ \mu &= \text{Poisson's ratio of the slab} = 0.25, \end{aligned}$$

- R = modulus of rupture of the slab = 3,000 psi,
 k_e = modulus of subgrade reaction for edge loading of
the slab = 55 pci,
 k_i = modulus of subgrade reaction for interior loading of the
slab = 35 pci.

Theoretical Considerations

10. In certain instances, Westergaard's theoretical analysis⁽¹⁾ was applicable to the evaluation of the behavior of the model slabs as indicated by measured strains. In order for the theory to be applicable to the model, it was necessary that certain assumptions inherent in the analysis be simulated in the model. As required by the theory, the Hydrostone was essentially homogeneous, isotropic and elastic. In all cases, the diameter of the loaded area was greater than the thickness of the slab; a condition which must obtain in order for the ordinary theory for the bending of thin plates to be used without the special corrections to account for the loaded area being "too small." It was believed that the action of the rubber subgrade was a reasonable simulation of the "dense liquid" subgrade of the Westergaard analysis, which required the reaction of the subgrade on the slab to be a vertical pressure, equal, per unit of area, to a constant, k , times the deflection.

(1) New Formulas for Stresses in Concrete Pavements of Airfields,
by H. M. Westergaard, Transactions, A. S. C. E., Volume 108, 1943.

PART III: CONSTRUCTION OF THE TEST SLABS

Casting

11. The form for casting the test slabs consisted of four 0.198 ± 0.001 -inch thick steel bars secured to a piece of plate glass $1/2$ inch thick by 24 inches square so that a $16-3/4$ -inch square area was enclosed. The Hydrostone gypsum slurry, having a water-cement ratio of 31.0% by weight, was poured into the form and the top surface of the slab was struck off immediately by sliding a second piece of plate glass $1/2$ inch thick by 18 inches square over the filled form. By using plate glass to form the top and bottom surfaces, each slab was relatively uniform in thickness and had smooth and plane surfaces ideally suited for the instrumentation.

Curing

12. The strike-off glass was removed approximately 45 minutes after a slab was cast. Approximately one hour after casting, the side forms were removed and the slab was separated from the glass and stood on edge to cure. The slabs were allowed to cure in air at room temperature (humidity = 50%, temperature = 73° F.) for seven days before they were used for testing.

Instrumentation

13. SR-4 electrical strain gages cemented to the bottom surface were used to instrument the slabs. In some instances, Type A-7 gages were used; in others, Type AFX-7 rosettes were used. All gages were allowed to air-dry for a period of at least 48 hours prior to testing. A description of the instrumentation associated with each test is included with the discussion of the results of the tests (See Part VI).

Cutting to Simulate Recesses and Sawkerfs

14. Recesses. Circular recesses to simulate holes cut in full-scale pavement to accommodate the inset light fixtures were bored in the model slabs with cutters made especially for this study. The cutting assembly consisted of a guide to hold the cutter perpendicular to the slab surface during boring, a collar for gauging the recess depth, the cutter, and an electric drill to turn the cutter. Figure 2 is a photograph showing the individual parts of one of the cutting assemblies. In the following paragraphs, the components of the cutting assemblies, except the electric drill, are described:

a. Cutter. The cutter was a 3-inch long piece of steel turned to the desired diameter. At one end of the piece, two equal sloping faces were cut from two points on opposite sides of and 1/2 inch from the end of the cutter to the center of the end so that a knife edge through the center and across the face of the end was formed. The diameter of 1/2 inch of the opposite end of the piece was reduced to 1/4 inch to fit the chuck of an electric drill

b. Guide. The guide was a steel block 1 inch square by 1-1/2 inches high. The block had a circular hole, 0.002 inch larger in diameter than the diameter of the cutter, running in the 1-1/2-inch direction and centered on the top and bottom faces.

c. Collar. The collar was a 1/4-inch thick steel ring having an outside diameter of 1 inch and an inside diameter 0.002 inch larger than the diameter of the cutter. Two set screws at 90° were provided for locking the collar on the cutter at various positions.

15. To use an assembly, the cutter was placed in the block on a flat surface so that the cutting edge and the bottom face of the block were flush. The collar was secured to the cutter with a space equal to the desired recess depth between the upper face of the block and the bottom side of the collar. The recesses were formed by placing the block and cutter on the slab and turning the cutter with the electric drill until the collar met the block and stopped the cutter from penetrating the slab further than the desired depth. The drilling operation is shown in Figure 3. Figure 4 shows the edge of a slab on the rubber subgrade with seven recesses bored partially through the slab.

16. Sawkerfs. Grooves were cut in the surface of the model slabs at appropriate locations to simulate the sawkerfs of the prototype. The tool for cutting the grooves consisted of a blade in a split-block holder. The holder had an offset in the bottom which was as wide as the spacing between and as thick as two straight edges used as a guide to position the grooves. To cut a groove, the blade was clamped in the holder so that it extended beyond the offset an amount equal to the depth of groove desired. The holder was passed back and forth on the guides until no material was removed in a pass of the blade. Figure 5 is a photograph of the blade and split-block holder. In Figure 6, the blade and holder are shown in position on the guides on a slab.

PART IV: DETERMINATION OF STRESSES

Experimental Stresses

17. In this investigation, the strains obtained were along and normal to an axis of symmetry of the loading. Major and minor principal strains at any point along the axis of symmetry were determined from curves through plotted points representing the experimental strains. The experimental stresses at a point some distance from the edge of the slab were computed from the experimental strains at that point by means of the following equations:

$$\sigma_x = \frac{E (\epsilon_x + \mu \epsilon_y)}{1 - \mu^2} \dots \dots \dots (1)$$

$$\sigma_y = \frac{E (\epsilon_y + \mu \epsilon_x)}{1 - \mu^2} \dots \dots \dots (2)$$

where

- σ_x, σ_y = major and minor principal stresses,
- E = modulus of elasticity of Hydrostone,
- ϵ_x, ϵ_y = major and minor principal unit strains,
- μ = Poisson's ratio of Hydrostone.

Stress at the edge parallel to the edge was determined by means of the following equation:

$$\sigma_e = E \epsilon_e \dots \dots \dots (3)$$

where

- σ_e = unit stress parallel to the edge at the edge,
- ϵ_e = unit strain parallel to the edge at the edge,
- E = modulus of elasticity of Hydrostone

The above equations assume that the stress in the vertical direction is negligible.

Theoretical Stresses

18. Interior Stress. The theoretical stress at the center of a circular area loaded in the interior of a slab was computed using Westergaard's analysis as follows:

$$\sigma_i = \frac{3P}{8\pi h^2} (1 + \mu) \log \frac{Eh^3}{kr^4} \dots \dots \dots (4)$$

where

- P = load,
- h = thickness of slab,
- E = modulus of elasticity of slab,
- μ = Poisson's ratio of slab,
- r = radius of loaded area,
- k = modulus of subgrade reaction.

19. Edge Stress. The theoretical stress at the point of tangency of a circular footprint to the edge of a slab was computed using Westergaard's analysis as follows:

$$\sigma_e = \frac{3(1+\mu)P}{\pi(3+\mu)h^2} \left[\log \frac{Eh^3}{100kr^4} + 1.84 - \frac{4}{3}\mu + \frac{(1-\mu)}{2} + 1.18(1+2\mu)\frac{r}{l} \right] \dots (5)$$

where, in addition to the notation given for interior stress,

l = radius of relative stiffness of slab.

PART V: TEST RESULTS

Definition of Load-Carrying Capacity

20. Load-carrying capacity, as used herein, is considered to be the maximum load a particular pavement loaded in a particular manner can carry without cracking occurring in the bottom of the pavement. It was assumed that, within the elastic range for the slab and subgrade, the stress per pound of load was constant. By this assumption, the load at initial cracking (load-carrying capacity) could be determined by dividing the modulus of rupture of the slab by the maximum stress per pound of load in the elastic range. By observing the effect recesses and grooves have on the maximum stress, the change in load-carrying capacity of a slab could be determined. The percent reduction in load-carrying capacity, C, was determined in accordance with the following equation:

$$C = \frac{P_o - P_r}{P_o} = \frac{(R/S_o) - (R/S_r)}{(R/S_o)} = \frac{S_r - S_o}{S_r} \dots \dots \dots (6)$$

where

S_o = maximum stress per pound of load for slab with no recesses or grooves, psi,

S_r = maximum stress per pound of load for slab with recesses and grooves, psi,

R = modulus of rupture of slab, psi,

P_o = failure load for slab with no recesses and no grooves = R/S_o , lbs.,

P_r = failure load for slab with recesses and grooves = R/S_r , lbs.

21. The assumption that stress per pound of load was constant in the elastic range for the condition where the slab contained recesses and grooves was verified by a supplementary test. In this test, a slab having eleven 0.100-inch deep recesses and an 0.015-inch deep groove from the center recess to the edge was loaded in 2-pound increments to a load of 10 pounds. The load was tangent to the edge at the groove. Strains measured 0.15 inch from the edge on the axis of symmetry of the loading were converted to stress and are shown in Figure 7. It can be seen from this figure that when recesses and a groove were present, stress per pound of load continued to be constant in the elastic range.

Effect of Simulated Centerline Inset Light Fixtures
on Load-Carrying Capacity of a Slab

22. In the prototype runway centerline inset light installations, fixtures are inserted in recesses bored in the pavement on or adjacent to the longitudinal centerline of the runway. Normally, the fixtures are spaced on 25-foot centers for the length of the runway. In most cases, there is a longitudinal construction joint on the runway centerline and the inset light fixtures are offset from the joint 12 to 18 inches. Sawkerfs 1 inch deep and 3/8 inch wide running parallel to and offset 24 to 30 inches from the centerline construction joint are provided to accommodate wires carrying power to the fixtures. An additional 1 inch deep by 3/8 inch wide sawkerf is provided from the main sawkerf to each light fixture. The main sawkerfs are deepened at their intersection with a joint to 1/2 inch below the depth (one-sixth to one-quarter of the slab thickness) of the weakened plane. The various model dimensions investigated and the prototype conditions they represent are listed in Table 1. Figure 8 is a schematic drawing showing the positions of the loads, recesses and grooves with respect to the edge of a model slab.

23. The model slabs were instrumented on the bottom with SR-4 electrical strain gages. In Test Nos. 1, 2, and 3, Type A-7 gages were used. Type AFX-7 rosettes were used in the balance of the tests covered by Table 1. In either case, the gages were arranged along a line normal to the edge so that five strain readings parallel to the edge and five readings perpendicular to the edge could be obtained. Figure 9 shows the bottom of a slab with strain rosettes attached. The recesses and the loads were positioned symmetrically about the line along which the gages were mounted. In a number of the early tests, strains were obtained for loads tangent to the edge, centered over a recess, and centered over the groove parallel to the edge. Since none of the strains produced by these loadings were greater than the strains observed with the load tangent to the edge, only tangent loadings were used for the balance of the testing.

24. Where the footprint overlapped a recess, the load was allowed to overhang the edge of the recess, unsupported. However, care was taken to hold the loading device so that the direction of the applied load was always normal to the surface of the slab. The clamp for holding the loading device in the desired position is shown in Figure 10. The "fingers" of the clamp are rubber-tipped to prevent, as far as possible, any of the load from being transferred from the loading device to the holder. The circular spirit level used to position the load is shown in the foreground.

25. In all cases, a load of 10 pounds was applied through a contact area comparable to a prototype single circular footprint having an area of 267 square inches (18.44-inch diameter). For each slab, the experimental strains were obtained first

for the slab with no recesses or grooves, and then for the slab with increasing depth of recess. After several depths of recess had been investigated, but before the recess depth equalled the slab thickness, the grooves representing the sawkerfs were introduced. Holding the groove depth constant for the balance of the testing, strain data were obtained first for the recess depth studied before cutting the groove, and then for several additional recess depths including that equal to the slab thickness.

26. The experimental strains obtained for each change to which the slab was subjected were converted to stress per pound of load, and the resulting stresses were plotted versus distance from the edge of the slab. Maximum stresses near the edge of the slab, taken from curves through the plotted values, were used with Equation 6 to determine the percent reduction in load-carrying capacity effected by each change. The reductions in load-carrying capacity, as indicated by the model for the runway centerline inset light fixtures, are presented in Table 2 and are shown graphically in Figure 11.

Effect of Simulated Narrow-Gauge Inset Light Fixtures on Load-Carrying Capacity of a Slab

27. In the prototype runway, a narrow-gauge light installation normally consists of a bank of five light fixtures inserted in bored recesses in the pavement. Narrow-gauge light installations are located on each side of the runway, 27-1/2 to 30 feet from the centerline, and at longitudinal spacings of 200 feet within the first 3200 feet of the runway. The transverse spacing of the light fixtures at each installation is 27 inches, center to center. The fixtures are located parallel to and offset 12 to 36 inches from a transverse joint. Power is carried to the fixtures in sawkerfs made along the edge of the transverse joint. Individual sawkerfs 1-1/2 inches deep by 3/8 inch wide are provided from the main wireway to each light fixture. The various model dimensions investigated and the prototype conditions they represent are listed in Table 3. Figure 12 is a schematic drawing showing the positions of the loads, recesses, and sawkerfs with respect to the edge of a model slab.

28. The model slabs were instrumented on the bottom in the same manner as the slabs used to simulate the centerline inset light installations. With the exception of Test 4, where Type A-7 gages were used, all the slabs for the tests covered by Table 3 were instrumented with Type AFX-7 rosettes. As in the tests where the centerline fixtures were simulated, the gages were arranged along a line normal to the edge of the model slab so that strains parallel and perpendicular to the edge were indicated. The recesses, loads, and grooves were positioned symmetrically about the line of gages.

29. The load in each case was applied tangent to the edge of the slab at the line

of gages and was held in such a way that the direction of the loading was normal to the surface of the slab. The contact area of the load, again, was representative of the full-scale single circular 267-square inch footprint. Experimental strains were obtained for each slab before cutting any recesses or grooves, and then after cutting each of several depths of recess. When the recess depth reached approximately one-half the slab thickness, the grooves representing the sawkerfs were formed. Strain data were obtained with the grooves for the recess depth investigated immediately prior to cutting the grooves, and for several additional recess depths, including that equal to the slab thickness.

30. The experimental strains were converted to stress per pound of load, and the resulting stresses were used to determine the maximum stress per pound of load near the edge of the slab for the various test conditions. Using Equation 6 and the maximum stress values indicated, the percent reduction in load-carrying capacity effected by each change was computed. The reductions in load-carrying capacity, as indicated by the model for the narrow-gauge landing light fixtures, are presented in Table 4 and are shown graphically in Figure 13.

Effect of Recess at Interior of Slab on Load-Carrying Capacity of a Slab

31. The purpose of this phase of the testing was to determine what effect recesses of various depths at the interior of a slab have on the load-carrying capacity of a slab. The prototype simulated by the model was a 15-inch thick slab with a 10-inch diameter recess and a load applied through an 18.44-inch diameter contact area. Comparable dimensions in the model were 0.200 inch for the slab thickness, 0.477 inch for the recess diameter, and 0.880 inch for the diameter of the loaded area. The horizontal dimensions were scaled in proportion to the respective radii of relative stiffness of the slabs; 58.51 inches for the prototype and 2.79 inches for the model (using 35 pounds per cubic inch for the modulus of subgrade reaction of the natural rubber for loading at the slab interior).

32. The slab used to make this investigation was instrumented on the bottom with five Type AFX-7, SR-4 electrical strain gage rosettes mounted with the gages parallel and perpendicular to a single line near the center of the slab. Using a single circular footprint centered over the line of rosettes, loads were applied and strains obtained with no recess, and with a recess of various depths, centered over the second rosette from the end of the line (see sketch in Table 5). Strains were obtained with the load centered over the recess, with the center of the load at one of the points common to the edge of the recess and the line of rosettes, and with the load tangent to the recess at one of the points common to the recess and the line of rosettes.

33. The observed strains were converted to stress per pound of load. The computed stresses per pound of load tangential to the recess are given in Table 5. Only tangential stresses are given because they are greater than the observed radial stresses. The more significant stresses given in Table 5 are shown graphically in Figure 14. The maximum stresses shown in Table 5 were obtained by interpolation and extrapolation from plots of stress data such as Figure 14. By using Equation 6 to compare the maximum stresses generated before and after cutting the recess, the percent reduction in load-carrying capacity effected by the recess was determined. The values obtained for the percent reduction in load-carrying capacity effected by a recess at the interior are shown in Table 5.

Effect of Sawkerf on Load-Carrying Capacity of a Slab

34. The purpose of this phase of the testing was to determine what effect a sawkerf perpendicular to the edge of a slab has on the load-carrying capacity of the slab. Two model slabs, tested similarly, were used to make this determination. The sawkerf simulated by the model was 1 inch deep in the interior deepened from the 1 inch depth 9 inches from the edge of the slab to a depth of one-sixth the slab thickness plus 0.50 inch at the edge. After the information for this particular sawkerf had been obtained, the groove was deepened to represent a sawkerf one-sixth the slab thickness plus 0.50 inch deep over its entire length. Table 6 gives data pertaining to the dimensions involved in this testing. Figure 15 shows schematically the sawkerf dimensions relative to the size of the loaded area.

35. As can be seen from Figure 15, the cutting required to simulate the sawkerf of variable depth in the 10-inch thick slab produced a groove deeper for a short distance close to the edge than the grooves cut subsequently to represent the uniformly deep sawkerf in the 15-inch thick slab and the 20-inch thick slab. It was assumed that this slight inaccuracy in groove depth at the edge had a negligible effect on the edge strains.

36. Each slab was instrumented on the bottom with five Type AFX-7, SR-4 electrical strain gage rosettes mounted with the gages parallel and perpendicular to a line normal to the edge of the slab along which the simulated sawkerf was to be cut. Using a single circular footprint placed tangent to the edge of the slab and centered on the line of gages, loads were applied and strains obtained before and after cutting the groove.

37. The observed strains were converted to stress. The stress at the edge of the slab for each load condition was obtained by plotting the stresses versus distance from the edge and extrapolating the resulting stress curves. The edge stresses determined by extrapolation are given in Table 7 as stress per pound of load.

These stresses are shown on Figure 16 with curves of average stress drawn through the points. Values of average stress taken from the curves of Figure 16 are presented in Table 7. By relating the edge stress before and after cutting the groove, according to Equation 6, the percent reduction in load-carrying capacity of the slab effected by the groove was determined. The resulting percentages are given in Table 7.

Comparison of Scaling to Radius of Relative Stiffness and Scaling to Slab Thickness

38. In order to gain some insight into the comparative effects of scaling the horizontal dimensions of the model to those of the prototype in proportion to slab thickness rather than radius of relative stiffness, two model slabs of different size and material were scaled to a single prototype and tested. One was a Hydrostone slab on the natural rubber subgrade, similar to the slabs used in the other phases of the study; the other was a concrete slab on a low-strength clay subgrade. The dimensions of the prototype simulated and the comparable dimensions of the models are given in Table 8.

39. The concrete slab used for these tests was the bonded-dowel side of a slab which had been used in an investigation to study the behavior, under repetitive loading, of pavement containing a doweled joint. Since traffic on the bonded-dowel side of the joint had been confined to a small area along the center portion of the joint, it was possible to conduct the tests described herein on portions of the slab which had received no prior loading. The slab was instrumented on the top at two locations with Type AX-5, SR-4 electrical strain rosettes positioned so that strains parallel and perpendicular to the edge along a line normal to the edge were indicated. The recesses and loads were positioned symmetrically about the lines of gages. In Figure 17a, the recess shown in the foreground is the recess scaled to the radius of relative stiffness. At this location, strains were obtained for a load applied tangent to the edge at the recess through a contact area scaled to the radius of relative stiffness. Also shown in Figure 17a, at the far edge of the slab, is the line of gages at the alternate test location. At this alternate position, strains were obtained with no recess for loadings applied tangent to the edge and scaled to the radius of relative stiffness and the slab thickness. After the strains were obtained for the plain slab, the recess scaled to the slab thickness was bored and strains were obtained for a loading scaled to the slab thickness. Figure 17b shows the edge of the slab after the recess scaled to the slab thickness had been bored. Figure 18 shows the loading device for the contact area scaled to the radius of relative stiffness in position to obtain strains for the slab without a recess. Stresses parallel to the edge computed from the measured strains are

given in Table 9. The stresses per pound of load shown in Table 9 for each method of scaling are presented graphically in Figure 19.

40. The Hydrostone slab used for these tests was instrumented on the top and bottom with Type AFX-7, SR-4 electrical strain rosettes mounted so that strains parallel and perpendicular to the edge along two lines normal to the edge were indicated. The recesses and loads were positioned symmetrically about the lines of rosettes. With the load applied tangent to the edge, strains were obtained with no recess in the slab and with a recess bored completely through the slab. As in the concrete slab, the strains were obtained at one of the lines of gages for: (1) the slab plain and the contact area of the load scaled to the radius of relative stiffness and to the slab thickness, and (2) the slab with a recess and the contact area of the load scaled to the slab thickness. Strains for the slab with a recess and the contact area of the load scaled to the radius of relative stiffness were obtained at the alternate line of gages. Stresses per pound of load parallel to the edge computed from the measured strains are given in Table 10. These same stresses are presented graphically in Figure 20.

41. The percent reduction in load-carrying capacity effected by the recess for each combination of slab material and scaling method is shown with the stress curves corresponding to each combination on Figures 19 and 20. These percentages of reduction in load-carrying capacity were based on maximum stresses obtained by extrapolation from the curves of these figures. Equation 6 was used to convert the maximum stresses into percent reduction in load-carrying capacity.

Behavior of Slabs Loaded to Complete Failure

42. In order to provide a better understanding of the behavior under load of slabs containing bored recesses near the edge, four model slabs were studied under load to failure with and without recesses. It was hoped that, besides indicating something of the nature of the cracking associated with failure, this supplemental investigation would yield information which would indicate whether the percentages of reduction in load-carrying capacity determined with low loads in the scheduled tests obtain over the entire range of elastic behavior.

43. In the majority of cases, the load was applied tangent to the edge; in the remaining instances, the load was centered over a recess. The load simulated was one having a 267-square inch circular contact area. The inset light represented by the model was the 10-inch diameter fixture centered 13 inches from the edge of a 10-inch thick slab. Where the tests were performed with the recess, the 8-inch deep and 10-inch deep (the entire depth of the slab) prototype recesses were simulated.

In a number of cases, the tests were performed with a plug simulating a light fixture filling the recess. Three of the slabs were instrumented on the bottom with SR-4 electrical strain gages. The fourth slab was not instrumented. For each loading on the instrumented slabs, there was at least one gage capable of indicating strain parallel to and approximately 0.15 inch from the edge. The relative positions of the loads, recesses, and gages are shown schematically in Figure 21.

44. The testing consisted of loading each slab in 1-pound increments until the slab cracked initially, and observing strains for each increment of load. After noting the crack pattern associated with the initial cracking, the loading was continued in 1-pound increments to complete failure. At complete failure, the crack pattern was noted again. Some of the resulting crack patterns are shown in Figure 22. As noted, each pattern shown on this figure is associated with a different set of loading conditions.

45. The gages for Slab 4 were arranged as they were in an endeavor to detect whether, in a slab having a recess, strains greater than the strain at the point of tangency of the load with the edge develop at any other point in the slab. The measured strains for the case where the gages were arranged so that strain at the edge could be compared with strain at several points on the periphery of an 0.166-inch deep recess are given in Figure 23. Figure 24 shows the strains measured near the edge and recess with the recess bored the full depth of the slab.

PART VI: ANALYSIS AND DISCUSSION OF TEST RESULTS

Effect of Simulated Centerline Inset Light Fixtures on Load-Carrying Capacity of a Slab

46. The test data accumulated to study the effect of centerline inset light fixtures on the load-carrying capacity of a slab, as given in Table 2 and Figure 11, indicate that the percent reduction in load-carrying capacity of the slab was affected most by change in recess depth when the recess was shallow or deep. When the recess depth was such that the bottom of the recess was at or slightly above or below the neutral axis of the slab, changes in depth did not affect greatly the percent reduction in load-carrying capacity of the slab. In all cases, the distance from the edge of the slab to the point on the edge of the recess nearest the edge of the slab represented a prototype distance of 8.0 inches, making the different diameter recesses centered different distances from the edge of the slab. For this reason, the effect of recess diameter on the percent reduction in load-carrying capacity could not be separated from the effect of the distance from the edge of the slab to the center of the recess. While the different effects cannot be isolated completely, there was some indication of the effect of recess diameter on the percent reduction in load-carrying capacity where the recess depth was approximately 50 to 60% of the slab thickness. The grooves were cut after several recess depths had been studied so that the effect of the groove could be isolated more easily. The data show that the highest stress, and thus the greatest percent reduction in load-carrying capacity, occurred with only the recess in the slab. The addition of the groove parallel to the edge of the slab relieved the critical stress, while the further addition of the groove from the groove parallel to the edge to the recess had a negligible effect on the stress. These responses indicate that the reduction in load-carrying capacity was less for the complete inset light installation (recess plus sawkerfs) than for a recess alone. The percentages of reduction in load-carrying capacity observed for the slabs with the recesses completely through and with the grooves are shown in Figure 25.

Effect of Simulated Narrow-Gauge Inset Light Fixtures on Load-Carrying Capacity of a Slab

47. The test data accumulated to study the effect of narrow-gauge inset light fixtures on the load-carrying capacity of a slab, as given in Table 4 and Figure 13, show that all recess depths investigated tended to reduce the load-carrying capacity of the slab. For the three prototype thicknesses simulated, the data show that a single 1-inch deep recess reduced the load-carrying capacity approximately 10%.

With the introduction of the additional 1-inch deep recesses required to simulate a narrow-gauge installation, the critical edge stresses were relieved slightly, resulting in a total reduction in load-carrying capacity of only 7 to 8%. As the depth of the recesses increased, the load-carrying capacity of the slab decreased. As with the centerline fixtures, the effect of the recess diameter on the load-carrying capacity was obscured by the fact that the distance of the recess from the edge of the slab was not held constant from one diameter to another. The grooves were cut from the fixture to the edge after several recess depths had been studied, so that the effect of the groove could be isolated more easily. The data show that cutting the grooves resulted in a significant increase in the critical stress and an additional reduction in the load-carrying capacity of approximately 5 to 9%. The percentages of reduction in load-carrying capacity observed for the recesses completely through the slab are shown graphically in Figure 25.

Effect of Recess at Interior of Slab on

Load-Carrying Capacity of a Slab

48. The results of the testing to determine the effect of a recess at the interior of a slab on the load-carrying capacity of the slab, given in Table 5 and Figure 14, show that, of the three load positions investigated, greatest stresses developed with the loaded area centered over the edge of the recess. Although it may have been possible to develop greater stresses using some slightly different load position, it was felt that the data obtained with the footprint centered over the edge of the recess were sufficient to demonstrate the existence of and, roughly, the magnitude of the reduction in load-carrying capacity resulting from a recess being introduced at the interior of a slab. It might be noted that the percentages of reduction in load-carrying capacity for this load position and the recesses 60 and 80% of the thickness deep agreed quite well with the percentages obtained for the edge loading of a slab of the same thickness and recess depth for a recess simulating a centerline inset light fixture of the same diameter (Table 5 and Figure 11). With the recess completely through the slab, the reduction in load-carrying capacity was approximately 15 percentage points more than that effected by a centerline fixture near the edge.

Effect of Sawkerf on Load-Carrying Capacity of a Slab

49. To study the effect of a sawkerf perpendicular to the edge on the load-carrying capacity of a slab, the stresses computed from the measured strains were compared with the theoretical stresses for plain slabs on Figure 16. The difference between the curve representing the average experimental stress for the model slab without a groove (plain) and the curve of theoretical stress was the same as had been

observed previously in testing similar models. The curves of average experimental stress for slabs with the grooves deepened at the edge and for slabs with uniformly deep grooves indicated that, over the slab thickness range investigated, each groove condition effected a more or less constant increase in the edge stress. Expressed in percent, the average experimental stresses for the plain slab and the slab having a groove deepened at the edge show that the reduction in load-carrying capacity varies from 12% for the 10-inch thick slab to 7% for the 20-inch thick slab (Table 7). Although the information obtained for the groove uniformly deep did not represent a condition now associated with inset light installation, the information may prove useful in evaluating proposed modifications to the installation procedures.

Comparison of Scaling to Radius of Relative Stiffness and

Scaling to Slab Thickness

50. It can be seen from the magnitude of the stresses given in Figures 19 and 20 that scaling to the slab thickness produced generally higher stresses than scaling to the radius of relative stiffness. Where no recess was present, the maximum stress for both the Hydrostone and concrete slabs and for both scaling methods occurred at the edge of the slab. With the horizontal dimensions scaled to slab thickness and a recess bored completely through the slab, maximum stress for both the Hydrostone and concrete slabs also occurred at the edge of the slab. However, with the horizontal dimensions scaled to the radius of relative stiffness and a recess bored completely through the slab, maximum stress for both the Hydrostone and concrete slabs occurred at the point where the edge of the recess was closest to the edge of the slab. The percentages of reduction in load-carrying capacity, as given on Figures 19 and 20, were in good agreement in that they were all of the same order of magnitude. The percentages, however, exhibited a slight inconsistency in that there was a reversal in the trends. Since the percent reduction in load-carrying capacity was quite sensitive to slight variations in the values on which it was based, this reversal may have resulted from the strains for the loadings scaled to radius of relative stiffness not being obtained at the same location with and without a recess.

51. The percent reduction in load-carrying capacity shown on Figure 20 for the case where the horizontal dimensions were scaled to the radius of relative stiffness (28.2%) was in good agreement with the results, with the groove effects removed, of Test 1 shown in Table 2, $31.1 + (20.8 - 15.9) = 36.0\%$. The stresses on which the percentages in these two cases were based were also in good agreement.

52. The results of this set of tests are not extensive enough to serve as a basis for making more than a superficial comparison of the two scaling methods. Since the strains for the plain slabs loaded through contact areas scaled to the radius of relative

stiffness were not obtained at the same test location as the strains for the slabs with a recess completely through, it is believed that some discrepancy exists in the tests to study scaling to the radius of relative stiffness. It should be noted, also, that the edge stresses for the plain slabs were, in all instances but one, equal to or greater than the theoretical stresses; whereas, past experience has shown the theoretical stresses to be greater than the measured stresses. Since these data were somewhat erratic, they are presented to indicate trends rather than as the basis for any quantitative conclusions.

Behavior of Slabs Loaded to Complete Failure

53. The data pertaining to the behavior of slabs loaded to complete failure, given in Table 11, were not extensive; however, they were sufficient, in several instances, to indicate trends. In Slab No. 2 with the load tangent to the edge, the initial cracking occurred at 43 pounds with no recess; and, in two cases, at 35 pounds and 34 pounds with a recess 0.160 inch deep and empty. These failure loads indicated an average reduction in load-carrying capacity of $(43.0 - 34.5)/43.0 = 19.8\%$. This value is in good agreement with the percent reduction in load-carrying capacity, 20.8%, shown on Table 2 for a 10-inch thick pavement with a 10-inch diameter recess 80% of the slab thickness deep. The fact that these two percentages agree is some indication that the percentages of reduction in load-carrying capacity determined in the scheduled tests using loads well below the initial crack load hold throughout the elastic range of the slab and subgrade.

54. Where the recess was completely through the slab, the average initial crack load for Slab No. 3 was 31.5 pounds. Using the 43-pound initial crack load for a plain slab obtained from Slab No. 2, instead of the 36-pound load obtained from Slab No. 3, which appears to be too low, the reduction in load-carrying capacity was $(43.0 - 31.5)/43.0 = 26.7\%$. This value is somewhat less than the comparable value, $31.1 + (20.8 - 15.9) = 36.0\%$, obtained from Test 1 and shown in Table 2.

55. The tests conducted with a plug in the recess were of an exploratory nature to investigate whether or not a fixture in a recess possessed some ability to restore a portion of the load-carrying capability which the boring of the recess removed from the slab. It appears from the data that having a plug in the recess caused the slab to fail initially at a lower load and at a lower unit stress than with the recess empty. It may have been that the plug used filled the recess in such a way that points of high stress concentration were developed. If high stress concentrations did develop at the plug, the conditions produced were unlike those associated with the fixtures cemented into the recesses in full-scale pavement. In the prototype, since the ability, if any, of a fixture to strengthen a pavement would vary from installation to installation and could not be evaluated, the scheduled tests were performed with no plug in the recess.

56. The crack patterns given in Figure 22 show schematically the cracking resulting from loading to complete failure for five of the loadings for which data are presented in Table 11. It can be seen from these patterns that the cracking associated with initial failure was practically the same for all conditions, whether the slab contained a recess or not. In each case, at initial failure, a single crack running perpendicular to the edge and along the axis of symmetry of the loading formed as a result of excessive tension in the bottom surface of the slab. On loading beyond the initial crack, however, the cracking associated with a plain slab was not as extensive as that associated with a slab containing a recess. In the plain slabs, additional loading beyond the initial crack load produced no additional cracks resulting from excessive tensile stresses in the bottom surface of the slab. In the slabs containing a recess, additional loading beyond the initial crack load produced cracks radiating from the recess as a result of excessive tension in the bottom of the slab. At complete failure, cracking resulting from excessive tensile stresses in the top surface developed around and at some distance from the load.

57. A portion of the strain data obtained from Slab No. 4 to determine whether strains greater than the strain at the point of tangency of the load with the edge of the slab developed at any other point in the slab are presented in Figures 23 and 24. Figure 23 gives the strains in the bottom of the slab parallel to the edge at the edge of the slab and at various points on the periphery of the recess, as shown in the diagram on the figure. In this test, the depth of the recess was approximately 80% of the slab thickness. It can be seen from the curves of measured strain that the gage nearest the edge of the slab indicated the greatest strain.

58. Figure 24 gives the strains in the bottom of the slab parallel to the edge at the edge of the slab and at two points near the edge of the recess, as shown in the diagram on the figure. In this test the recess had been bored completely through the slab. It can be seen from the curves of measured strain that the gage at the edge of the recess closest to the edge of the slab indicated the greatest strain. It was observed later in some of the scheduled tests that for low loads this condition existed. These data indicated that throughout the elastic range of the slab and subgrade, the strain parallel to the edge and at the edge of the recess closest to the edge of the slab is greater than the strain at the edge of the slab for loads tangent to the edge.

Comparison of Model Test Results with Prototype Pavement Performance

59. Because model tests of the type employed in this study have been used successfully in the past to analyze the structural behavior of rigid pavement, the quantitative results of the tests described herein are considered accurate and truly

indicative of the stress conditions in prototype slabs for the range of conditions simulated by the model. However, in evaluating the significance of the absolute numbers comprising the results, a realistic view of the implications associated with these numbers must be taken. The model tests compare the critical stresses for slabs loaded at or near the most critical load position, and the impression may be obtained that an entire pavement could be weakened by the introduction of sawkerfs and bored recesses to the degree indicated by the absolute numbers. In reality, the stated reductions apply only in the vicinity of a finite number of isolated points and for the exact loading conditions simulated by the model tests. In full-scale pavement, such isolated points may receive only infrequent loadings of the type and orientation used in the model tests; while the balance of the pavement, having the full design load-carrying capacity, carries the bulk of the traffic.

60. Since the model tests did not simulate the prototype conditions exactly, the installation of light fixtures in full-scale pavement may not be as detrimental as the model tests indicate. In full-scale pavement, the fixtures are cemented into the bored recesses which permits a load applied to the fixture to be distributed to the pavement along the walls of the fixture as well as through the bottom of the fixture. Since the model tests were conducted either with an uncemented plug in the recess or with the recess empty, the loading conditions for the model tests are considered to be more severe than those for a prototype installation. Similarly, the model tests were performed using a free-edge condition for the simulated slab. In full-scale pavement, all joints along which lights will be installed have load transfer devices to transfer part of the load on the loaded slab to the adjoining unloaded slab. While the degree of load transfer in the initial pavement design is assumed to be 25%, actual field tests indicate this is generally a minimum value and, depending upon the type and condition of joint, can be as high as 50%. Therefore, a reserve load transfer capability is usually available so that, as a loaded slab is weakened, additional load is transferred to the adjoining slab at that point and the maximum stress in the loaded slab is reduced.

61. It should be pointed out also that experience indicates that holes bored in pavement may not be as detrimental as the model tests would indicate. For example, in full-scale test track studies of rigid pavement, 6-inch diameter holes have been bored through the depth of the slab at the interior and along the edges for gage installations or foundation investigations. Traffic was continued on these test pavements and, insofar as it was possible to determine, the bored holes did not affect materially their performance. Similarly, holes have been cored through in-place rigid pavement for various investigations. Normally these holes are refilled with mortar or concrete, but without special efforts to bond the replacement concrete to the in-place pavement. There have been no positive indications that such holes have affected materially either pavement performance or pavement life.

62. It is probable that the increased stresses in the slab resulting from the recesses or sawkerfs occur as localized stress concentrations. In the inelastic range, stress concentrations in full-scale slabs may produce a different action than in model slabs. At points where the stress concentrations exceed the strength of the full-scale slab, minute cracking may occur in the bottom of the slab, permitting a redistribution of the stresses. While the stresses will continue to be higher than for the condition of no recesses and no sawkerfs, the stress levels may not be as high as the model tests indicate. Failure (cracking from the bottom to the top of the slab) of the slab having minute cracking in the bottom would result then from repetitive loading. Although the static load model tests indicate that recesses and sawkerfs combined reduce pavement life, the reduction may not be as great as the test data imply.

PART VII: SUMMARY OF TEST RESULTS

63. The analyses of the data obtained from the small-scale model tests performed to study the effect of sawkerfs and bored recesses on the load-carrying capacity of a slab permitted the following general observations:

a. A recess of any depth in a slab tends to lower the load-carrying capacity of that slab. The test data indicate that the percent reduction in load-carrying capacity of the slab is affected most by change in recess depth when the recess is shallow or deep. When the bottom of the recess was near the neutral axis of the slab, changes in recess depth did not effect large changes in the percent reduction in load-carrying capacity. The test results indicate that a 1-inch deep recess in slabs from 10 to 20 inches thick effects a reduction in load-carrying capacity of approximately 10% (Figures 11 and 13). With the recess simulating a centerline fixture completely through the slab, the reduction in load-carrying capacity indicated by the tests was as much as 34% (Figure 11). With the recesses simulating the narrow-gauge fixtures completely through the slab, the reduction in load-carrying capacity indicated was as much as 39% (Figure 13).

b. Since the different diameter recesses were centered different distances from the edge of the slab, the individual effects of recess diameter and of distance from the center of the recess to the edge of the slab on the percent reduction in load-carrying capacity were obscured. However, some indication as to the different effects can be noted where the recess depth was approximately 40 to 60% of the slab thickness. Increasing the diameter of the recess from 10 to 12 inches had relatively little effect on the percent reduction in load-carrying capacity (Figures 11 and 13). Increasing the recess diameter from 8 to 10 inches, however, did effect a material increase in the percent reduction in load-carrying capacity (Figure 11).

c. With the recess depth as much as 80% of the slab thickness, maximum strain parallel to the edge occurs at the edge of the slab (Figure 23). With a recess near the edge of a slab and completely through the slab, the strain parallel to the edge and at the point on the edge of the recess closest to the edge of the slab is greater than the strain at the edge of the slab for a load tangent to the edge (Figure 24).

d. In a slab containing a recess, a sawkerf, or both, the ratio of the maximum stress to the load is constant throughout the elastic range of the slab and subgrade (Figure 7).

e. In a centerline fixture installation, the primary sawkerf parallel to the edge of the slab tends to relieve the critical stresses (Table 2).

f. In a centerline installation, the sawkerf from the primary sawkerf to the fixture has little or no effect on the load-carrying capacity of the slab (Table 2).

g. In a narrow-gauge fixture installation, the critical stresses at one fixture tend to be relieved slightly by the presence of adjacent fixtures. The percent increase in load-carrying capacity effected by the adjacent fixtures was, in the model, from 2 to 3 percentage points (Table 4). It was possible to make this observation only for the shallowest recesses investigated.

h. In a narrow-gauge fixture installation, the sawkerfs from the fixtures to the edge effect a reduction in the load-carrying capacity of the slab. For the same depth sawkerf, the model tests showed a reduction in load-carrying capacity of approximately 8 percentage points for the 10-inch thick slab to approximately 3 percentage points for the 20-inch thick slab (Table 4).

i. The model tests indicated that a prototype sawkerf 1 inch deep, deepened from 1 inch deep 9 inches from the edge to a depth of one-sixth of the slab thickness plus 0.5 inch at the edge, reduces the load-carrying capacity from 9% for a 10-inch thick slab to 6 percent for a 20-inch thick slab (Table 7).

j. The crack pattern associated with initial cracking is practically the same for a slab with a recess near the edge and a slab with no recess (Figure 22).

k. The crack pattern associated with complete failure is not the same for a slab with a recess near the edge and a slab with no recess (Figure 22).

l. The results of an investigation involving a single case in the model indicated that having the contact area of the load centered on or approximately on a point on the periphery of a recess at the interior of a slab produces the most severe interior loading condition. It was indicated also that, percentagewise, with a recess depth of up to 80% of the slab thickness, the reduction in load-carrying capacity effected by the recess at the interior is similar to that effected by a centerline fixture near the edge (Table 5 and Figure 14). With the recess completely through the slab, however, the percent reduction in load-carrying capacity is greater than that effected by a centerline fixture near the edge (Table 2 and Table 5).

m. Scaling the model to slab thickness rather than to radius of relative stiffness produces greater stresses (Figures 19 and 20).

n. The model with a Hydrostone slab and the model with a concrete slab respond similarly to scaling to slab thickness (maximum stress at edge with and without recess) and scaling to radius of relative stiffness (maximum stress at edge without recess and at edge of recess closest to edge of slab with recess completely through slab) (Figures 19 and 20).

PART VIII: CONCLUSIONS

64. Based on the analyses of the data obtained from the small-scale model tests performed to study the effect of sawkerfs and bored recesses on the load-carrying capacity of a slab, the following conclusions, applicable only to the range of prototype conditions simulated by the model, have been drawn:

a. A recess of any depth in a slab tends to lower the load-carrying capacity of that slab. With the recess depth as much as 80% of the slab thickness, the load-carrying capacity of the slab is dependent on the maximum strain developed parallel to and at the edge of the slab. With the recess near the edge of the slab and completely through the slab, the load-carrying capacity is dependent on the maximum strain developed parallel to the edge of the slab at the point on the edge of the recess closest to the edge of the slab.

b. In a slab containing a recess, a sawkerf, or both, the ratio of the maximum stress to the load is constant throughout the elastic range of the slab and subgrade.

c. Sawkerfs perpendicular to the edge of a slab, such as the sawkerfs from the fixtures to the edge in a narrow-gauge fixture installation, effect a reduction in the load-carrying capacity of that slab.

d. A sawkerf perpendicular to the edge of the slab, such as the sawkerf from the primary sawkerf to the fixture in a centerline fixture installation, has little effect on the load-carrying capacity of that slab.

e. The deeper the sawkerf perpendicular to the edge of the slab, the greater the reduction in load-carrying capacity of that slab.

Table 1

Prototype and Model Dimensions for
Runway Centerline Inset Light Tests

Test No.	13*	14*	15	1	2	3	7	8	9
Slab Thickness, in.	Prototype Model	15 0.200	20 0.200	10 0.200	15 0.200	20 0.200	10 0.200	15 0.200	20 0.200
Radius of Relative Stiffness, in.	Prototype Model	58.51 2.50	72.60 2.50	43.17 2.50	58.51 2.50	72.60 2.50	43.17 2.50	58.51 2.50	72.60 2.50
Diameter of Recess, in.	Prototype Model	8 0.463	8 0.343	8 0.275	10 0.580	10 0.345	12 0.695	12 0.513	12 0.413
Distance from Edge to Recess Center, in.	Prototype Model	12 0.695	12 0.513	12 0.413	13 0.753	13 0.555	14 0.810	14 0.598	14 0.483
Distance from Edge to Sawkerf, in.	Prototype Model	24 1.390	24 1.025	24 0.828	24 1.390	24 1.025	24 1.390	24 1.025	24 0.825
Depth of Sawkerf at Interior, in.	Prototype Model	1 0.020	1 0.013	1 0.010	1 0.020	1 0.010	1 0.020	1 0.013	1 0.010
Depth of Sawkerf at Edge, in.	Prototype Model	2.17 0.043	3.00 0.040	3.83 0.038	2.17 0.043	3.00 0.040	2.17 0.043	3.00 0.040	3.83 0.038
Diameter of Contact Area of Load, in.	Prototype Model	18.44 1.070	18.44 0.790	18.44 0.636	18.44 1.070	18.44 0.790	18.44 1.070	18.44 0.790	18.44 0.636

* Tests scheduled but not completed.

For Prototype - Subgrade Modulus = 100 pci
Modulus of Elasticity = 4×10^6 psi
Poisson's Ratio = 0.20

For Model - Subgrade Modulus = 55 pci
Modulus of Elasticity = 3×10^6 psi
Poisson's Ratio = 0.25

Reduction in Load-Carrying Capacity Effected by Centerline Inset Light Fixtures

Single Circular Footprint, 267 sq. in. Contact Area

Prototype Slab Thickness	15"	10"	Recess Depth in Percent of Slab Thickness	20.0	30.0	60.0	80.0	80.0	80.0	100.0	--	--
			Percent Reduction in Load-Carrying Capacity	5.5	10.5	17.4	20.8	15.9a	15.9b	31.1	--	--
Prototype Slab Thickness	15"	10"	Recess Depth in Percent of Slab Thickness	10.1	30.2	60.5	80.6	80.6	80.6	100.0	--	--
			Percent Reduction in Load-Carrying Capacity	9.9	18.1	23.2	22.7	23.2a	23.8b	33.5	--	--
Prototype Slab Thickness	15"	10"	Recess Depth in Percent of Slab Thickness	6.5	20.0	40.0	66.7	66.7	66.7	100.0	--	--
			Percent Reduction in Load-Carrying Capacity	10.3	14.0	20.0	20.9	20.9a	20.9b	27.6	--	--
Prototype Slab Thickness	15"	12"	Recess Depth in Percent of Slab Thickness	6.5	19.9	39.8	66.2	66.2	66.2	79.6	100.0	--
			Percent Reduction in Load-Carrying Capacity	7.7	14.4	18.7	22.7	20.0a	21.4b	22.7	30.2	--
Prototype Slab Thickness	15"	8"	Recess Depth in Percent of Slab Thickness	5.0	15.0	30.0	50.0	50.0	50.0	65.0	80.0	100.0
			Percent Reduction in Load-Carrying Capacity	2.7	5.7	7.1	12.5	9.7a	11.0b	15.0	15.4	24.2
Prototype Slab Thickness	20"	10"	Recess Depth in Percent of Slab Thickness	5.1	18.7	30.3	49.5	49.5	49.5	100.0	--	--
			Percent Reduction in Load-Carrying Capacity	7.2	18.2	23.2	30.2	26.4a	26.8b	27.7	--	--
Prototype Slab Thickness	12"	12"	Recess Depth in Percent of Slab Thickness	5.0	14.9	29.7	49.5	49.5	49.5	74.3	100.0	--
			Percent Reduction in Load-Carrying Capacity	9.0	14.1	19.3	24.2	23.1a	25.5b	23.8	32.4	--

a - With sawkerf parallel to edge.

b - With sawkerfs parallel and perpendicular to edge.

Table 3

Prototype and Model Dimensions for
Narrow-Gauge Inset Light Tests

Test No.		4	5	6	10	11	12	16*	17*	18*
Slab Thickness, in.	Prototype Model	10 0.200	15 0.200	20 0.200	10 0.200	15 0.200	20 0.200	10 0.200	15 0.200	20 0.200
Radius of Relative Stiffness, in.	Prototype Model	43.17 2.50	58.51 2.50	72.60 2.50	43.17 2.50	58.51 2.50	72.60 2.50	43.17 2.50	58.51 2.50	72.60 2.50
Diameter of Recess, in.	Prototype Model	10 0.580	10 0.428	10 0.345	12 0.695	12 0.513	12 0.413	14 0.810	14 0.598	14 0.483
Distance from Edge to Recess Center, in.	Prototype Model	13 0.753	13 0.555	13 0.448	14 0.810	14 0.598	14 0.483	15 0.868	15 0.640	15 0.518
Distance Between Fixtures, c to c, in.	Prototype Model	27 1.563	27 1.153	27 0.930	27 1.563	27 1.153	27 0.930	27 1.563	27 1.153	27 0.930
Depth of Sawkerf, in.	Prototype Model	1.50 0.030	1.50 0.020	1.50 0.015	1.50 0.030	1.50 0.020	1.50 0.015	1.50 0.030	1.50 0.020	1.50 0.015
Diameter of Contact Area of Load, in.	Prototype Model	18.44 1.070	18.44 0.790	18.44 0.636	18.44 1.070	18.44 0.790	18.44 0.636	18.44 1.070	18.44 0.790	18.44 0.636
* Tests scheduled but not completed.										

For Prototype - Subgrade Modulus = 100 pci
Modulus of Elasticity = 4×10^6 psi
Poisson's Ratio = 0.20

For Model - Subgrade Modulus = 55 pci
Modulus of Elasticity = 3×10^6 psi
Poisson's Ratio = 0.25

Table 4

Reduction in Load-Carrying Capacity Effected by Narrow-Gauge Inset Light Fixtures
Single Circular Footprint, 267 sq. in. Contact Area

Prototype Slab Thickness		15"		20"		Prototype Recess Diameter										10"	
Recess Depth in Percent of Slab Thickness	10"	10.0	10.0	30.0	60.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	100.0	100.0	--	--
Percent Reduction in Load-Carrying Capacity	11.7a	8.4b	17.1	17.9	20.2	25.3c	28.1d	36.7	--	--	--	--	--	--	--	--	--
Recess Depth in Percent of Slab Thickness	10.0	28.9	59.7	80.1	80.1	80.1	100.0	--	--	--	--	--	--	--	--	--	--
Percent Reduction in Load-Carrying Capacity	11.6b	16.4	20.2	22.3	29.0c	26.0d	39.3	--	--	--	--	--	--	--	--	--	--
Recess Depth in Percent of Slab Thickness	6.5	6.5	20.0	40.0	68.5	68.5	68.5	80.0	100.0	--	--	--	--	--	--	--	--
Percent Reduction in Load-Carrying Capacity	12.4a	12.7b	18.6	19.5	18.2	19.3c	21.5d	22.5	31.9	--	--	--	--	--	--	--	--
Recess Depth in Percent of Slab Thickness	6.6	20.3	40.6	67.5	67.5	67.5	83.8	100.0	--	--	--	--	--	--	--	--	--
Percent Reduction in Load-Carrying Capacity	12.7b	16.7	16.4	16.1	23.1c	25.0d	23.8	36.5	--	--	--	--	--	--	--	--	--
Recess Depth in Percent of Slab Thickness	5.9	5.9	14.9	31.7	49.5	49.5	49.5	76.7	100.0	--	--	--	--	--	--	--	--
Percent Reduction in Load-Carrying Capacity	9.3a	6.9b	13.7	16.6	22.5	22.8c	22.5d	24.0	28.7	--	--	--	--	--	--	--	--
Recess Depth in Percent of Slab Thickness	5.0	15.1	30.2	50.4	50.4	50.4	65.5	80.1	100.0	--	--	--	--	--	--	--	--
Percent Reduction in Load-Carrying Capacity	9.2b	13.2	18.8	21.8	26.9c	24.5d	27.4	28.6	33.5	--	--	--	--	--	--	--	--

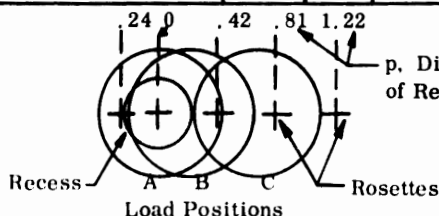
a - With one recess.
b - With all recesses.

c - With sawkerf to center recess.
d - With sawkerfs to all recesses.

Table 5

**Stress per Pound of Load Tangential to
Recess at Interior of Slab**

Recess Depth, d, in.		0	0.013	0.040	0.080	0.118	0.160	0.199
d/Slab Thickness		0	6.5	20.1	40.2	59.3	80.4	100.0
Loading	p	Stress per Pound of Load, psi						
A	0	36.1	35.2	38.0	40.2	39.4	38.4	--
	0.24	34.0	33.2	34.3	36.6	36.8	36.7	--
	0.42	32.0	32.1	34.5	34.4	34.8	36.5	42.8
	0.81	22.8	23.4	24.4	24.3	24.6	25.1	26.2
	1.22	18.4	18.6	19.0	18.7	18.9	19.6	19.6
Maximum Stress	--	36.1	35.2	38.0	40.2	39.4	38.4	53.0
% Reduction in Load-Carrying Capacity	--	--	--	5.0	10.2	8.4	6.0	31.9
B	0	--	--	--	--	38.0	37.7	--
	0.24	--	--	--	--	44.5	47.9	--
	0	--	--	--	--	35.2	33.8	--
	0.42	--	--	--	--	41.9	43.2	52.2
	0.81	--	--	--	--	31.0	32.4	34.7
	1.22	--	--	--	--	23.3	23.4	25.2
Maximum Stress	--	--	--	--	--	44.5	47.9	62.5
% Reduction in Load-Carrying Capacity	--	--	--	--	--	18.9	24.6	42.2
C	0	--	--	--	--	30.9	31.6	--
	0.24	--	--	--	--	39.2	42.6	--
	0	--	--	--	--	29.4	--	--
	0.42	--	--	--	--	39.8	--	--
	0.81	--	--	--	--	37.3	--	--
	1.22	--	--	--	--	30.6	--	--
Maximum Stress	--	--	--	--	--	39.8	--	--
% Reduction in Load-Carrying Capacity	--	--	--	--	--	9.3	--	--



p. Distance of Rosettes from Center of Recess, in.

NOTE: 15-in. thick slab and 10-in. diameter recess simulated.

Table 6

Dimensions for Tests to Determine Effect of Sawkerf on
Load-Carrying Capacity of Slab

	A		B		C	
	Prototype	Model	Prototype	Model	Prototype	Model
Slab Thickness, h, in.	10	0.200	15	0.200	20	0.200
Modulus of Elasticity, E, psi	4×10^6	3×10^6	4×10^6	3×10^6	4×10^6	3×10^6
Poisson's Ratio, μ	0.20	0.25	0.20	0.25	0.20	0.25
Subgrade Modulus, k, pci	100	55	100	55	100	55
Radius of Relative Stiffness, l , in.	43.17	2.50	58.51	2.50	72.60	2.50
Diameter of Loaded Area, $2r$, in.	18.44*	1.070	18.44*	0.790	18.44*	0.636
Sawkerf Depth, d, in.	1.00	0.020	1.00	0.013	1.00	0.010
Sawkerf Depth at Edge, $D, ((h/6) + (1/2))$, in.	2.17	0.043	3.00	0.040	3.83	0.038
Length of Deepened Portion of Sawkerf, L, in.	9.00	0.521	9.00	0.385	9.00	0.310

* 267 sq. in.
Loaded Area

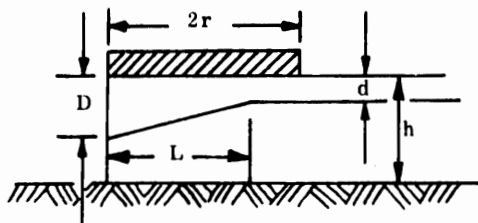


Table 7

Percent Reduction in Load-Carrying Capacity
Effected by Sawkerfs

Test No.	Prototype Slab Thickness, in.	Stress per Pound of Load, psi*				Percent Reduction in Load-Carrying Capacity	
		Plain		Sawkerf Deepened at Edge	Sawkerf Uniformly Deep	Sawkerf Deepened at Edge	Sawkerf Uniformly Deep
		Theory	Meas.	Meas.	Meas.		
	10	57.4	--	--	--	--	--
1-A		--	50.6	55.5	59.3	--	--
2-A		--	50.3	59.4	63.0	--	--
Avg.		--	50.5	57.5	61.2	12.2	17.5
	15	67.6	--	--	--	--	--
1-B		--	57.8	63.8	68.5	--	--
2-B		--	61.5	64.5	71.5	--	--
Avg.		--	59.7	64.2	70.0	7.0	14.7
	20	75.1	--	--	--	--	--
1-C		--	67.5	73.8	77.9	--	--
2-C		--	66.7	70.9	76.8	--	--
Avg.		--	67.1	72.4	77.4	7.3	13.3
* Stress parallel to edge of slab.							

Table 3

Prototype and Model Dimensions for
Scaling Comparison Tests

	Prototype	Concrete Model Slab		Hydrostone Model Slab	
Slab Thickness, in.	10	1.75		0.200	
Modulus of Elasticity, E, psi	4×10^6	4×10^6		3×10^6	
Poisson's Ratio, μ	0.20	0.16		0.25	
Subgrade Modulus, k, pci	100	16.5		55	
Radius of Relative Stiffness, l , in.	43.17	18.26		2.50	
		Scaled to h	Scaled to l	Scaled to h	Scaled to l
Load Diameter, in.	18.44*	3.23	7.80	0.369	1.070
Recess Diameter, in.	10	1.75	4.24	0.200	0.580
Center of Recess from Edge, in.	13	2.28	5.50	0.260	0.753
*267 square inch contact area					

Table 9

**Comparison of Scaling to Radius of Relative Stiffness
and Scaling to Slab Thickness**

1.75-in. Thick Concrete Slab on Untreated Low-Strength Subgrade

Dimensions Scaled to Radius of Relative Stiffness of Slab 7.80-in. Diameter Loaded Area, 4.24-in. Diameter Recess Full Depth of Slab Centered 5.50 in. from Edge							
Load, lb.	Stress Parallel to Edge, psi						
	Plain (No Recess)				With Recess		
	Distance from Edge, in.						
	0.54	2.89	3.65	8.12	0.38	2.85	8.08
50	50	44	32	13	25	57	-2
100	87	76	69	60	46	83	24
150	103	117	76	69	82	141	54
200	163	133	126	93	112	191	79
250	212	170	168	118	135	229	91
300	233	212	182	122	168	269	108
350	258	242	215	123	193	308	141
400	288	273	252	153	217	348	156
450	325	298	287	176	242	387	169
500	367	301	296	201	--	--	--
550	400	353	342	236	--	--	--
600	435	378	380	246	--	--	--
1*	0.722	0.653	0.618	0.402	0.538	0.860	0.376
* Based on values taken from load-stress curves for 450 pounds. (Theoretical stress per pound of load at the edge, 0.732 psi)							
Dimensions Scaled to Slab Thickness 3.23-in. Diameter Loaded Area, 1.75-in. Diameter Recess Full Depth of Slab Centered 2.28 in. from Edge							
	Distance from Edge, in.						
	0.54	2.89	3.65	8.12	0.54	3.65	8.12
50	57	51	43	9	83	54	23
100	105	86	95	31	186	104	40
150	163	123	123	50	248	142	60
200	220	183	155	92	336	188	84
250	287	215	201	109	402	232	83
300	335	260	231	122	442	243	93
350	384	297	257	122	--	--	--
400	430	348	308	151	--	--	--
1**	1.088	0.860	0.780	0.400	1.608	0.928	0.332
** Based on values taken from load-stress curves for 250 pounds. (Theoretical stress per pound of load at the edge, 1.116 psi)							

Table 10

Comparison of Scaling to Radius of Relative Stiffness
and Scaling to Slab Thickness

0.200-in. Thick Hydrostone Slab on Natural Rubber Subgrade

Dimensions Scaled to Radius of Relative Stiffness of Slab 1.070-in. Diameter Loaded Area, 0.580-in. Diameter Recess Full Depth of Slab Centered 0.753 in. from Edge							
	Gages	Plain (No Recess)			With Recess		
Distance from Edge, in. Stress per Pound of Load, psi	Top	0.08 54.4	0.52 46.1	1.17 35.5	0.14 73.2	-- --	1.17 39.6
Distance from Edge, in. Stress per Pound of Load, psi	Bottom	0.06 51.6	0.50 46.2	1.17 32.4	0.12 69.2	-- --	1.18 37.0
Distance from Edge, in. Stress per Pound of Load, psi	Bottom	-- --	-- --	-- --	0.07* 83.2*	0.34* 84.0*	1.22* 51.2*
* Data from limited testing to establish slope shown on Figure 20 (Theoretical stress per pound of load at edge, 57.4 psi)							
Dimensions Scaled to Slab Thickness 0.369-in. Diameter Loaded Area, 0.200-in. Diameter Recess Full Depth of Slab Centered 0.260 in. from Edge							
	Gages	Plain (No Recess)			With Recess		
Distance from Edge, in. Stress per Pound of Load, psi	Top	0.08 89.3	0.52 57.2	1.17 30.3	0.08 122.8	0.52 67.5	1.17 32.1
Distance from Edge, in. Stress per Pound of Load, psi	Bottom	0.06 91.8	0.50 56.6	1.17 28.3	0.06 120.3	0.50 66.1	1.17 29.5
(Theoretical stress per pound of load at edge, 94.2 psi)							

Table 11

Failure Loads for 0.200-in. Thick Slab1.070-in. Diameter Contact Area - 0.580-in. Diameter Recesses

Loading				Slab Number							
				1	2			3		4	
Load Tangent	Plain	--	Load at initial failure, lbs.	49	43	--	--	36	--	--	--
			Distance of strain from edge, in.	0.16	0.15	--	--	--	--	--	--
			Strain at initial failure, psi x 10 ⁶	949	814	--	--	--	--	--	--
			Load at complete failure, lbs.	--	--	--	--	94	--	--	--
	With Plug	Recess depth/slab thickness	--	0.80	0.81	0.82	--	--	--	--	
		Load at initial failure, lbs.	--	32	31	24	--	--	--	--	
		Distance of strain from edge, in.	--	0.16	0.13	0.15	--	--	--	--	
		Strain at initial failure, psi x 10 ⁶	--	698	715	568	--	--	--	--	
		Load at complete failure, lbs.	--	--	64	--	--	--	--	--	
	Empty	Recess depth/slab thickness	0.82	0.82	0.80	--	--	--	0.82	0.80	
		Load at initial failure, lbs.	27	35	34	--	35	--	37	41	
		Distance of strain from edge, in.	0.15	0.15	0.14	--	--	--	0.10	0.10	
		Strain at initial failure, psi x 10 ⁶	684	801	824	--	--	--	889	973	
		Load at complete failure, lbs.	--	--	80	--	67	--	79	76	
	Empty	Recess depth/slab thickness	--	--	--	--	--	--	--	--	
		Load at initial failure, lbs.	--	--	--	--	31*	32	26	--	
		Distance of strain from edge, in.	--	--	--	--	--	--	0.10	--	
		Strain at initial failure, psi x 10 ⁶	--	--	--	--	--	--	398	--	
		Load at complete failure, lbs.	--	--	--	--	53*	55	74	--	
Load over Recess	With Plug	Recess depth/slab thickness	--	0.81	0.86	--	--	--	--	--	
		Load at initial failure, in.	--	33	30	--	--	--	--	--	
		Distance of strain from edge, in.	--	0.15	0.15	--	--	--	--	--	
		Strain at initial failure, psi x 10 ⁶	--	619	620	--	--	--	--	--	
		Load at complete failure, lbs.	--	92	--	--	--	--	--	--	
	Empty	Recess depth/slab thickness	0.81	--	--	--	--	--	--	--	
		Load at initial failure, lbs.	37	--	--	--	--	--	--	--	
		Distance of strain from edge, in.	0.14	--	--	--	--	--	--	--	
		Strain at initial failure, psi x 10 ⁶	671	--	--	--	--	--	--	--	
		Load at complete failure, lbs.	--	--	--	--	--	--	--	--	

*Spalling at bottom edge of recess.

Prototype Simulated: 10-in. diameter fixture in 10-in. thick slab, 267 sq in. single circular load contact area, recess for fixture centered 13 in. from edge.

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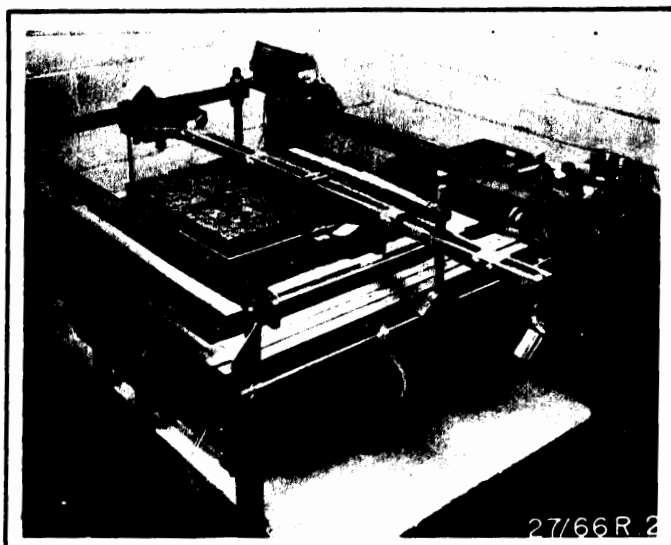


Figure 1. General view of model table with reaction beam used to apply static loads to test slabs.

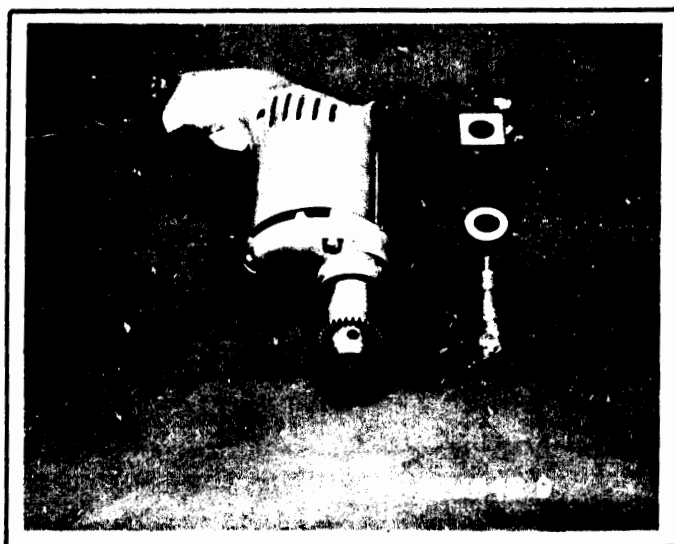


Figure 2. View showing electric drill and components of an assembly for cutting recesses in a slab.



Figure 3. View showing electric drill being used with cutting assembly to bore recess in slab.

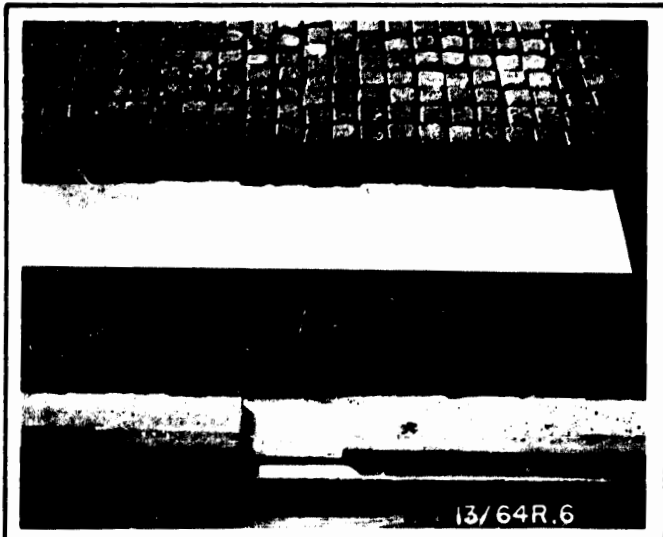


Figure 4. Lead cubes removed from edge of slab to show seven recesses bored partially through slab.

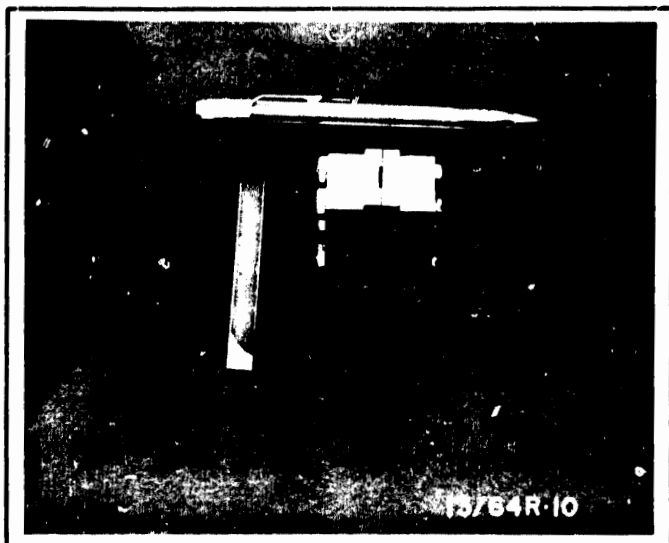


Figure 5. Components of tool for cutting grooves in slab to simulate sawkerfs.

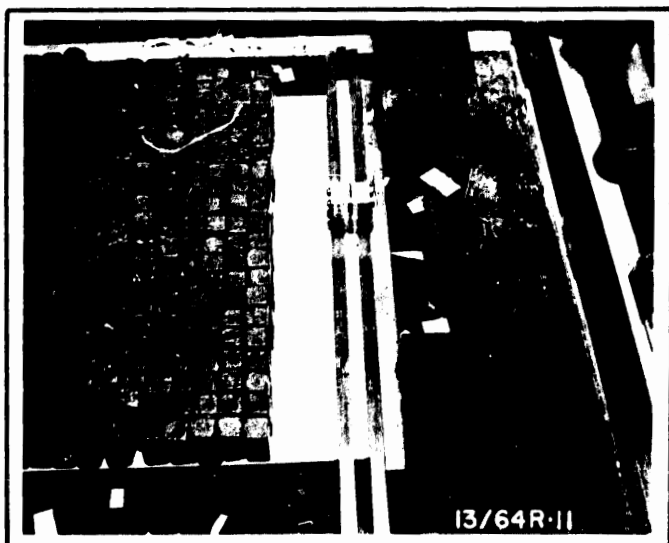
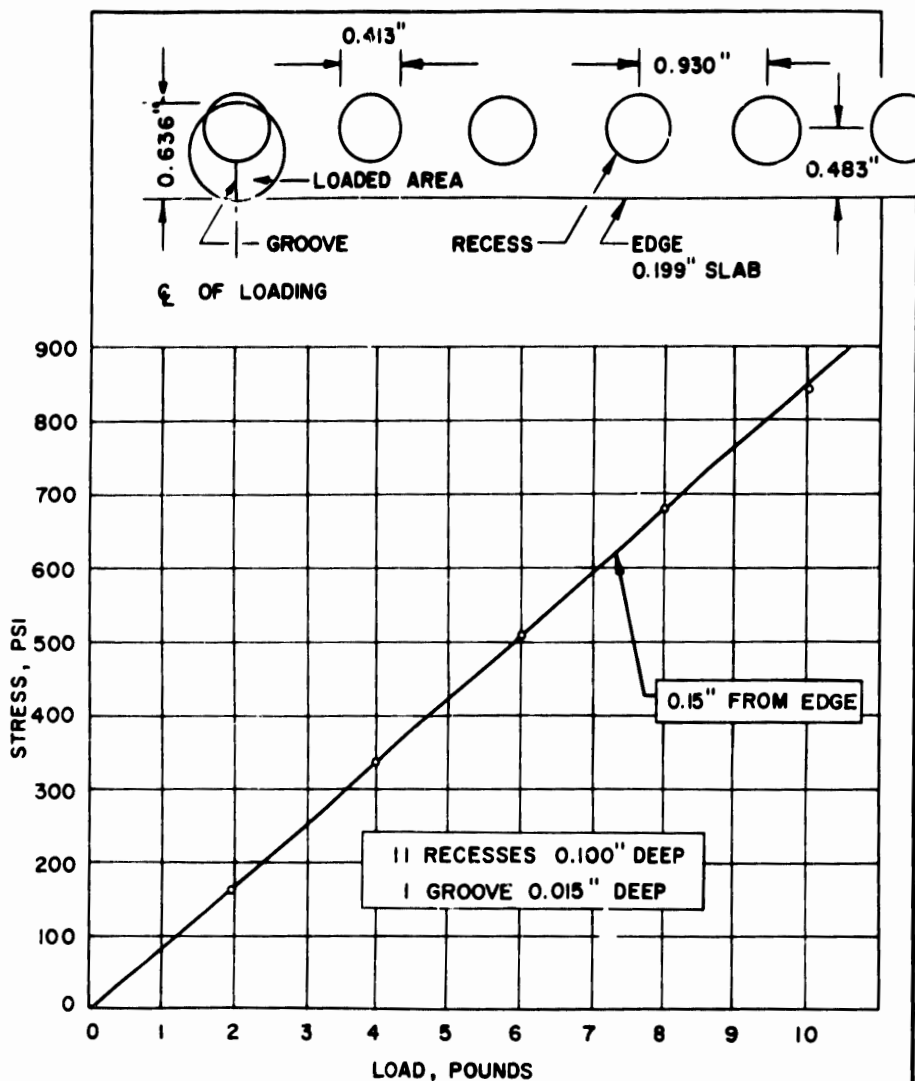


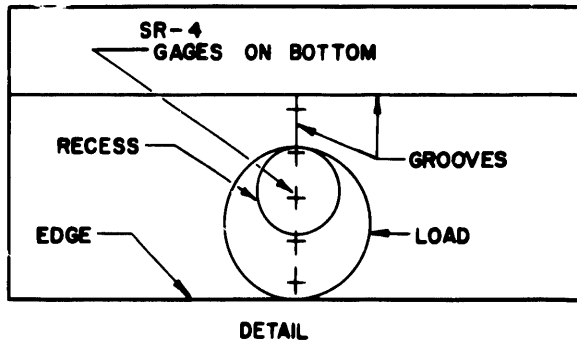
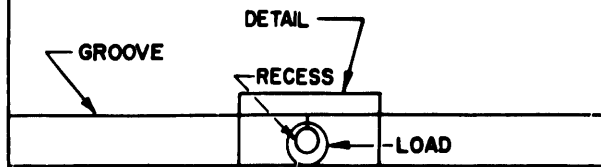
Figure 6. Tool for cutting grooves in slab in position on guides.



CURVE SHOWING LINEAR RELATIONSHIP BETWEEN
LOAD AND STRESS FOR SLAB WITH RECESSES
AND GROOVE LOADED IN ELASTIC RANGE

FIGURE 7

16.75 " x 0.200 "
HYDROSTONE SLAB



LOCATION OF RECESS, GROOVES, LOAD AND STRAIN
GAGES FOR CENTERLINE INSET LIGHT TESTS

FIGURE 8

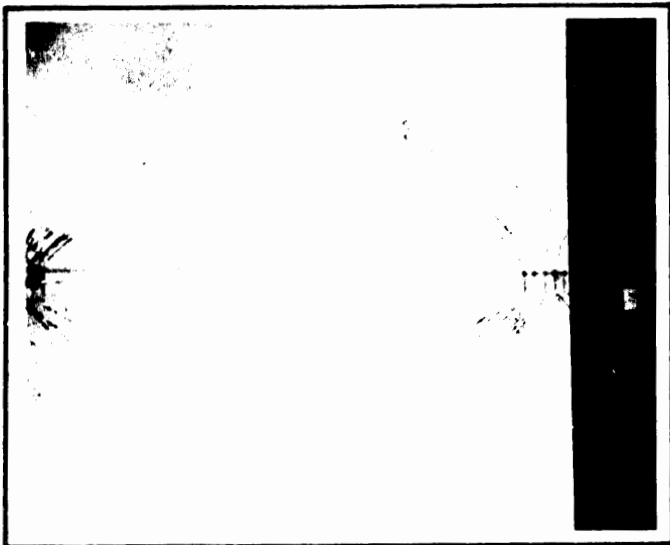


Figure 9. Bottom of a model slab showing Type AFX-7, SR-4 strain rosettes mounted along a line normal to edge with gages parallel and perpendicular to edge.

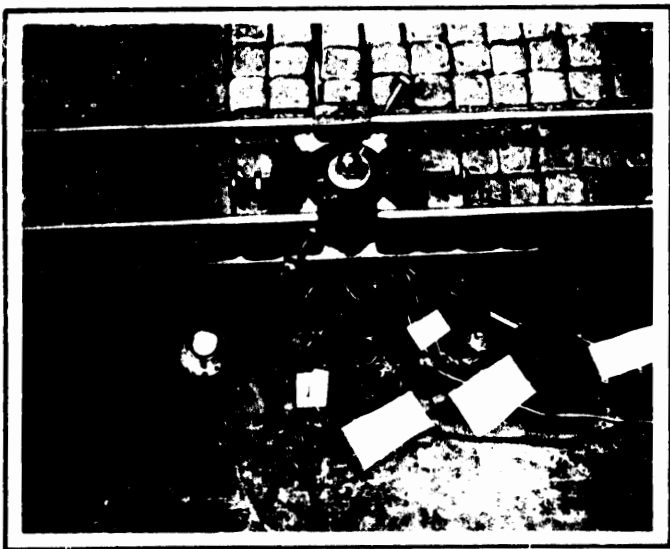
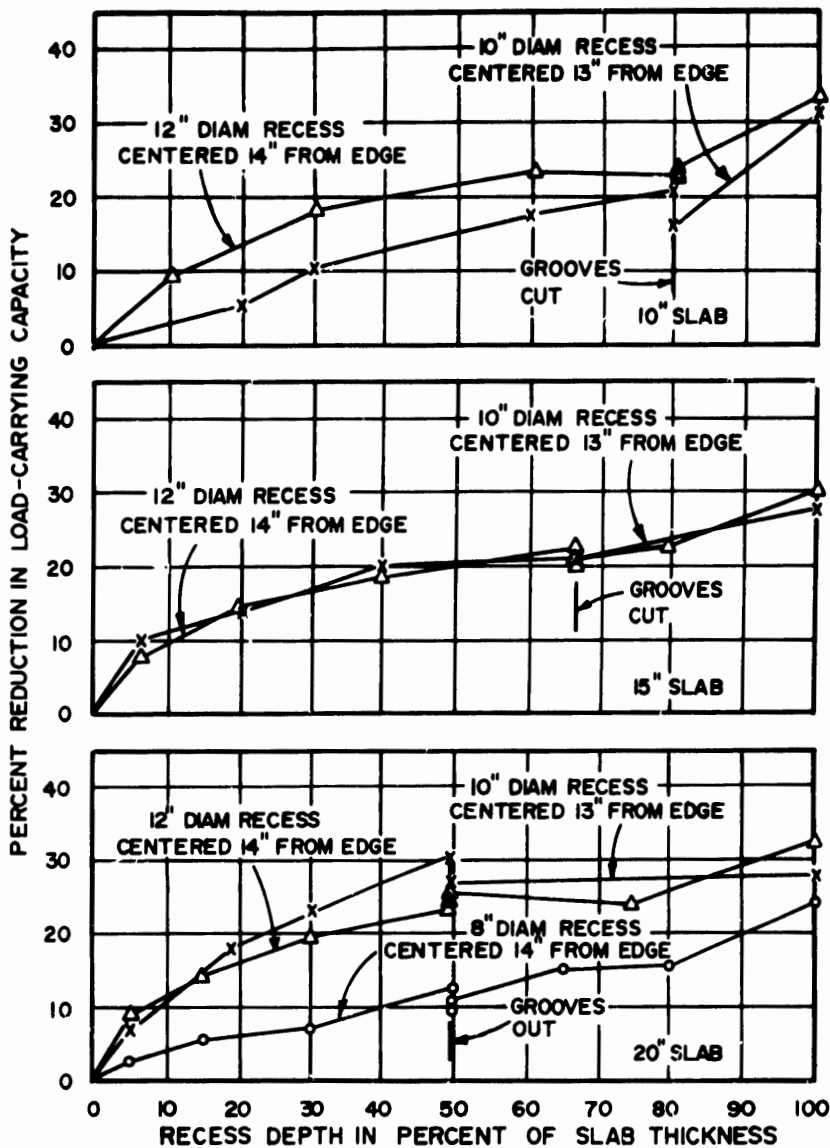


Figure 10. Clamp holding loading device so that load is applied normal to slab. Circular spirit level used to position load is shown in foreground.



REDUCTION IN LOAD-CARRYING CAPACITY
CENTERLINE INSET LIGHT FIXTURES
SINGLE 267 SQ. IN. CONTACT AREA

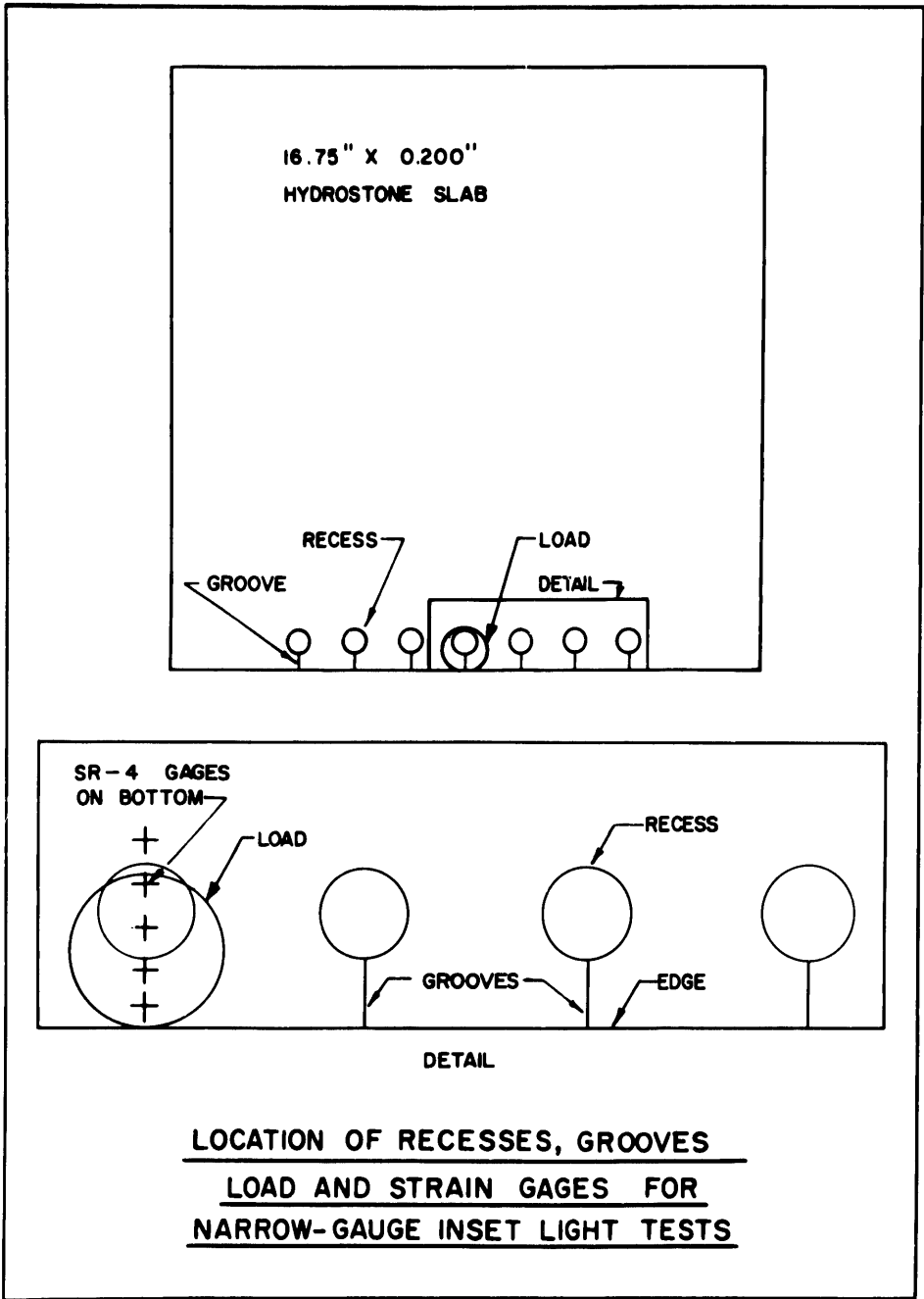
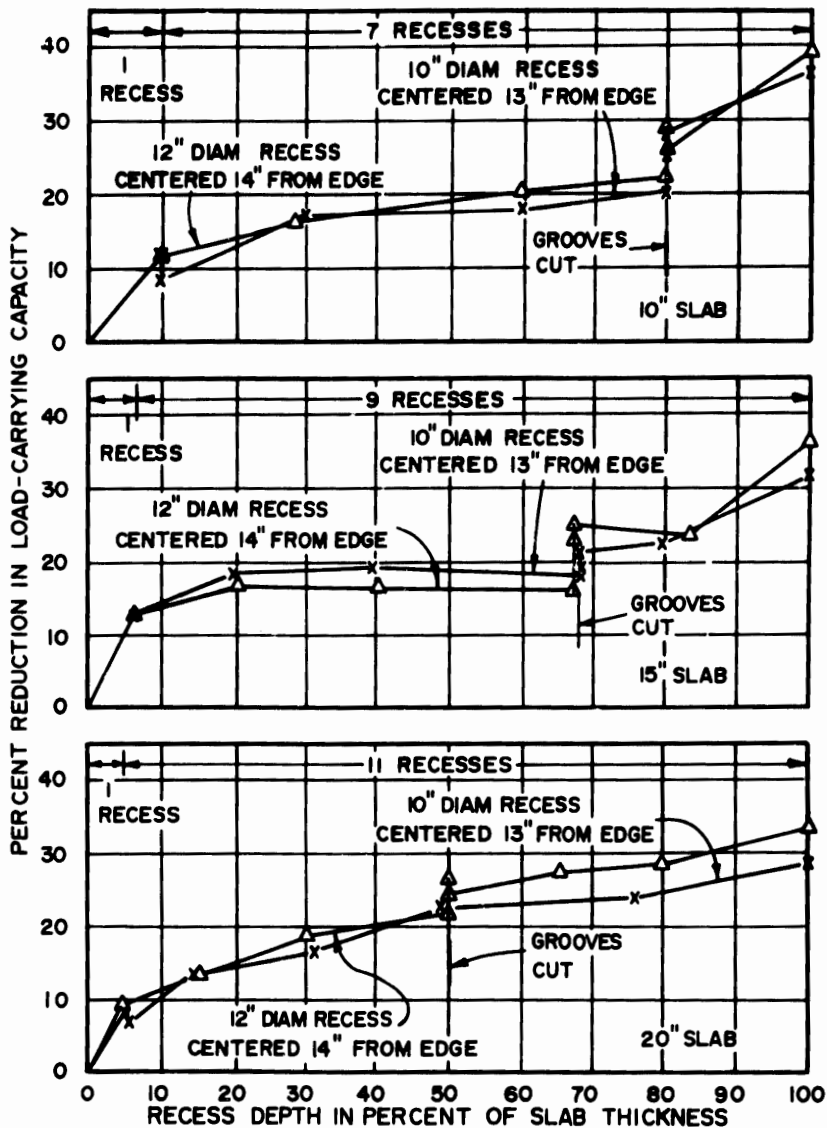
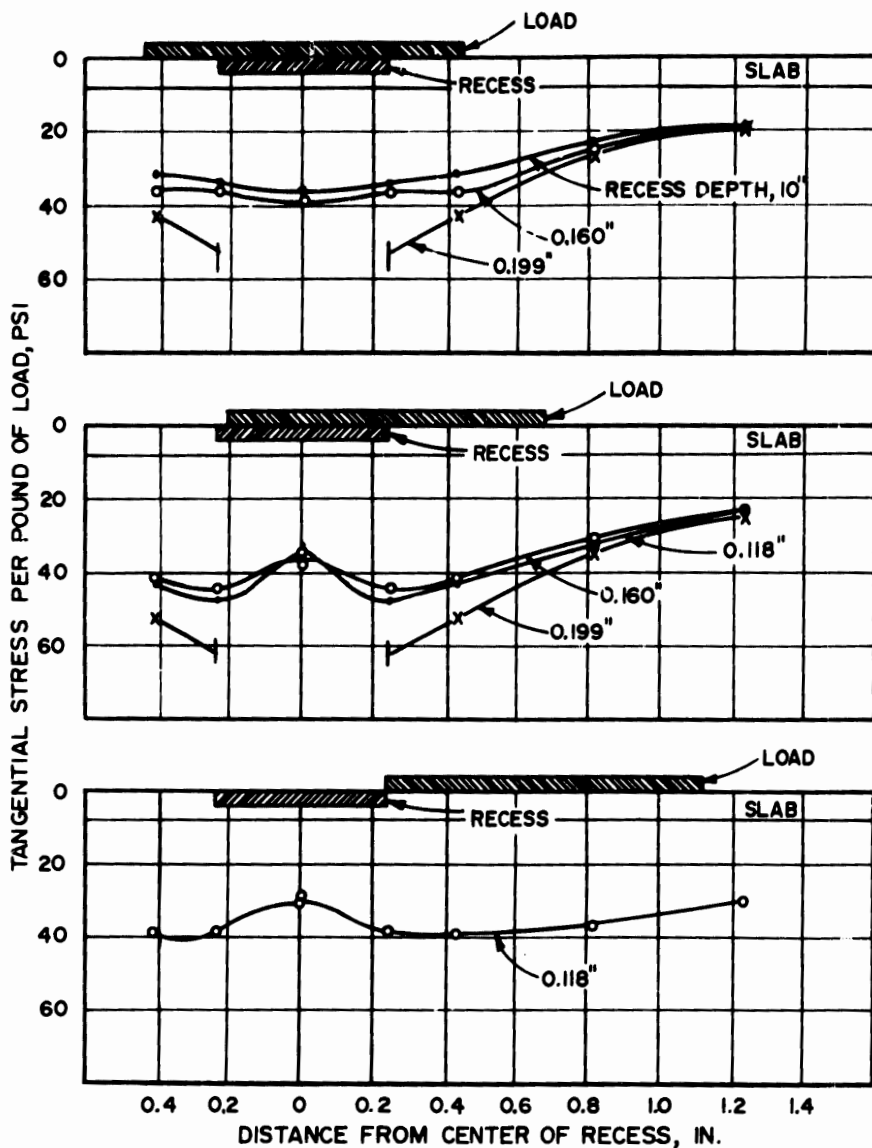


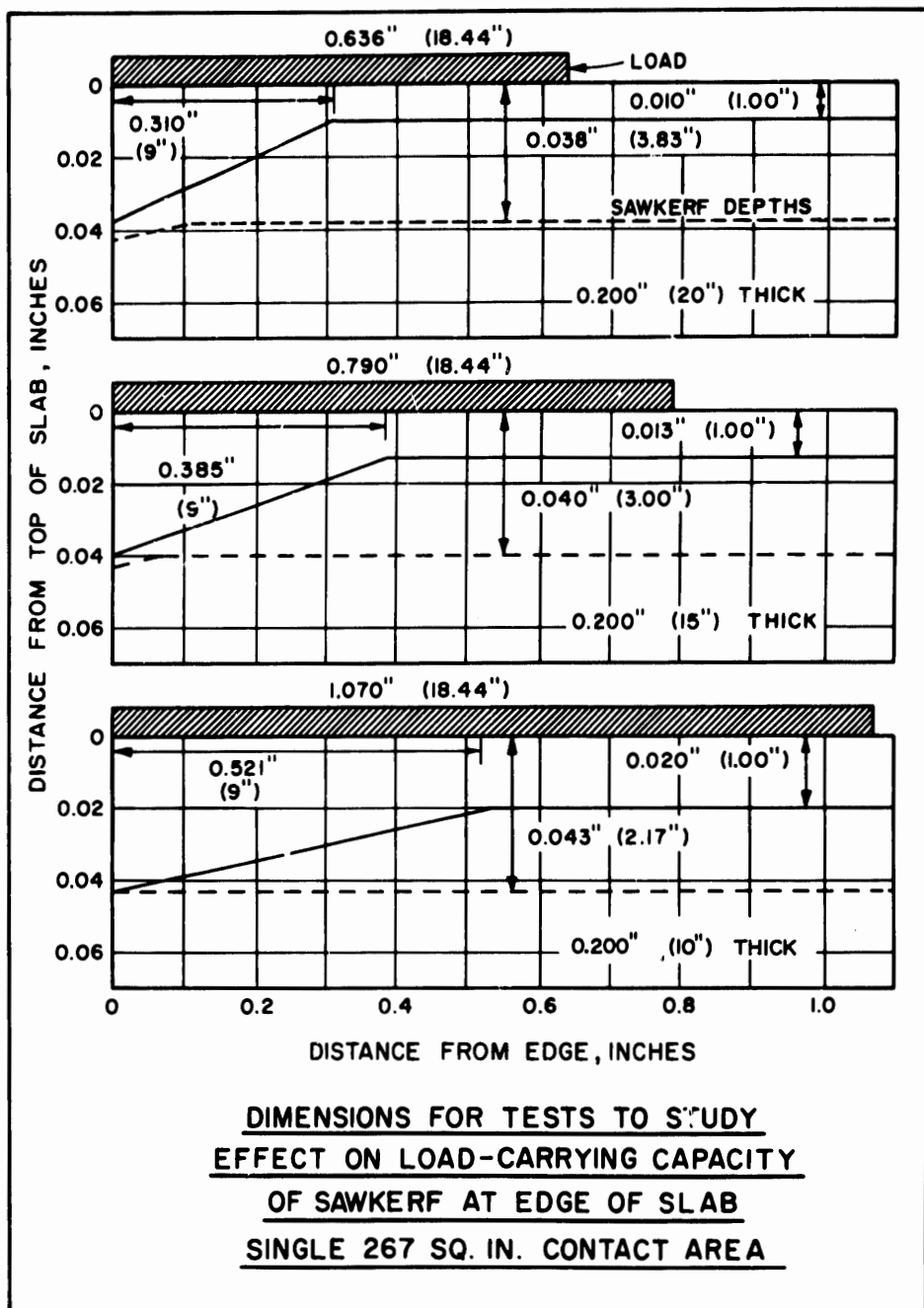
FIGURE 12

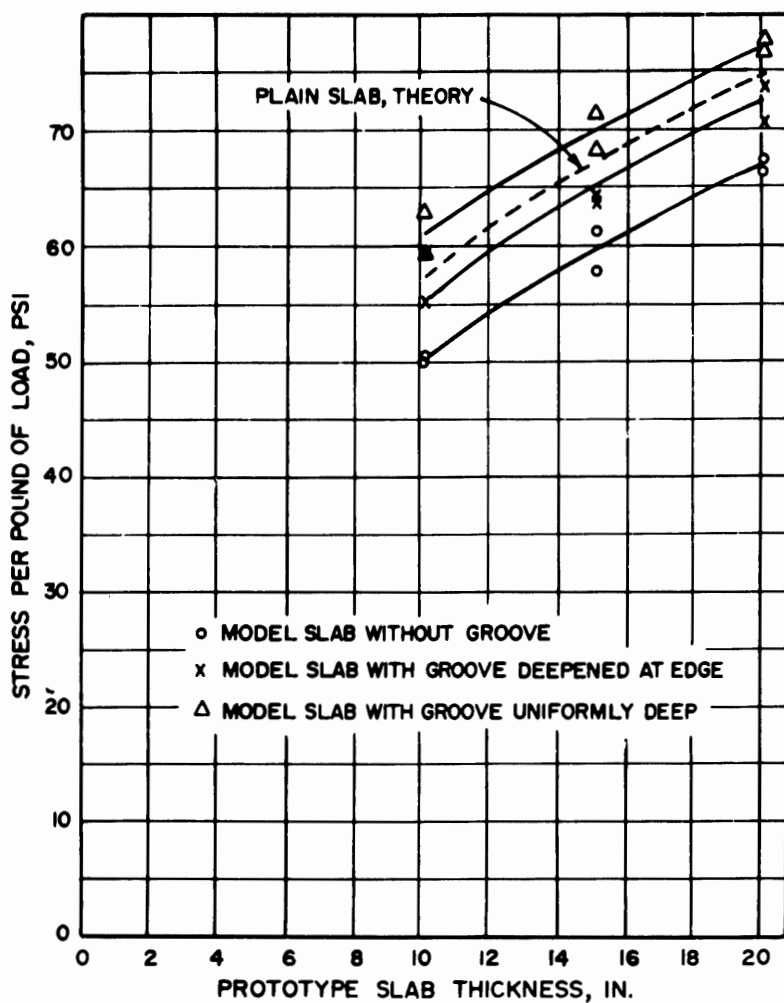


REDUCTION IN LOAD-CARRYING CAPACITY
NARROW-GAUGE INSET LIGHT FIXTURES
SINGLE 267 SQ. IN. CONTACT AREA



STRESS TANGENTIAL TO
RECESS AT INTERIOR OF SLAB





CURVES SHOWING EFFECT OF
SAWKERFS ON STRESS
PER POUND OF LOAD



Figure 17a. View showing recess scaled to radius of relative stiffness of slab.



Figure 17b. View showing recess scaled to thickness of slab.

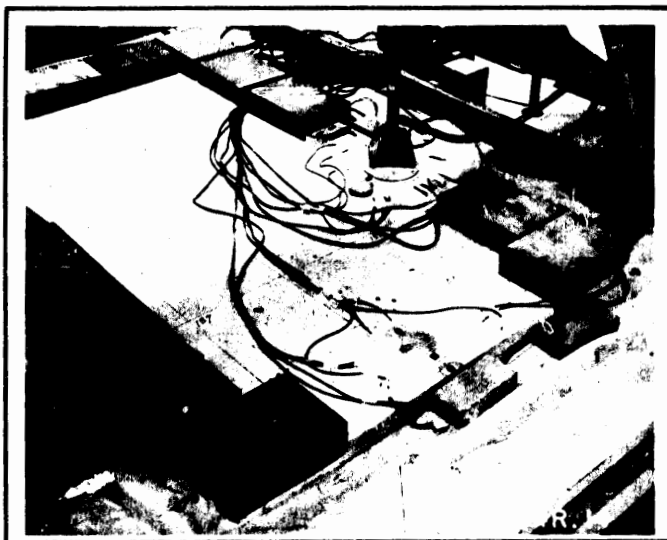
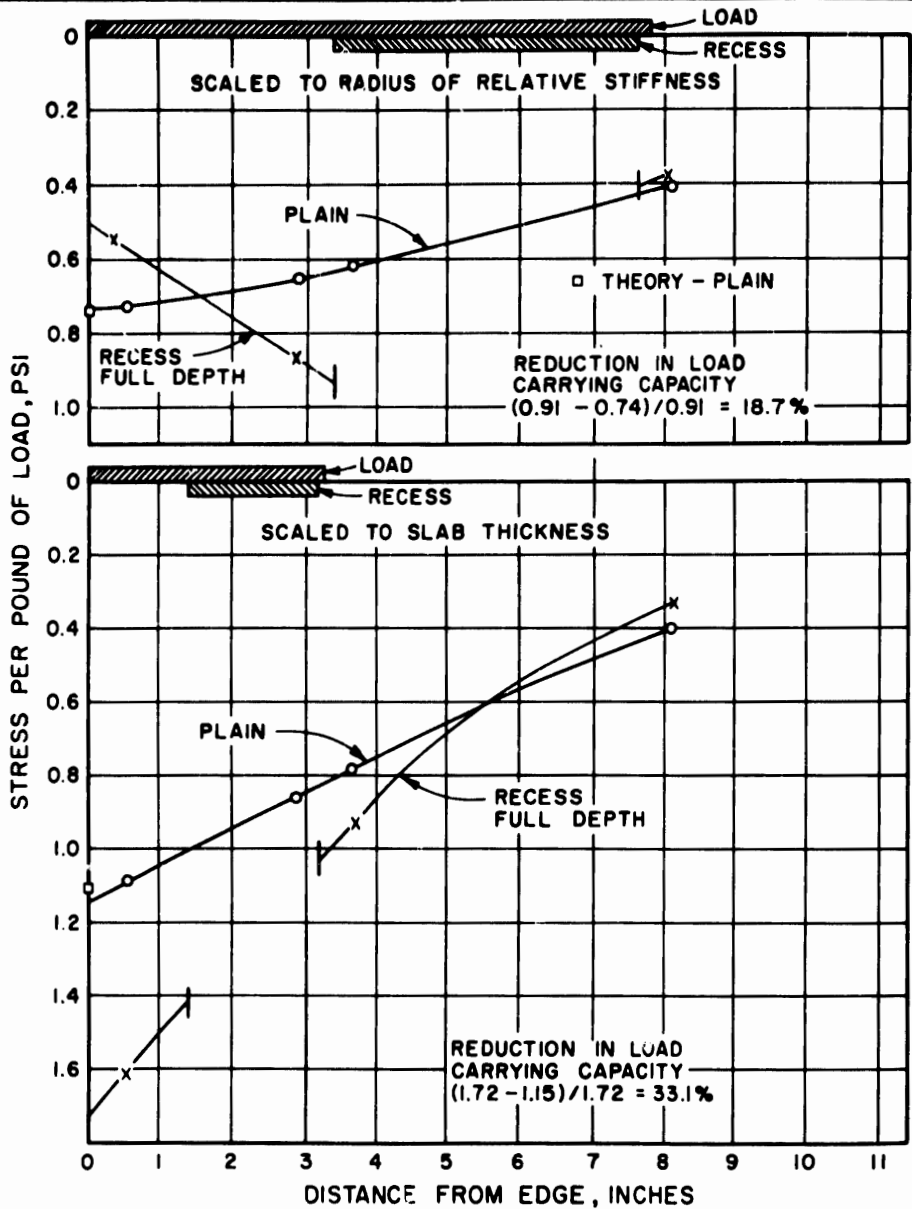
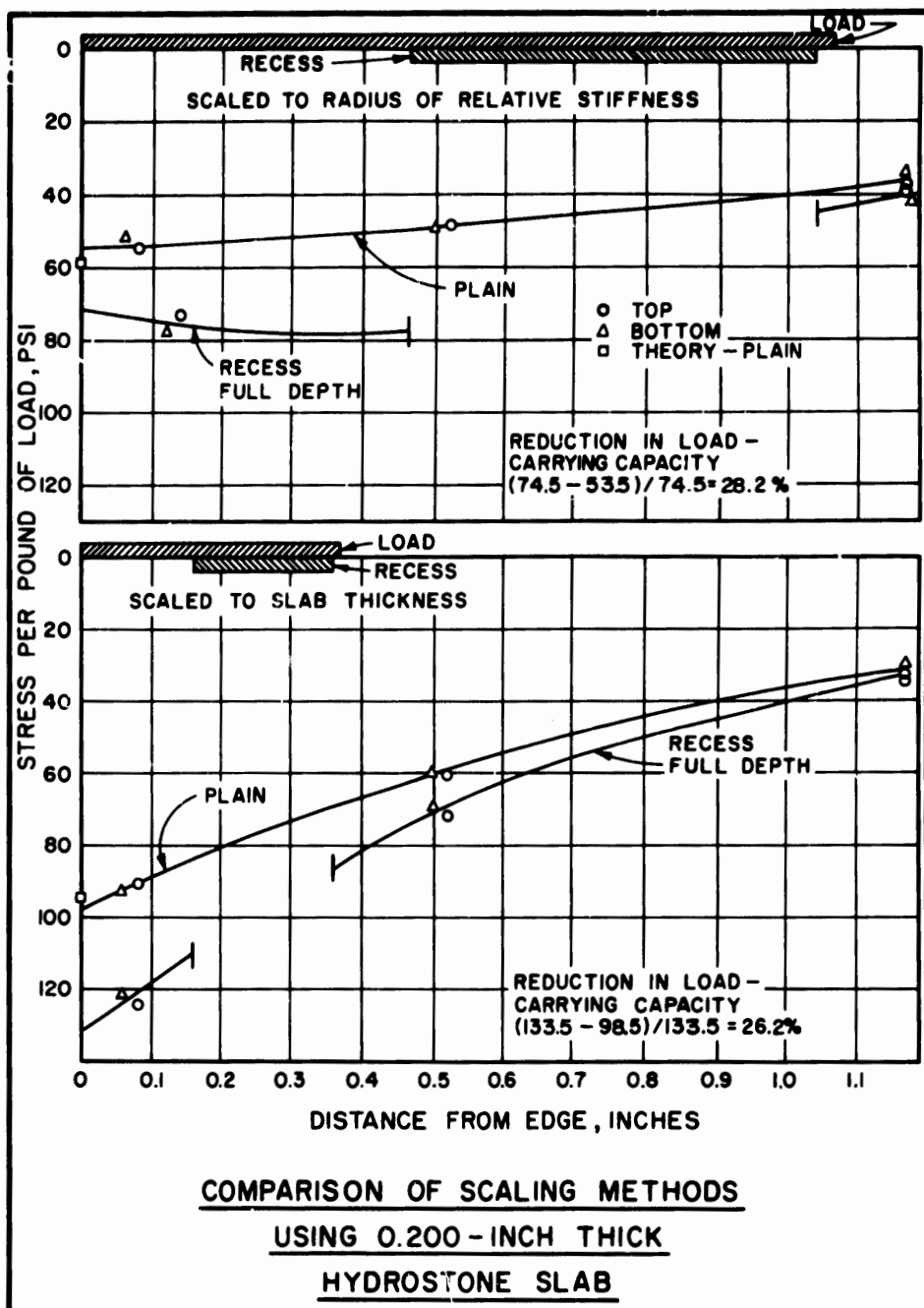
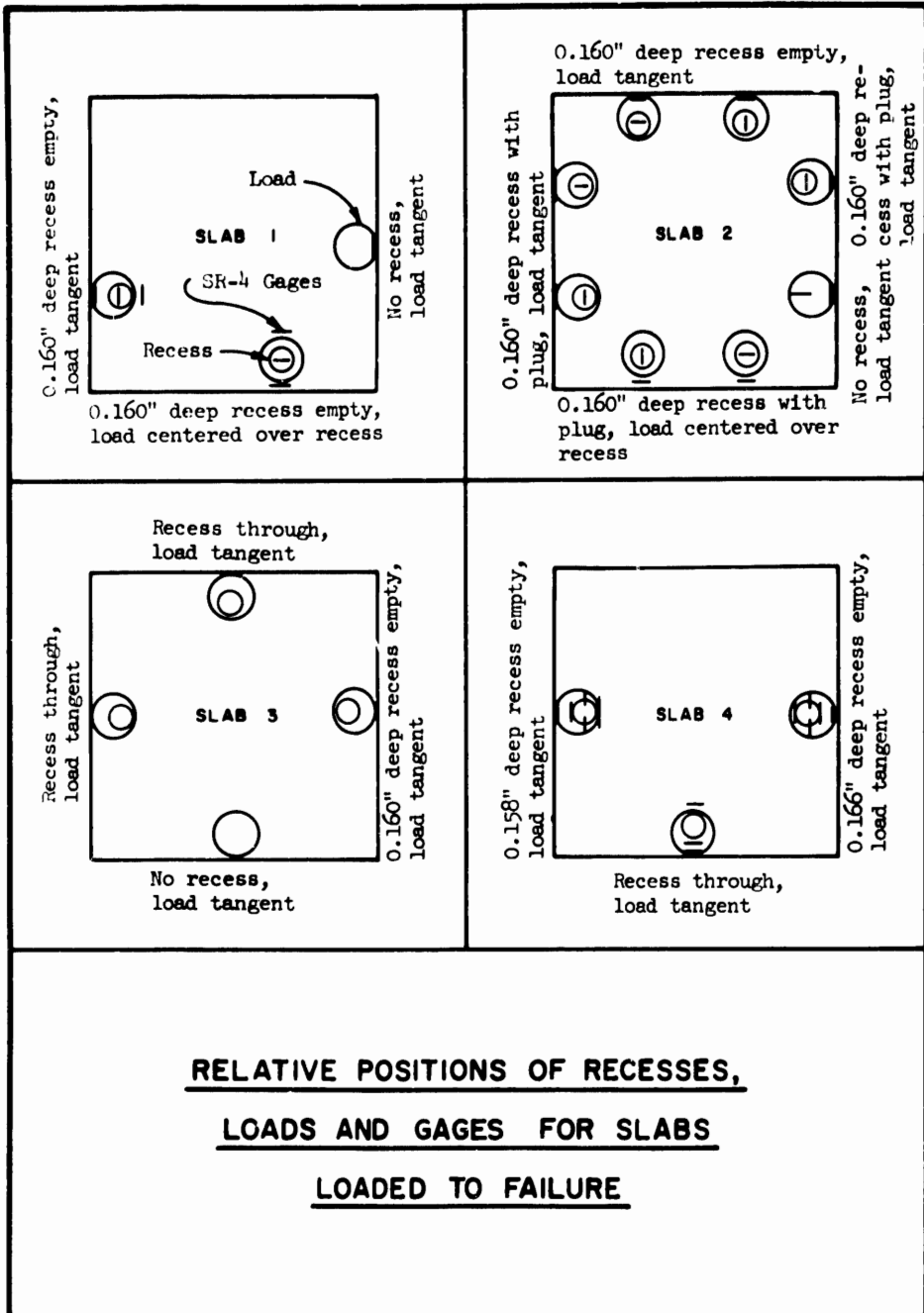


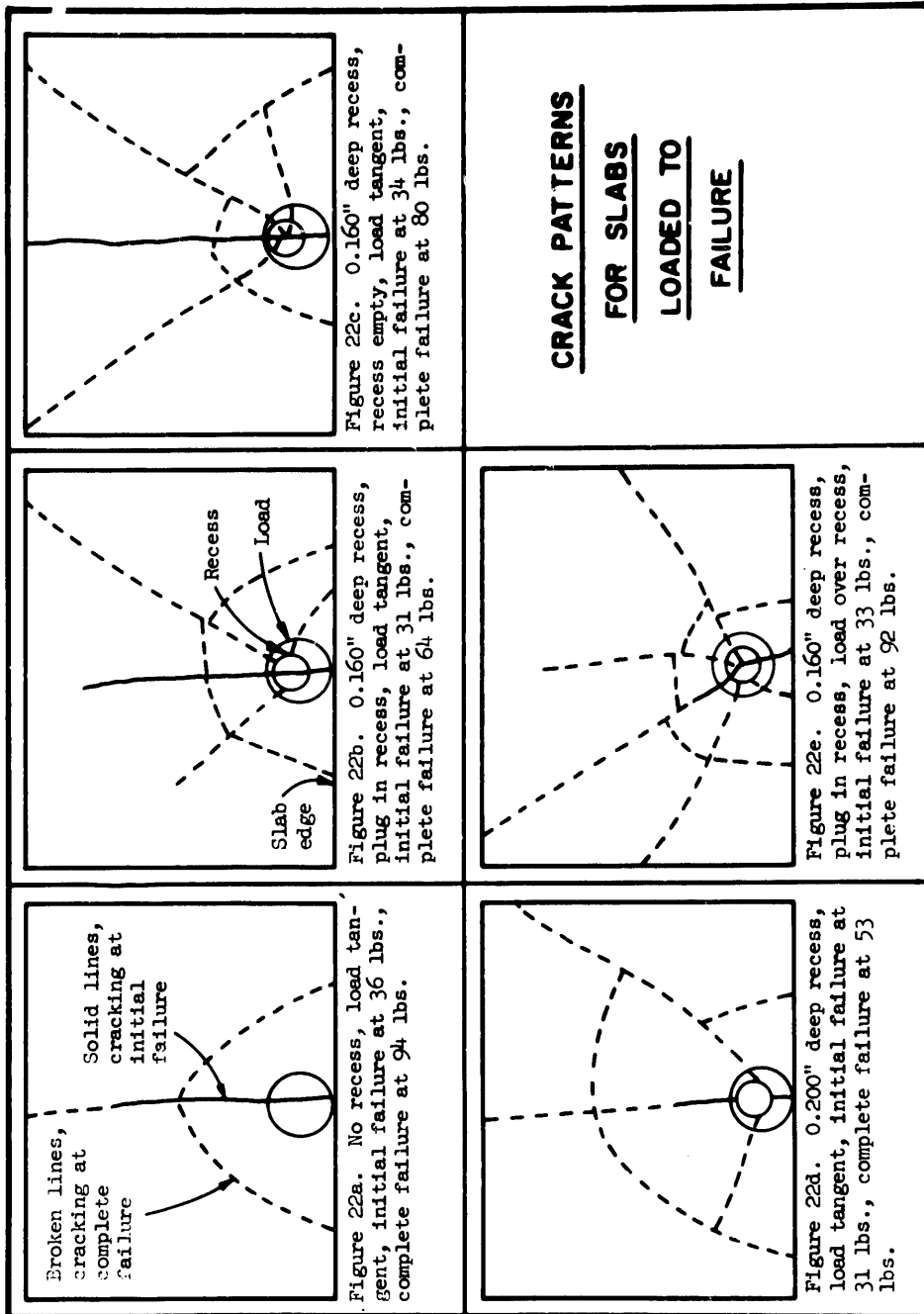
Figure 18. View showing loading device for contact area scaled to radius of relative stiffness in position to obtain strains for slab with no recess.

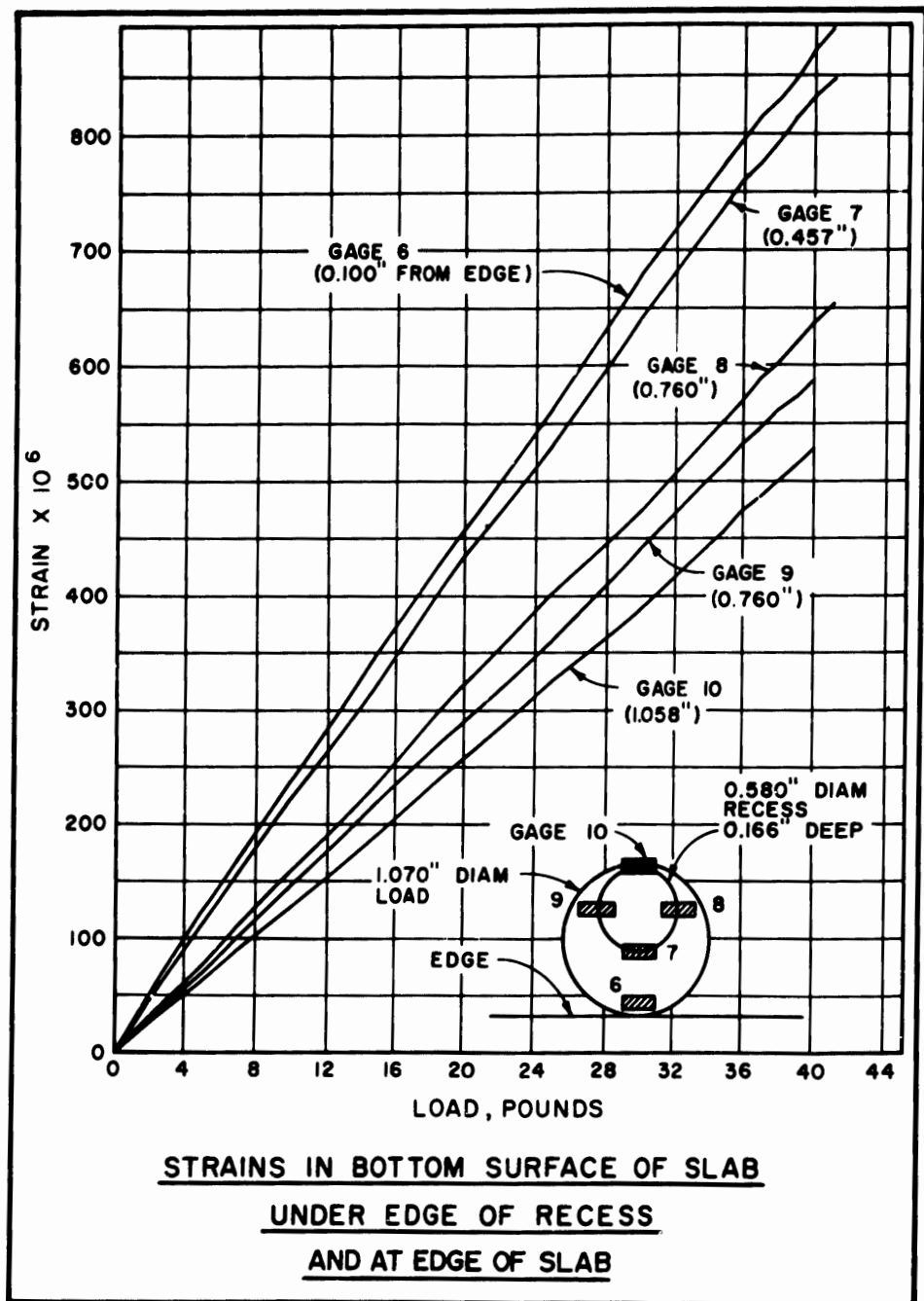


**COMPARISON OF SCALING METHODS
USING 1.75 - INCH THICK CONCRETE SLAB**









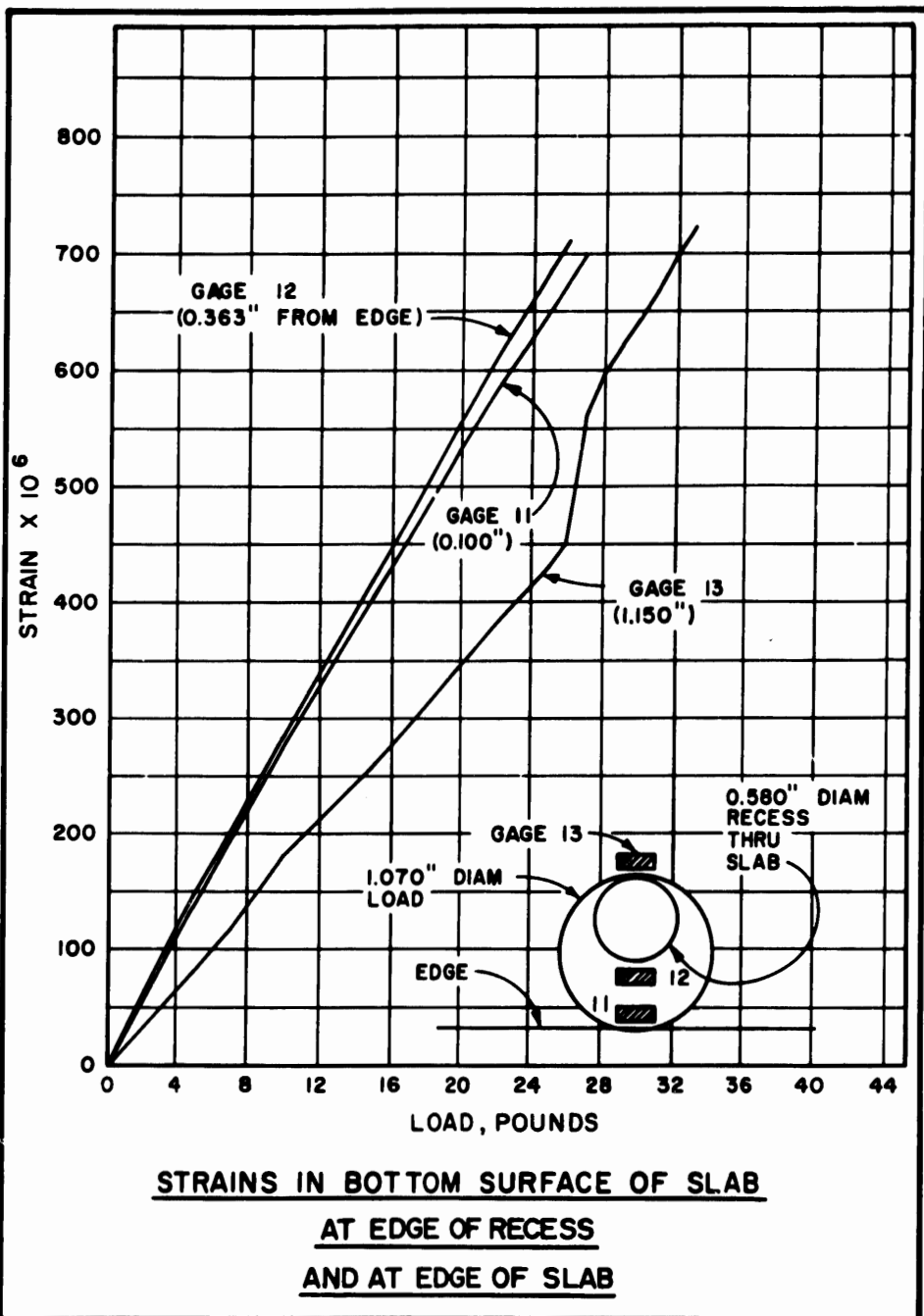
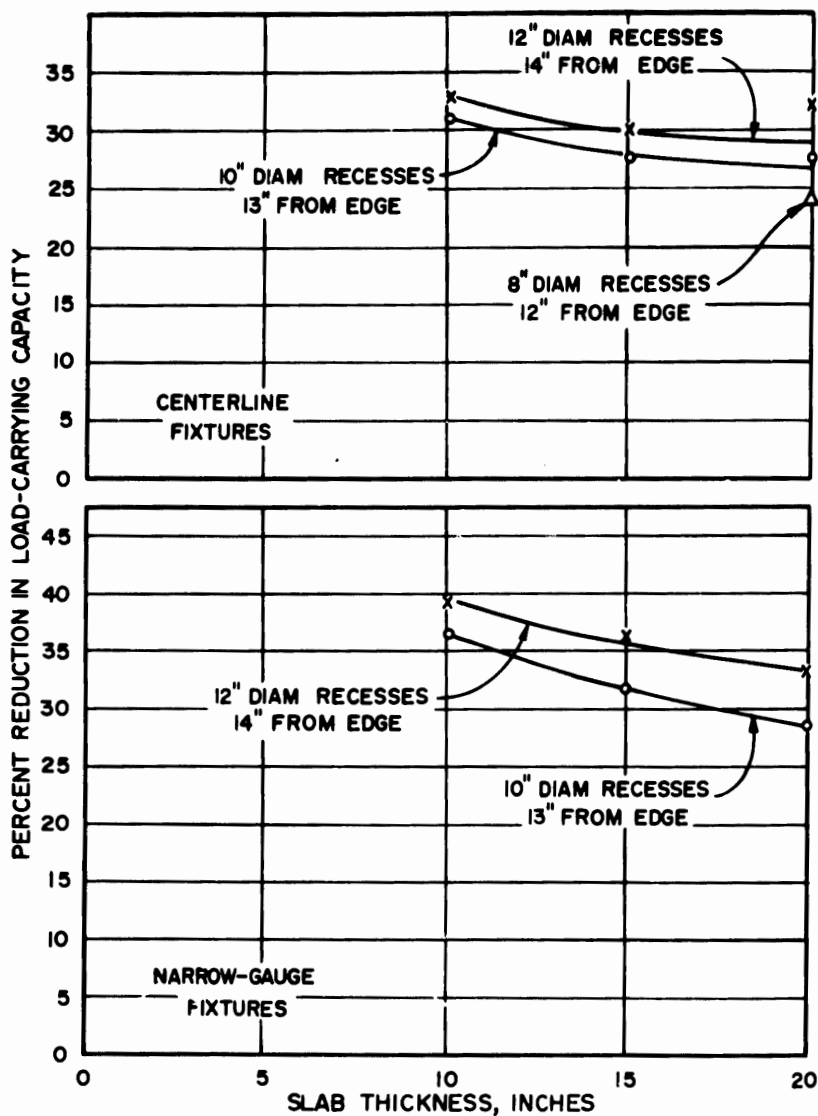


FIGURE 24



REDUCTION IN LOAD-CARRYING CAPACITY
EFFECTED BY RECESSES
COMPLETELY THROUGH SLAB

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13. ABSTRACT Full-scale pavement was simulated in the model tests reported by Hydrostone slabs 0.200 inch in thickness by 16 3/4 inches square, supported by a natural rubber subgrade. For the range of prototype conditions represented by the model, the test results indicated the following: a. A recess of any depth tends to lower the load-carrying capacity of a slab. Depend- ing on the type of fixture, the load-carrying capacity could be reduced as much as 39% by extending the recess completely through the slab. b. Sawkerfs perpendicular to the edge tend to reduce the load-carrying capacity of a slab, the amount of reduction being dependent on the depth of the sawkerfs. c. In a slab containing a recess, a sawkerf, or both, the stress per pound of load is constant throughout the elastic range of the slab and subgrade. d. Crack patterns associated with the initial failure of a plain slab and a slab contain- ing a recess are practically identical. e. Cracking associated with the complete failure of a slab containing a recess is more extensive than that associated with a plain slab. f. With a recess near the edge and completely through a slab, critical stresses may develop at the edge of the recess rather than at the edge of the slab.		

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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