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DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON

ENGWE

27 December 1951

MEMORANDUM TO ALL CONCERNED

SUBJECT: Forms and Form Linings

1. The data contained in this Technical Memorandum No. 6-336, subject, "Tests on Concrete and Mortar Surfaces Cast against Various Types of Forms and Form Linings," have been prepared by the Waterways Experiment Station under Item CW 611 "Investigation of Formed Concrete Surfaces" of the Civil Works Investigation Program, and are being distributed for general information.

2. This investigation was begun during the period when absorptive form lining was being used extensively by the Corps of Engineers in its Civil Works construction program in an attempt to eliminate unsightly surface voids, to aid in surface curing, and to produce a hard dense concrete surface more resistant to abrasion and weathering. Since that time, it has become increasingly apparent that other more important factors mitigated against the general use of absorptive form lining. These factors were cost, misuse, and difficulty in handling (installation and removal), in that order.

3. The subject report is necessarily limited in its scope. It does indicate, however, that in general the use of absorptive form lining does eliminate surface voids but not sub-surface voids, and it does increase resistance to abrasion and moisture penetration when compared with surfaces cast against non-absorptive forms. None of these findings can offset the more important factors against its use as outlined in paragraph 2 above.

4. A study is currently under way in this office on a possible modification of the present "FORMS" section of the guide concrete specification. Until such time as a modification is adopted and issued to all field offices, the procedure governing the selection and use of forms and linings for Civil Works construction will be in strict accord with Multiple Letter ENGWE 411.8 dated 26 July 1949, subject "Absorptive Form Lining" from this office.

BY ORDER OF THE CHIEF OF ENGINEERS:

Stanley G. Reiff

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TESTS ON CONCRETE AND MORTAR SURFACES CAST AGAINST VARIOUS TYPES OF FORMS AND FORM LININGS

TECHNICAL MEMORANDUM NO. 6-336

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

ARMY-MRC VICKSBURG, MISS.

FEBRUARY 1952

PREFACE

Authorization for the test program described herein was contained in Item 611, Civil Works Investigations of Formed Concrete Surfaces, implemented by correspondence with the Office, Chief of Engineers, March 1948.

The reported investigation was conducted at the Concrete Research Division of the Waterways Experiment Station during the spring and summer of 1949.

Other agencies have conducted investigations on materials for lining concrete forms, notably the Bureau of Reclamation and the Ohio River Division Laboratories of the Corps of Engineers. A list of references follows the text of this report.

Proprietary materials for use in this investigation were procured from the following companies:

Celotex Corporation, Chicago, Illinois

Dant and Russell, Inc., Portland, Oregon

Dewey and Almy Chemical Co., Cambridge, Mass.

Economy Forms Corp., Des Moines, Iowa

Irvington Tank and Forms Corp., New York, N. Y.

Plastergon Wall Board Co., Buffalo, N. Y.

U. S. Rubber Co., Passaic, N. J.

Wm. E. Hooper and Sons Co., Philadelphia, Pa.

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SYNOPSIS

This investigation attempted to evaluate the surface characteristics of mortar and concrete cast against seven types of non-absorptive forms and 13 absorptive form linings. A total of 250 mortar specimens, 4- by 12- by 16-in., and 76 concrete specimens, 6- by 48- by 48-in., were made and used to evaluate adhesion characteristics of the lining to the surface, appearance, abrasion resistance, existence of sub-surface voids, resistance to moisture penetration, and the effect of consolidation by prolonged high-frequency vibration.

Test results showed that all the surfaces cast against the non-absorptive forms contained surface voids and were less resistant to abrasion and moisture penetration than those cast against the linings.

Some of the linings were removed easily after 14-days curing while others were very difficult to remove.

All the lining materials, except one, practically eliminated surface voids, increased abrasion resistance and decreased moisture penetration; however, all the linings produced sub-surface voids. The use of prolonged high-frequency vibration reduced the number of surface blemishes.

A test method for the evaluation of form-lining materials is included as Appendix A to this report. Tests of a special finish material for concrete surfaces are described in Appendix B hereto.

TESTS ON CONCRETE AND MORTAR SURFACES CAST AGAINST VARIOUS TYPES OF FORMS AND FORM LININGS

PART I: INTRODUCTION

1. The investigation reported herein was undertaken to obtain knowledge of the effect of several types of forms and form-lining materials on the appearance and properties of mortar and concrete surfaces formed against them. Specifically, the investigation attempted to evaluate seven non-absorptive forms and 13 absorptive linings in various combinations through a study of the following properties of mortar and concrete surfaces cast against them:

Properties	Surfaces
Adhesion of lining to surface	Mortar and concrete
Appearance	Mortar and concrete
Resistance to abrasion	Mortar and concrete
Sub-surface voids	Concrete
Resistance to moisture penetration	Mortar

PART II: MATERIALS, EQUIPMENT, TEST SPECIMENS

Materials

Forms

2. Forms for the mortar tests were of 1-in. tongue-and-groove lumber to make specimens 4 in. thick, 8 in. wide and 16 in. high with panels of the lining material cut to size and inserted in the wood form on both sides. Forms for the concrete tests were of similar material to make specimens 6 in. thick, 48 in. high and 48 in. wide with panels of the appropriate lining attached. Some tests were also made using commercial steel form units.

Linings

3. The following non-absorptive forming materials were used:

- a. Sheet steel, 16 gage, with joints every 2 ft each way for the concrete specimens; used oiled.
- b. Pressed hardboard, oil treated, waterproof, 1/8 in. thick; used oiled.
- c. Tongue-and-groove, No. 1, 4-in. yellow pine; used oiled.
- d. Same as c, but used wet.
- e. Plywood, 5/8-in.-thick Douglas fir; used oiled.
- f. Same as e, but used wet.
- g. Steel forms of patented construction, made of 6-in. pressed steel channels, bolted together with a "tongue-and-groove" effect.
- h. Same as g, but with 8-in. channel elements.

4. The absorptive lining materials used are listed and described on the following page:

Code No.	
A	Wallboard-type lining, 5/16 in. thick, composed of cane fibers.
B	Wallboard-type lining, 3/8 in. thick of felted wood fibers.
C	Wallboard-type lining, 5/16 in. thick of felted spent licorice root fibers with white sizing paint on one side. Designated C(1) when used with uncoated side to mortar or concrete, and C(2) when used with coated side to mortar or concrete.
D	Same material as C, except unpainted, and with one side finished smooth for use against the concrete.
E	Blotter-type paper lining, approximately 1/16 in. thick, with one side slightly glazed; similar in appearance to inner-sole material of cheaper grade shoes.
F	Muslin-covered chipboard material, approximately 1/14 in. thick.
G	Canvas duck, 10-oz, commercially laundered.
H	Canvas duck, 14-oz, commercially laundered.
I	Canvas duck, 18-oz, commercially laundered.
J	Canvas G, rewashed in laboratory with a synthetic detergent prior to use.
K	Canvas H, rewashed.
L	Canvas I, rewashed.
M	Cotton cloth of open weave and soft texture, regularly used in the paper-making industry. Weight about 14 oz per sq yd.

Adhesives

5. The flexible-type linings were fastened to the hard forms (steel and pressed wood) by use of a rubber cement adhesive and to the tongue-and-groove and plywood forms with light-weight wire staples. The wallboard-type linings were fastened with lath nails.

Aggregates

6. The sand used was a natural, clean, siliceous material, data on which follow:

Specific gravity = 2.63; absorption = 0.5 per cent;

Sieve Analysis

Sieve No.	Cumulative % Passing
4	97
8	87
16	75
30	47
50	14
100	3
200	1
Fineness modulus	2.77

7. The coarse aggregate was a recrushed traprock, data on which follow:

Specific gravity = 2.90; absorption = 1.2 per cent;

Sieve Analysis

Sieve No.	Cumulative % Passing
1-1/2	100
1	73
3/4	55
1/2	35
3/8	20
No. 4	4

Cement

8. The cement used was laboratory stock, SS-C 192 type II.

Mortar mixtures

9. The following three mortar mixtures were used:

	Mixture		
	A	B	C
Water-cement ratio (gal/bag)	4.20	4.42	4.51
Nominal slump (in.)	1/2	2	4
Avg unit wt (lb/cu ft) (actual)	140.5	138.1	137.5
Cement factor (bags/cu yd)	10.5	10.2	10.1
Air, %	4.1	5.2	5.4
AEA (NVR in sol.) % (solids to cement)	0.008	0.008	0.008

Concrete mixtures

10. The following three concrete mixtures were used, all with 5.5 gal per bag water-cement ratios:

	Nominal Slump, In.		
	1/2	2	4
Sand to total aggregate (% by vol)	42	41	40
Unit wt (lb/cu ft) (actual)	154.8	152.7	152.8
Cement factor (bags/cu yd)	4.50	4.75	5.15
Bleeding (% of mixing water)	6.7	6.1	6.4
Air, %	4.3	5.5	4.8
AEA (NVR in sol.) % (solids to cement)	0.015	0.013	0.010

Equipment

11. The equipment consisted essentially of a mixer, vibrators, and

abrasion testers. A 10-S rocking, tilting, sealed drum mixer was used for mixing both mortar and concrete. Three sizes of vibrators were used as follows:

- a. 1-1/8- by 8-in. flexible shaft electric, 7000 vpm, for the mortar panels.
- b. 1-3/4- by 10-in. flexible shaft electric, 4500 vpm, for normally vibrated concrete conditions.
- c. 2- by 19-1/2-in. flexible shaft electric, 13,000 vpm for prolonged high-frequency concrete conditions.

The abrasion testers used were:

- a. Drill-press abrasion device, described in paragraph 2(g) of Appendix A and illustrated in figs. A-1 and A-2 of the appendix, for the tests on mortar.
- b. Sand-blast abrasion equipment with compressed air in ample volume maintained at 70 psi for the tests on concrete.

Test Specimens

Mortar

12. Three rounds of mortar specimens, one specimen per round, were cast representing each slump, form, and form-lining condition. A total of 225 mortar specimens were made. The form and lining conditions are listed below:

(1) Steel, oiled.

(2) Pressed hardboard, oiled.

(3) Tongue-and-groove, oiled.

(4) Tongue-and-groove, wet.

(5) Plywood, oiled.

(6) Plywood, wet.

(7) Lining A, over tongue-and-groove.

(8) Lining B, over tongue-and-groove.

(9) Lining C, plain side to mortar, over tongue-and-groove.

(10) Lining C, coated side to concrete, over tongue-and-groove.

(11) Lining D, over tongue-and-groove.

(12) Lining E, over steel.

(13) Lining E, over plywood.

(14) Lining F, over steel.

(15) Lining F, over plywood.

(16) Lining G, over steel.

(17) Lining H, over steel.

(18) Lining I, over steel.

(19) Lining G, over plywood.

(20) Lining H, over plywood.

(21) Lining I, over plywood.

(22) Lining J, over steel.

(23) Lining K, over steel.

(24) Lining L, over steel.

(25) Lining M, over plywood.

13. Placing was in three lifts and consolidation was effected by the minimum required amount of vibration from the 1-1/8-in.-diameter, 7000-vpm vibrator. Specimens were removed from the forms at 48 hr and the absorptive lining removed from one face. Specimens were cured in the fog room to 14-days age at which time the lining was removed from the other face.

Concrete

14. A total of 76 simulated wall panels were cast, with form, form-lining, and concrete condition as shown in the tabulation on the next page.

The panels were cast with absorptive lining and non-absorptive form lining on opposite faces at every opportunity to conserve labor and materials:

(1) - (25) as for the mortar specimens.

(26) Lining M, over steel.

(27) Lining J, over plywood.

(28) Lining K, over plywood.

(29) Lining L, over plywood.

(30) Steel channel forms, 6 in., vertical orientation with strips of form lining F between channels.

(31) Same as (30), but without strips of F between channels.

(32) Same as (30), but with channels oriented horizontally.

(33) Same as (31), but with channels oriented horizontally.

(34) Same as (30), but with 8-in. wide channels.

(35) Same as (31), but with 8-in. wide channels.

(36) Same as (32), but with 8-in. wide channels.

(37) Same as (33), but with 8-in. wide channels.

Each of the above conditions was represented by 1/2-, 2-, and 4-in. slump concrete vibrated normally. An additional set of 2-in. slump specimens representing all 37 conditions was made and vibrated by prolonged high-frequency vibration.

15. The normally vibrated specimens were all cast in four, 12-in. lifts. Each lift was vibrated, using the 4500-vpm vibrator, in five equally spaced spots for a duration of approximately 7 sec per spot for the 1/2-in. slump concrete, to 3 sec per spot for the 4-in. slump concrete. The prolonged high-frequency vibrated specimens were cast in three 16-in.

lifts, vibrated in 3 spots per lift for 15 sec per spot, using the 13,000-vpm vibrator.

16. The forms were removed from all panels at 48 hr and the panels were cured to 14-days age in the fog room. All the normally vibrated specimens were cured with linings in place for the 14 days. The linings were removed from the specimens subjected to prolonged high-frequency vibration at the time of form removal.

PART III: TESTS AND RESULTS

Tests

Lining materials

17. The absorptive lining materials were tested for:

a. Absorption of limewater by floating three 4-in. squares of each of the room-dry linings on saturated limewater and noting the increase in weight at intervals up to two hours. The rewashed canvases were not tested for absorption.

b. Color developed in a 3 per cent sodium hydroxide solution when a 10-g sample of each lining material (except the rewashed canvases) was cut into small pieces and soaked for 24 hr in 7 oz of that solution.

Mortar

18. Each mortar specimen was tested for:

a. Adhesion of lining to the mortar surfaces by observing the ease or difficulty with which the lining materials were removed.

b. Appearance by visual evaluation.

c. Abrasion resistance by abrading three places on each side of each specimen by means of the drill-press rig and the procedure described in Appendix A. Tests were made on one side of each specimen immediately after forms were removed (2 days) and on the reverse side at 21 days, after 14-days curing and 7-days drying in the laboratory air. The weight of the material, in grams, abraded from the surface was determined.

d. Moisture penetration by subjecting an unabraded area of each slab, on the face tested for abrasion at 21 days, to a water column 15 in. high in a 3-in. pipe section (sealed around its outside perimeter to the slab face to prevent leakage) for 48 hr. Phenolphthalein in the water acted as an indicator and the specimens were broken and the depth of moisture penetration, as shown by the red color, determined to the nearest 1/64 inch.

Concrete

19. Each concrete panel was tested for:

a. Adhesion of lining to the concrete surfaces by observing the ease or difficulty with which the lining materials were removed.

b. Appearance by visual evaluation.

c. Abrasion resistance by sandblasting following a 7-day drying period in the laboratory air after removal from curing. Sandblasted area was 12 in. in diameter (as outlined by a rubber shield), treated with a 20-lb charge of silica sand, 100 per cent passing the No. 16 sieve, at a nozzle distance of 8 in. and an air pressure of 70 psi.

d. Sub-surface voids by rubbing an area approximately 6 in. wide by 18 in. long, on each panel face near the sandblasted area, with a coarse-grit carborundum stone, to break the surface skin and reveal any sub-surface voids.

Test Results

Absorptive linings

20. Absorption. Results of the absorption-of-limewater test on the absorptive lining materials follow:

Absorption of Limewater, Average of 3 Tests
(G per Sq Ft)

Form Lining	Time in Minutes						
	5	10	15	30	45	60	120
A	150.3	178.2	195.3	239.4	268.2	293.4	365.4
B	23.4	36.0	48.6	90.9	124.2	162.0	301.5
C(1)	2.7	3.6	4.5	5.4	5.4	9.0	10.8
C(2)	14.4	15.3	17.1	23.4	26.1	31.5	43.2
D	5.4	7.2	9.0	10.8	13.5	14.4	17.1
E	28.8	53.1	76.5	90.0	100.8	114.3	162.0
F	159.3	171.0	175.5	182.7	180.1	182.7	190.8
G	9.9	13.5	15.3	17.1	20.7	23.4	30.6
H	15.3	18.9	21.6	27.0	33.3	36.9	42.3
I	10.8	15.3	16.2	18.9	26.1	31.5	47.7
M	0.9	0.9	2.7	3.6	5.4	6.3	15.3

(1) Uncoated side to water; (2) coated side to water.

Note: The order in which the linings occur above does not correspond to the order in which the suppliers are listed in the Preface.

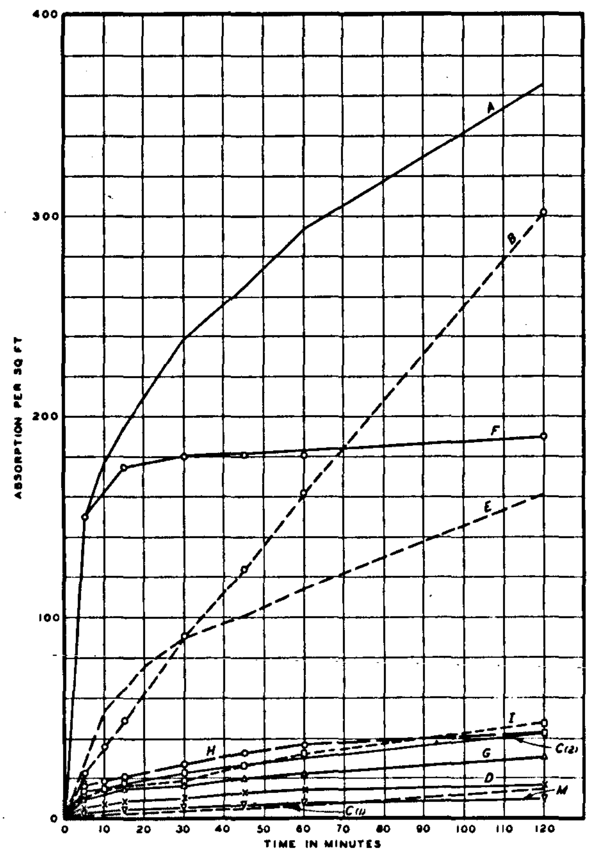

Fig. 1. Absorption test on form-lining materials

The preceding data are plotted in fig. 1. Lining A had the greatest total absorption and also a rapid rate of absorption for the first 5 minutes. Lining F had the most rapid rate of absorption of the materials tested for the first 5 minutes, after which little further absorption occurred. B had a moderate, even rate of absorption for the entire 2-hr test period. E had a moderate rate of absorption for the first 15 minutes after which the rate decreased and remained steady for the rest of the test period. G, H, and I (canvases) gained rapidly for the first few minutes after which there was slight further gain. M, D, and $C^{(1)}$ (uncoated side to water) all showed very low absorption. $C^{(2)}$ (coated side to water) had about the same absorption capacity as the canvases.

21. Color. The lining materials arranged according to the color (from darkest to lightest) that they caused the 3 per cent sodium hydroxide solution to turn, are as follows: B, D, C, A, F, E, M, G, H, I. The order of color approximates roughly the order of ease of removal from the concrete, the linings causing the darkest color exhibiting least bond to the concrete.

Mortar

22. Adhesion of lining. There was very little difference relative to ease of stripping the lining from the mortar surfaces between the 1/2-, 2-, and 4-in. slump mortars. All the linings were more difficult to remove at 14 days than at 2 days.

Ease of Lining Removal

Lining	Remarks
A	Removed easily, and cleanly.
B	Removed easily, left an occasional fuzzy spot which was easily brushed off.
C(1)	Removed easily, and cleanly.
C(2)	Removed easily, but left patches of coating on mortar surface.
D	Removed easily, and cleanly.
E	Almost impossible to remove cleanly, even after prolonged soaking and wire-brushing and scraping. No difference noted whether this lining was used over steel or plywood.
F	Fairly easy to remove, mortar in a few spots seemed to penetrate muslin and form very strong bond to it. No difference noted whether this lining was used over steel or plywood.
G	Somewhat more difficult to remove than F. Left slight fuzz adhering to the surface.
H	Slightly harder to remove than G.
I	Slightly harder to remove than H.
M	Removed with fair ease at 48 hr, but very difficult to remove after 14-days curing.

23. Appearance of surfaces. Plates 1, 2, and 3 show the appearance of one set of the 1/2-in. slump mortar panels and are typical of the appearance of the panels of the three slumps tested. A qualitative

description follows:

a. Steel oiled, pressed hardboard oiled, plywood oiled, and plywood wet produced smooth surfaces which, however, contained a considerable number of air voids.

b. Tongue-and-groove, oiled and wet, produced surfaces with somewhat fewer voids than those in a above.

c. A produced a clean, pit-free surface.

d. B produced pit-free surfaces with a few small, easily removed fuzzy spots.

e. $C^{(1)}$ produced surfaces with a few pits, and somewhat stained from material leached from the lining during curing.

f. $C^{(2)}$ produced surfaces with a few pits, with coating adhering to the panels in spots.

g. D produced fairly pit-free surfaces but stained as were the panels formed against $C^{(1)}$.

h. E produced surfaces which were somewhat pitted.

i. F produced smooth, pit-free surfaces.

j. G produced smooth, pit-free surfaces.

k. H same as j, possibly a little better.

l. I same as k.

m. M produced surfaces with an interesting texture and very few pits. The surface on removal of lining at 48 hr was somewhat dusty.

24. Abrasion resistance. Test results of the abrasion test on the mortar panels at 2 and 21 days are given in table 1. It will be noted that the abrasion resistance increased greatly with age, being two to three times as great at 21 days as at two. It will also be noted that the unlined forms (non-absorptive surfaces) all had about the same abrasion resistance.

25. Lining E did little or nothing to increase the abrasion resistance

of the mortar formed against it. The canvases G and H (10 and 14 oz) and lining F appeared quite effective in hardening the surface. The extra laundering given the canvases appeared to increase the abrasion resistance. Lining B appeared to be the most effective of the wallboard-type linings.

26. Effect of slump was appreciable at 2 days, but not distinguishable at 21 days.

27. Whether the lining material was used over steel or plywood made little or no difference in the abrasion resistance of the resulting surfaces.

28. Moisture penetration. The moisture penetration results for the mortar specimens, shown in table 2, were inconclusive quantitatively but all the linings except E reduced the amount of penetration. Depth of penetration increased with slump for the surfaces cast against hard forms but did not necessarily increase with slump for those cast against absorbent forms.

Concrete

29. Adhesion of lining. Difference in slump or whether the linings were applied over steel or plywood backing had no noticeable effect on the adhesion of the lining material to the surface. The non-absorptive forms, of course, all stripped cleanly and easily. All of the linings on the panels consolidated by prolonged high-frequency vibration came off cleanly and easily except for cloth M, wherein the mortar penetrated the weave of the cloth and made it necessary to tear the material into strips for removal. The relative difficulty or ease with which the lining materials were removed from the normally vibrated specimens is described on the following page:

Lining	Remarks
A	Came off cleanly and easily, leaving an occasional patch of fibers loosely bonded to surface. No fuzzy spots.
B	Stuck fairly tightly to surface. Occasional fuzzy spots remained which were easily removed by wire brush.
$C^{(1)}$	Lining very soft and soggy, removed largely with scrapers and wire brush.
$C^{(2)}$	Same as $C^{(1)}$.
D	Same as $C^{(1)}$.
E	Almost impossible to remove. Tight layer of paper against the concrete had to be peeled and scraped away with knives and spatulas. Wire brushes would not remove it.
F	Tightly bonded to surface. Removed by tearing into 8-in.-wide strips.
G	Tightly bonded to surface. Removed by tearing into 8-in. strips.
H	Tightly bonded to surface. Removed by tearing into 7-in. strips.
I	Tightly bonded to surface. Removed by tearing into 6-in. strips.
J	Same as G.
K	Same as H.
L	Same as I.
M	Very tightly bonded to surface. Removed by tearing into 4-5-in. strips.

30. Appearance of surfaces. There seemed to be no difference in surface appearance whether the backing for the absorptive lining was steel or plywood. There was also no apparent difference in surface appearance due to slump. Surface voids decreased slightly with increased slump where the specimens were formed against non-absorptive materials. Washing the canvas

linings in the laboratory prior to use made no difference in surface appearance. The surface appearance of all the specimens consolidated by prolonged high-frequency vibration was similar, but superior, to those formed by normal-frequency vibration. Plates 4 through 22 are close-up views of each type of surface in the high-frequency vibration series. A qualitative description of all of the surfaces follows:

a. Steel oiled, pressed hardboard oiled, plywood, oiled and wet, produced smooth surfaces with normal number of voids.

b. Tongue-and-groove, oiled and wet, produced surfaces with slightly fewer voids than a.

c. A produced pleasing surface practically void-free.

d. B produced surface similar to lining A.

e. C(1), C(2) and D produced surfaces similar to lining A, but considerably stained by material leaching out of the lining during curing.

f. E produced surfaces with about as many voids as plywood judging from the small areas revealed by peeling the lining from the surfaces.

g. F produced surfaces relatively free of voids and of a pleasing appearance.

h. G, H, I, produced surfaces similar to lining F.

i. M produced surfaces with an interesting texture resulting from cloth weave.

j. Articulated steel channel forms produced interesting, pleasing surfaces, with about as many voids as the tongue-and-groove forms. The use of strips of lining F between channels did not decrease the voids, and only complicated form assembly.

31. Abrasion resistance. The slump of the concrete had no apparent effect on the sandblast abrasion resistance judged by visual inspection. The use of prolonged high-frequency vibration appeared in every case to increase the abrasion resistance, also judged by visual inspection. An

attempt was made to determine the abrasion resistance quantitatively, by measurement of the depth of penetration of the 2-in. slump, normally vibrated series, for relative rating of surface hardness. The results are given in table 3.

32. The oiled steel and 8-in. channel articulated steel forms produced surfaces least resistant to sandblasting. The tongue-and-groove and 6-in. articulated steel forms produced surfaces midway in resistance between the plate steel forms and absorptive lining formed surfaces. Plywood formed surfaces compared favorably with the tongue-and-groove surfaces.

33. Lining A appeared to produce the most resistant surface of the wallboard-type linings. (Lining B was most effective in the mortar tests.)

34. Lining E was not effective. The canvas linings over a steel backing produced surfaces quite resistant to sandblasting and better than the same linings produced over plywood backing. (In the mortar tests, little difference was noted whether canvas was used over steel or plywood.) The weight of canvas did not make much difference. Fabric M behaved about the same over steel or plywood and produced surfaces somewhat less resistant than those produced by the canvases. Lining F produced surfaces similar in abrasion resistance to most of the wallboards and canvases.

35. Sub-surface voids. The areas rubbed by carborundum stone to reveal sub-surface voids are evident in plates 4 through 22. All the surfaces, except those cast against lining E, were extremely hard and difficult to break with the rubbing stone. All the form-lined surfaces contained sub-surface voids and those formed against the flexible linings contained more voids than those formed against the wallboard liners.

PART IV: CONCLUSIONS

36. It is concluded, solely on the basis of the results of this laboratory investigation, that:

- a. The non-absorptive forms all produced surfaces containing surface voids, with those cast against tongue-and-groove lumber and articulated steel channel forms producing the least number of voids.
- b. Absorptive form linings generally were removed easily and cleanly at 48 hours, but may become very tightly bonded by the end of 14-days curing.
- c. Absorptive form linings generally eliminated surface voids, but not sub-surface voids.
- d. Absorptive form linings generally increased resistance to abrasion especially at early ages.
- e. Absorptive form linings generally increased the resistance to moisture penetration.

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3. Corps of Engineers, Office of the Chief of Engineers, "Concrete Conference (minutes)." Kansas City, Missouri, 1, 2 and 3 March 1949.

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5. Corps of Engineers, Waterways Experiment Station, "Durability of Concrete Exposed to Natural Weathering." Technical Memorandum No. 6-226, Vicksburg, Mississippi, August 1947.

6. Corps of Engineers, Waterways Experiment Station, "Jetcrete, Hydron-formed and Conventional-formed Concrete Comparative Tests." Vicksburg, Mississippi, 27 July 1949.

7. Johnston, W. R., "The Use of Absorptive Wallboards for Concrete Forms." American Concrete Institute Journal, vol 37 (June 1941).

8. Vidal, E. N. and Blanks, R. F., "Absorptive Form Lining." American Concrete Institute Journal, vol 38 (January 1942).

TABLES

Table 1

ABRASION LOSS (GRAMS) ON MORTAR SPECIMENS

Form or Lining	2 Days Slump, in. 1/2	2	4	2 Days Rel. Abr. Resistance*	21 Days Slump, in. 1/2	2	4	21 Days Rel. Abr. Resistance*
Non-absorptive Forms:								
Steel, oiled	21.0	23.3	26.8	.33	10.6	8.8	8.3	.32
Pressed hardboard, oiled	20.7	28.0	26.8	.31	7.1	8.8	7.5	.38
Tongue-and-groove, oiled	18.5	26.8	30.3	.31	10.0	11.6	10.2	.28
Tongue-and-groove, wet	20.2	22.2	28.8	.33	9.8	9.5	8.5	.32
Plywood, oiled	19.2	24.5	31.8	.31	10.3	10.2	9.7	.30
Plywood, wet	16.8	28.7	30.0	.31	9.2	9.2	8.8	.33
Wallboard-type Linings:								
A	9.7	17.8	19.3	.50	6.6	6.2	5.5	.49
B	8.0	11.2	15.1	.68	5.1	4.0	4.7	.64
C(1)	10.6	12.3	18.2	.57	5.5	5.5	5.5	.54
C(2)	10.2	15.2	18.0	.54	5.5	7.1	5.5	.49
D	14.4	13.8	18.8	.50	6.5	6.5	5.3	.49
Flexible Linings:								
E on steel	17.9	26.0	27.5	.33	10.1	10.1	10.3	.29
E on plywood	18.1	26.2	28.3	.32	10.8	9.0	9.7	.30
F on steel	9.5	7.8	10.5	.84	4.4	4.7	4.2	.67
F on plywood	7.2	7.2	9.0	1.00	4.9	4.3	4.0	.67
G on steel	11.1	16.3	18.7	.51	4.3	5.7	5.2	.59
H on steel	10.3	12.8	15.8	.60	3.4	4.9	5.5	.65
I on steel	8.2	13.7	17.4	.60	4.5	5.3	5.7	.58
G on plywood	7.6	13.5	16.3	.63	4.3	4.9	4.7	.64
H on plywood	9.2	9.3	15.8	.68	5.3	5.3	4.2	.60
I on plywood	18.4	12.5	23.8	.43	6.9	5.1	5.0	.52
J on steel	5.3	11.5	8.2	.94	4.5	4.9	3.0	.72
K on steel	4.7	8.0	12.2	.94	3.2	2.9	2.8	1.00
L on steel	10.2	7.0	11.3	.82	3.6	4.5	5.2	.67
M on plywood	11.2	16.2	20.2	.49	5.7	7.0	6.7	.46

Notes:

Each value shown represents nine tests, three on each of three panels.

* Value of 1.00 indicates maximum abrasion resistance for each age group.

Table 2

MOISTURE PENETRATION, INCHES, ON MORTAR SPECIMENS

Form or Lining	Slump, in. 1/2	2	4	Relative Resistance to Penetration*
Non-absorptive Forms:				
Steel, oiled	0.5938	0.3438	0.4063	0.07
Pressed hardboard, oiled	0.0625	0.4688	0.2500	0.12
Tongue-and-groove, oiled	0.1563	0.5313	0.5938	0.07
Tongue-and-groove, wet	0.3125	0.6563	0.3125	0.07
Plywood, oiled	0.2813	0.6875	0.5625	0.06
Plywood, wet	0.2813	0.5000	0.5000	0.07
Average	0.2813	0.5313	0.4375	
Wallboard-type Linings:				
A	0.0625	0.0313	0.0313	0.75
B	0.0938	0.0313	0.0313	0.60
C(1)	0.0625	0.0313	0.0313	0.75
C(2)	0.0625	0.0313	0.0313	0.75
D	0.0313	0.0313	0.0313	1.00
Average	0.0625	0.0313	0.0313	
Flexible Linings:				
E on steel**	0.1875	0.3125	0.3438	0.11
E on plywood**	0.2813	0.4375	0.2813	0.09
F on steel	0.0625	0.0313	0.0621	0.60
F on plywood	0.0625	0.0313	0.0625	0.60
G on steel	0.0625	0.0625	0.0938	0.43
H on steel	0.0313	0.0625	0.1563	0.38
I on steel	0.0313	0.0938	0.0938	0.43
G on plywood	0.0938	0.0625	0.0625	0.43
H on plywood	0.0938	0.0625	0.0938	0.38
I on plywood	0.0625	0.0625	0.0938	0.43
J on steel	0.0625	0.0313	0.0938	0.50
K on steel	0.0938	0.0938	0.0938	0.33
L on steel	0.0625	0.0313	0.0313	0.75
M on plywood	0.0938	0.0625	0.0625	0.43
Average	0.0677	0.0573	0.0834	

Notes:

Each value shown is average of three tests, one each on three separate specimens.

* Value of 1.00 indicates maximum resistance to penetration.

** Not included in average.

Table 3

SANDBLAST TEST ON NOMINAL 2-IN. SLUMP

4-ft x 4-ft x 6-in. Concrete Panels

Form or Lining	Average Depth of Penetration, In.
Non-absorptive forms:	
Steel, oiled	0.1906
Pressed hardboard, oiled	not determined*
Tongue-and-groove, oiled	not determined*
Tongue-and-groove, wet	0.1188
Plywood, oiled	0.1500
Plywood, wet	0.1000
Articulated steel forms, 6-in. vertical channels, with lining F strips between channels	not determined*
Articulated steel forms, 6-in. vertical channels, no strips between channels	not determined*
Articulated steel forms, 8-in. vertical channels, with lining F strips between channels	0.1844
Articulated steel forms, 8-in. vertical channels, no strips between channels	0.1531
Articulated steel forms, 6-in. horizontal channels, with lining F strips between channels	0.1219
Articulated steel forms, 6-in. horizontal channels, no strips between channels	0.1218
Articulated steel forms, 8-in. horizontal channels, with lining F strips between channels	0.1504
Articulated steel forms, 8-in. horizontal channels, no strips between channels	0.2250
Wallboard linings:	
A	0.0594
B	0.0938
C(1)	0.0906
C(2)	0.0719
D	0.0625

(Continued)

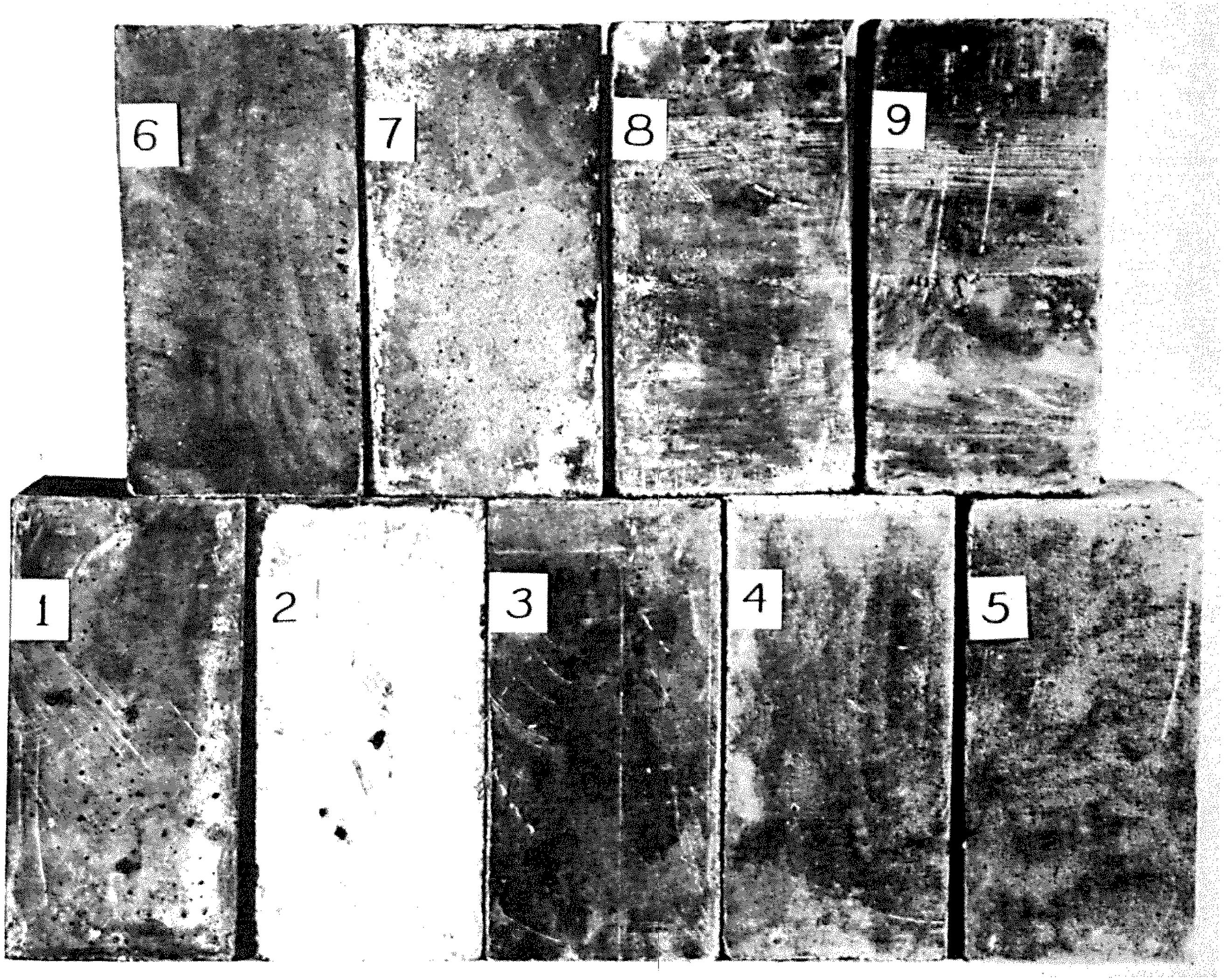
Table 3 (Cont'd)

Form or Lining	Average Depth of Penetration, In.
Flexible linings:	
E on steel	0.1188
E on plywood	0.1281
F on steel	0.0781
F on plywood	0.1031
G on steel	0.0969
H on steel	0.0656
I on steel	0.0625
G on plywood	0.1156
H on plywood	0.1019
I on plywood	0.0938
J on steel	0.0750
K on steel	0.0781
L on steel	0.0781
M on steel	0.1063
M on plywood	0.0906
J on plywood	0.1156
K on plywood	0.0844
L on plywood	0.500

* Specimen used for special finish tests covered in Appendix B before depth of sandblast abrasion could be measured.

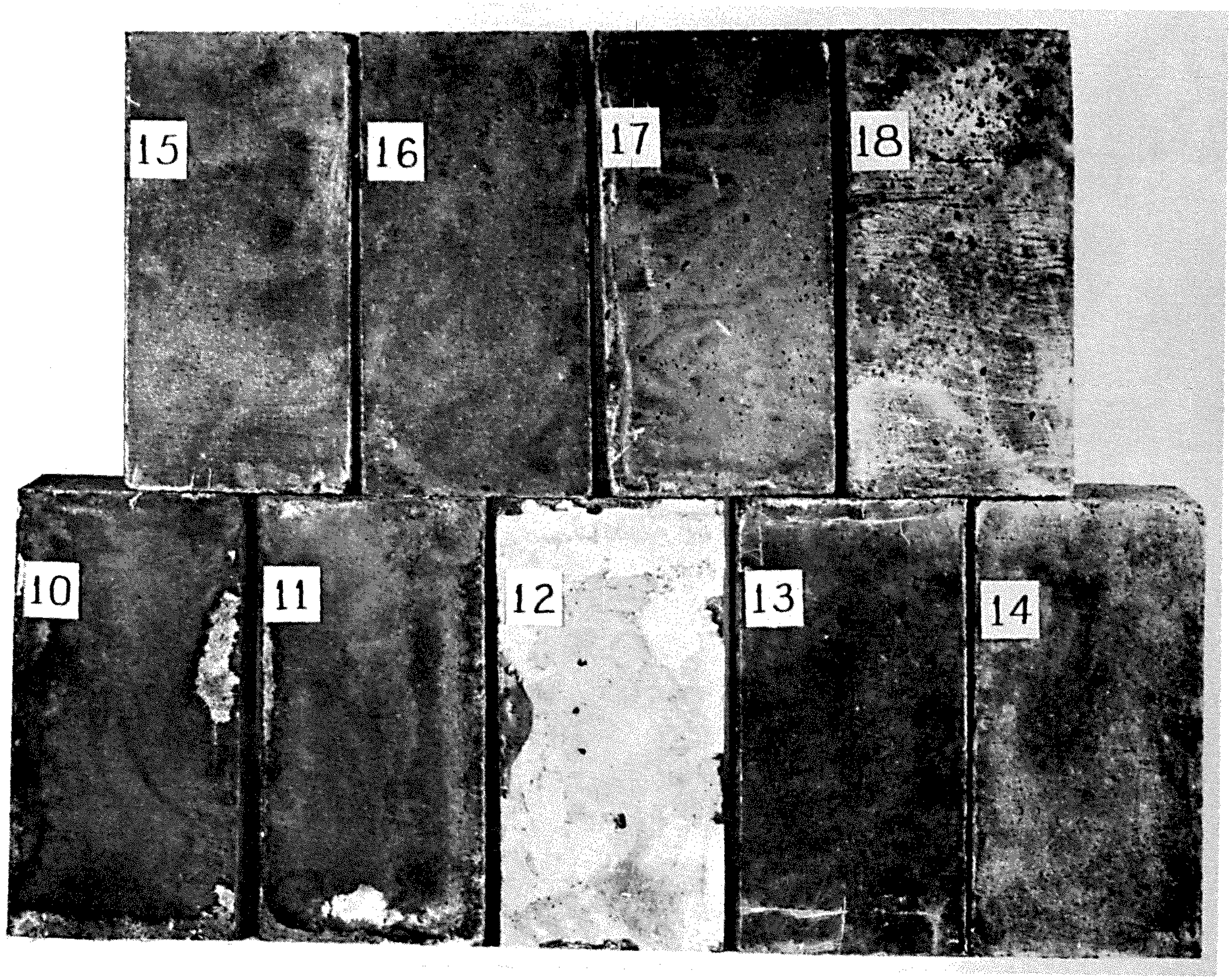
PLATES

PLATE 1



Mortar specimens, 1/2-in. slump. Specimen 2 has very thin layer of lining still bonded to surface. Scuffed place near center resulted from attempt at removal of lining with penknife. Large black spots are air voids. 1, steel, oiled; 2, E on steel; 3, F on steel; 4, G canvas on steel; 5, H canvas on steel; 6, I canvas on steel; 7, pressed hardboard, oiled; 8, tongue-and-groove, oiled; 9, tongue-and-groove, wet

PLATE 2



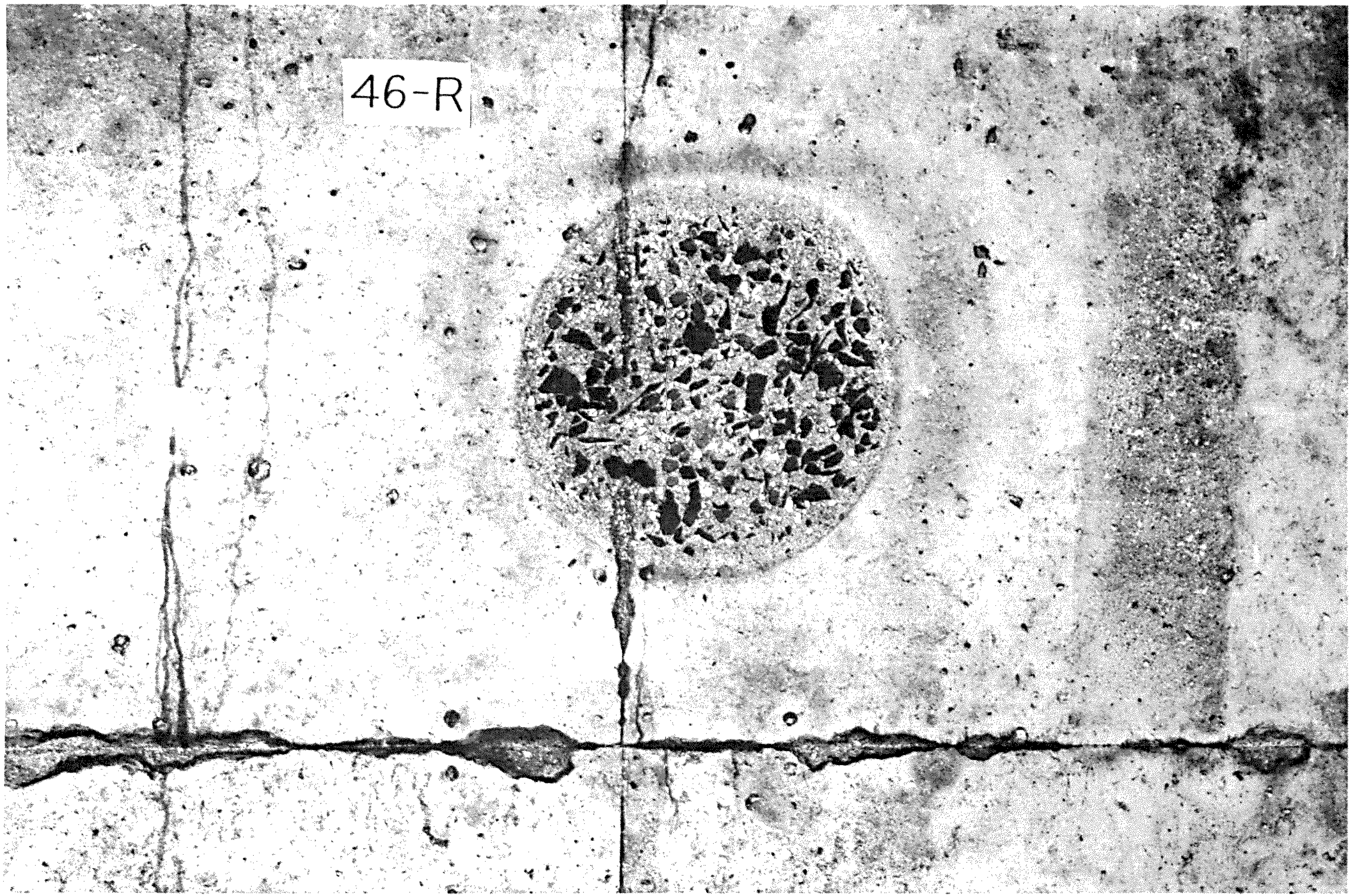
Mortar specimens, 1/2-in. slump
10. A; 11. B; 12. E on plywood; 13. F on plywood; 14. G canvas on plywood; 15. H canvas on plywood; 16. I canvas on plywood; 17. Plywood, wet; 18. Plywood, oiled

PLATE 3

Mortar specimens, 1/2-in. slump

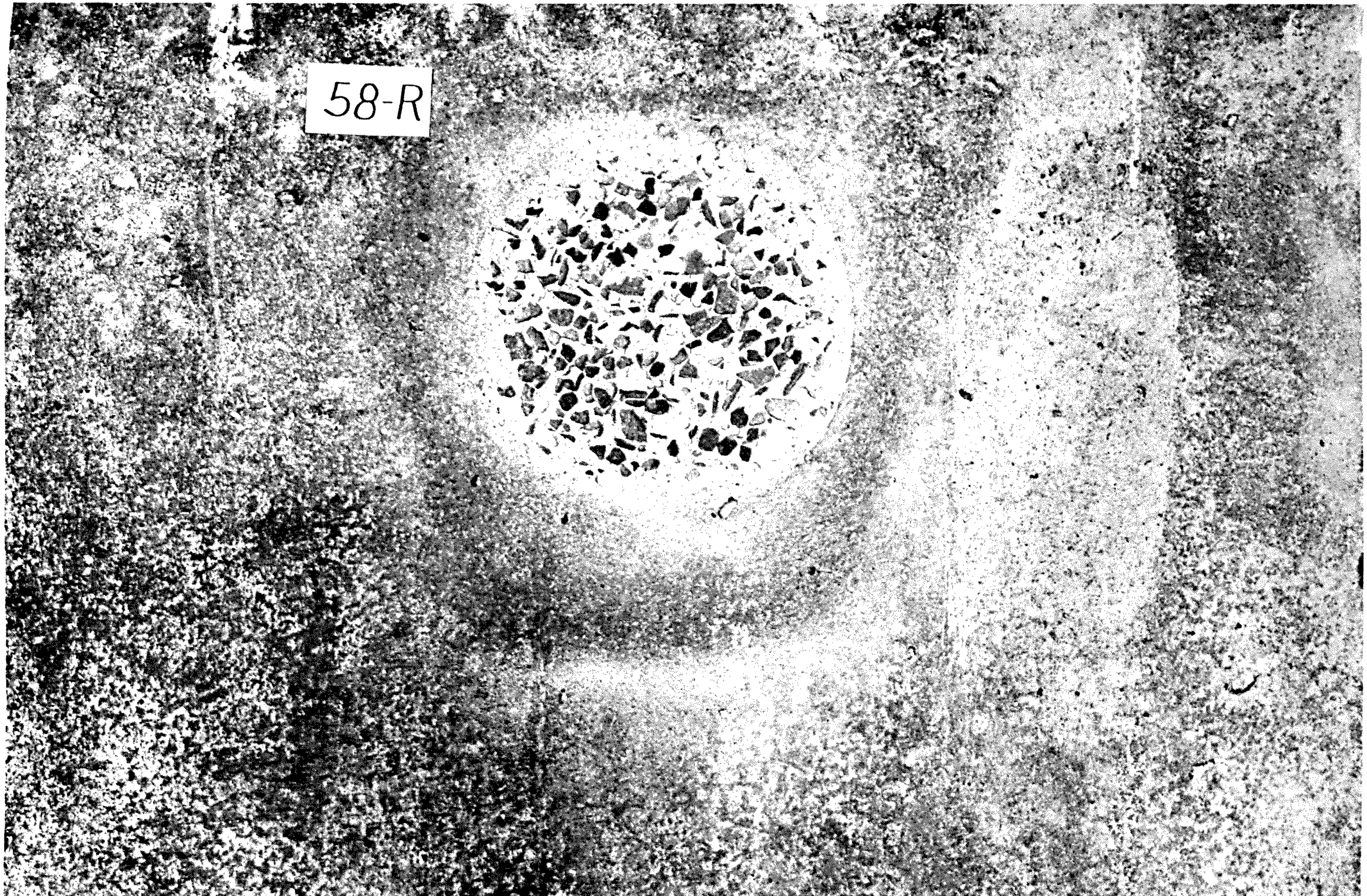
19. J on steel; 20. K on steel; 21. L on steel; 22. M on plywood; 23. (11); 24. (12); 25. D

PLATE 4



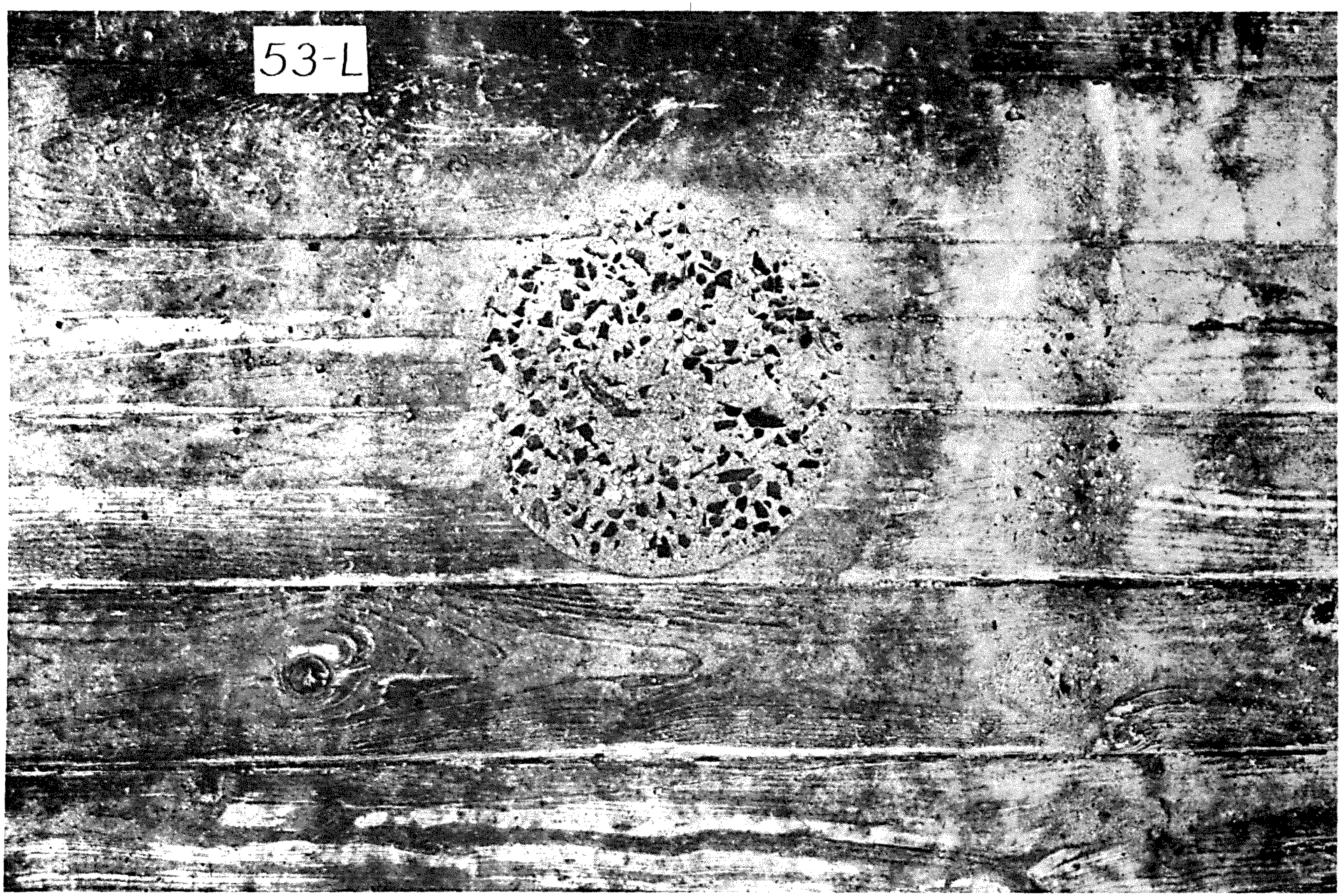
Panel of 2-in. slump concrete cast against oiled steel form by means of prolonged high-frequency vibration after sandblasting and rubbing of small area to the right with a carborundum stone

PLATE 5



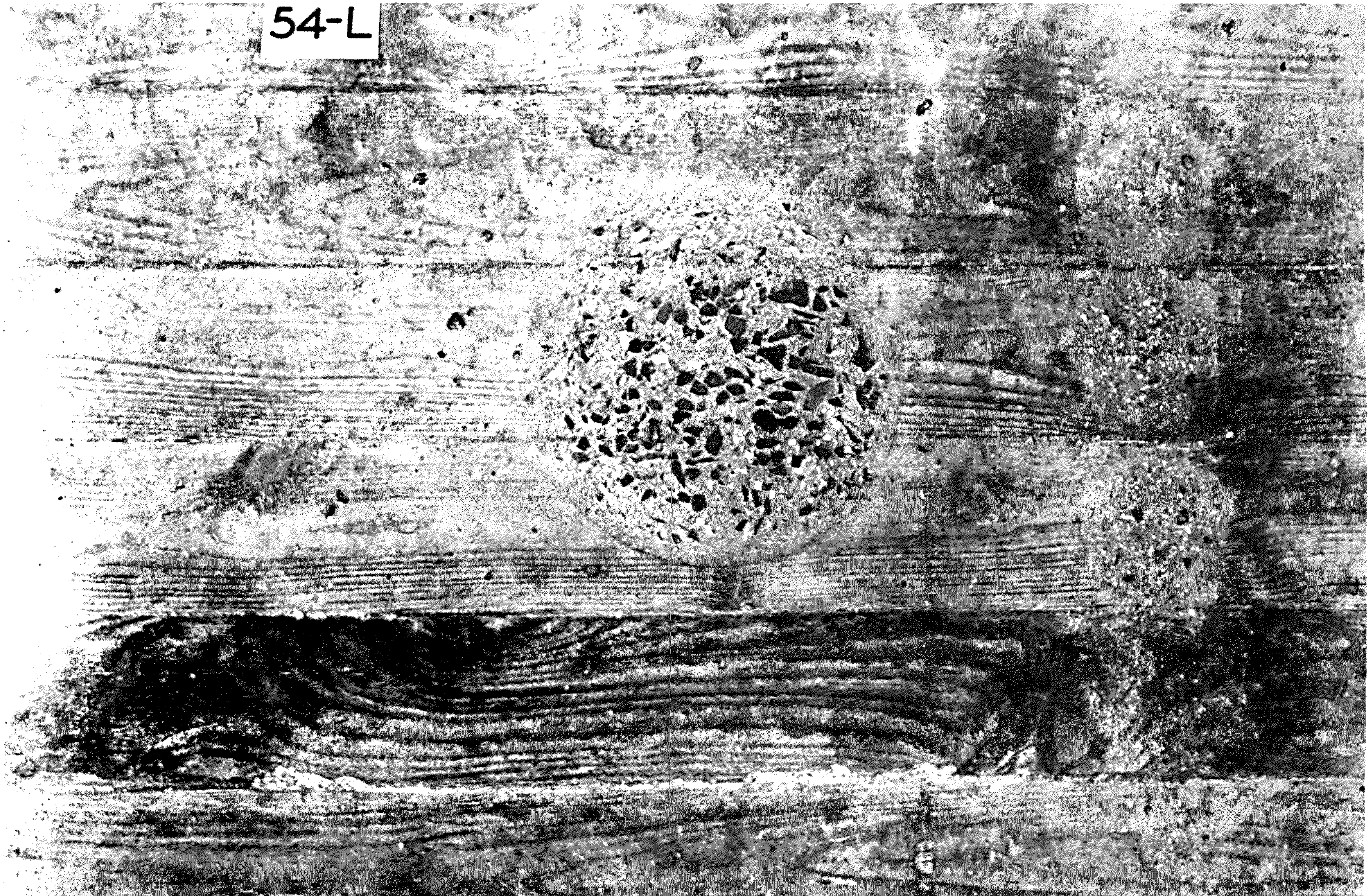
Panel of 2-in. slump concrete cast against oiled pressed hardboard by use of prolonged high-frequency vibration after sandblasting and rubbing with carborundum stone. Note small number of surface voids

PLATE 6

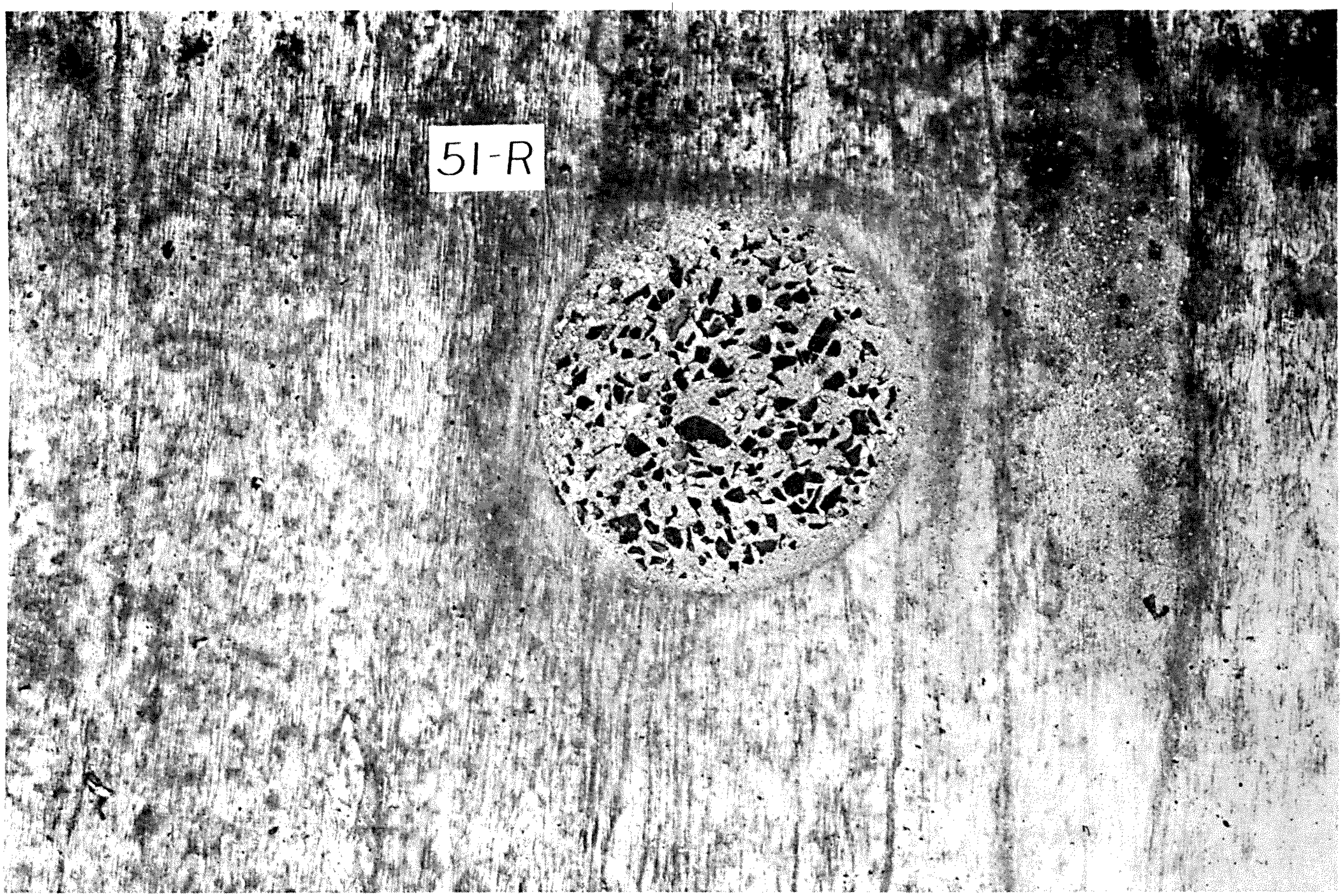


Panel of 2-in. slump concrete cast against oiled tongue-and-groove form by use of prolonged high-frequency vibration after sandblasting and rubbing with carborundum stone. Note relatively few surface voids

PLATE 7



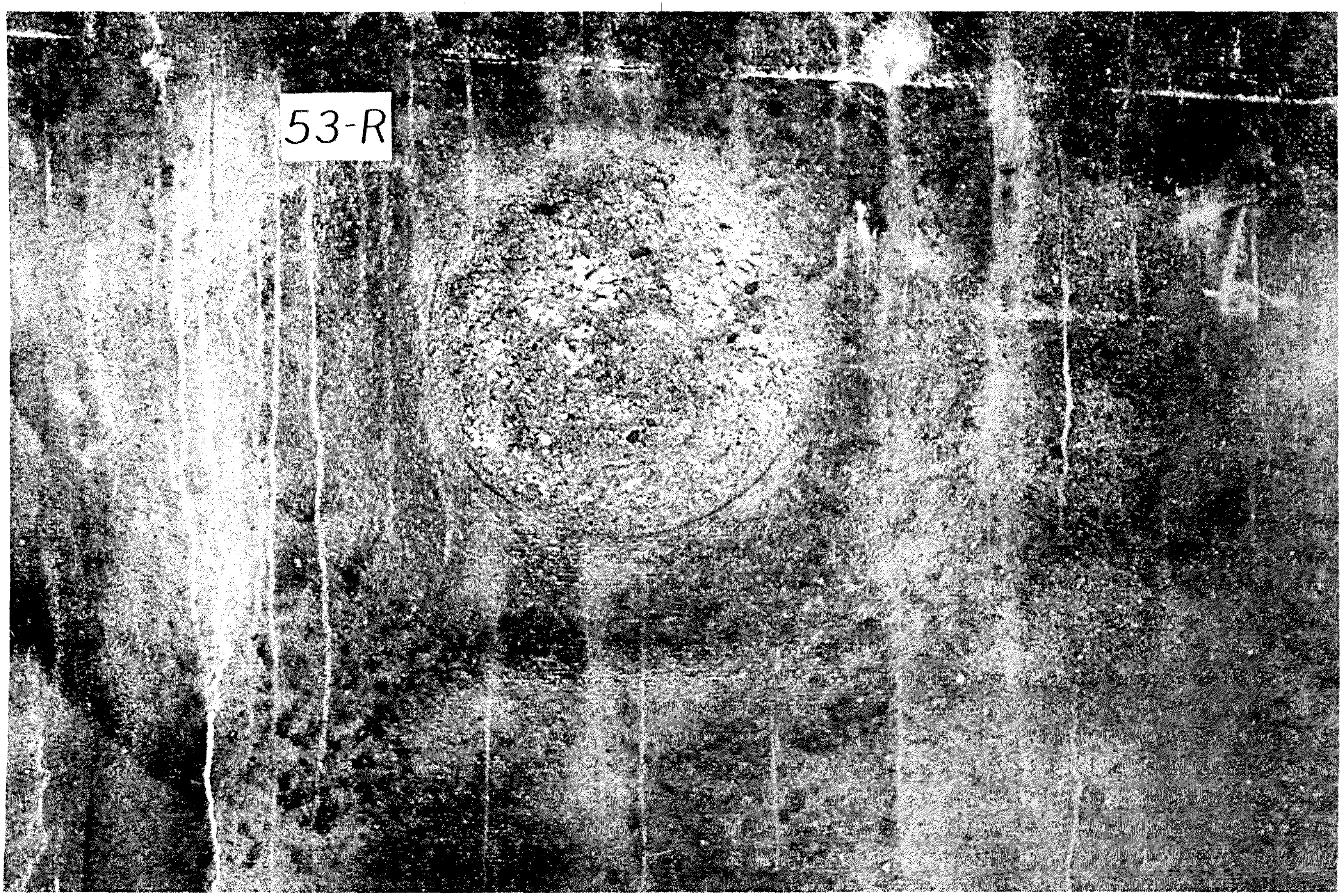
Panel of 2-in. slump concrete cast against wet tongue-and-groove forms by use of prolonged high-frequency vibration after sandblasting and rubbing with carborundum stone. Note presence of very few surface voids



Panel of 2-in. slump concrete cast against oiled plywood by use of prolonged high-frequency vibration after sandblasting and rubbing with carborundum stone. Note small number of surface voids

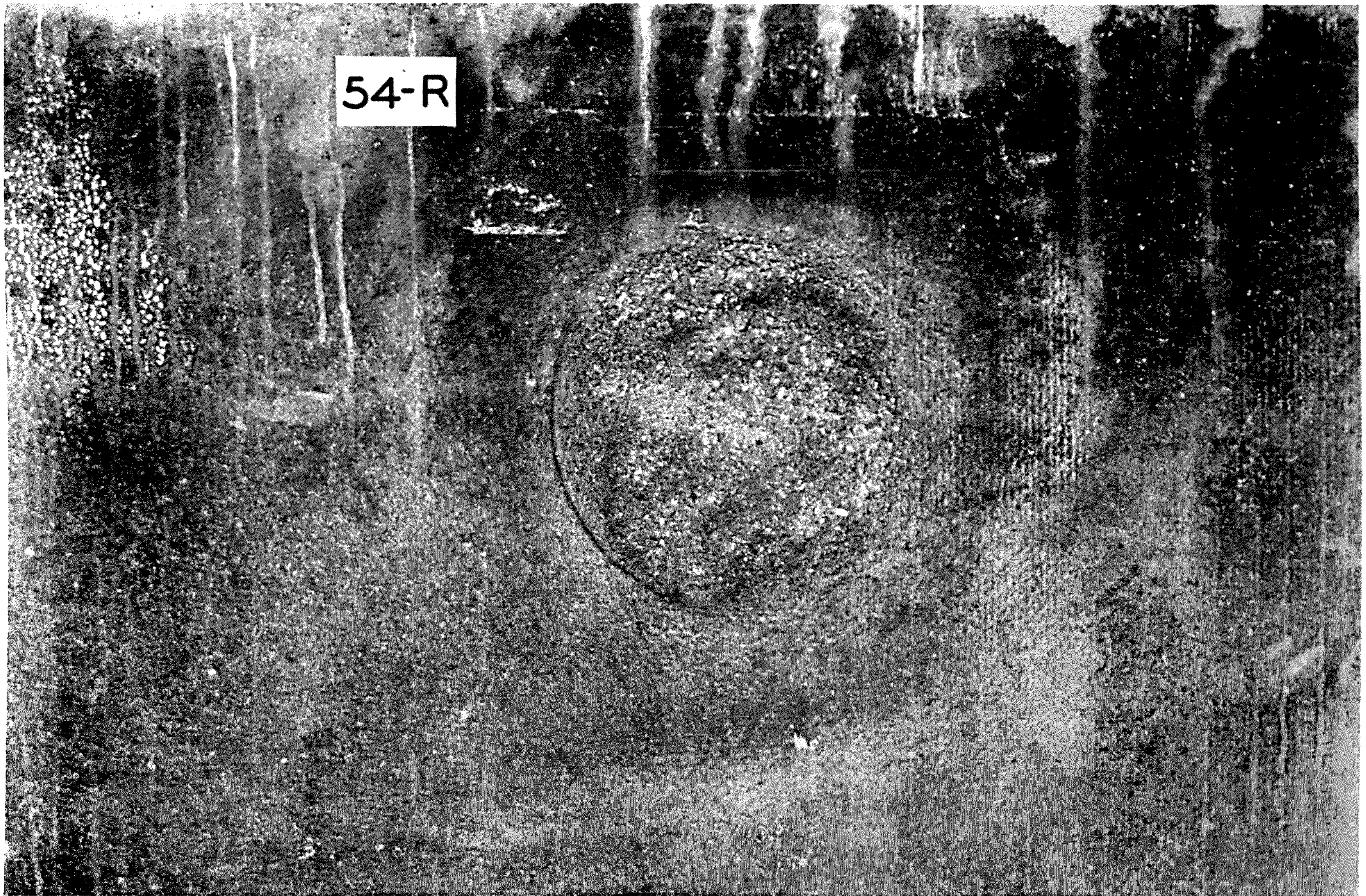
PLATE 9

Panel of 2-in. slump concrete cast against wet plywood by use of prolonged high-frequency vibration after sandblasting and rubbing with carborundum stone. Note relatively few surface voids



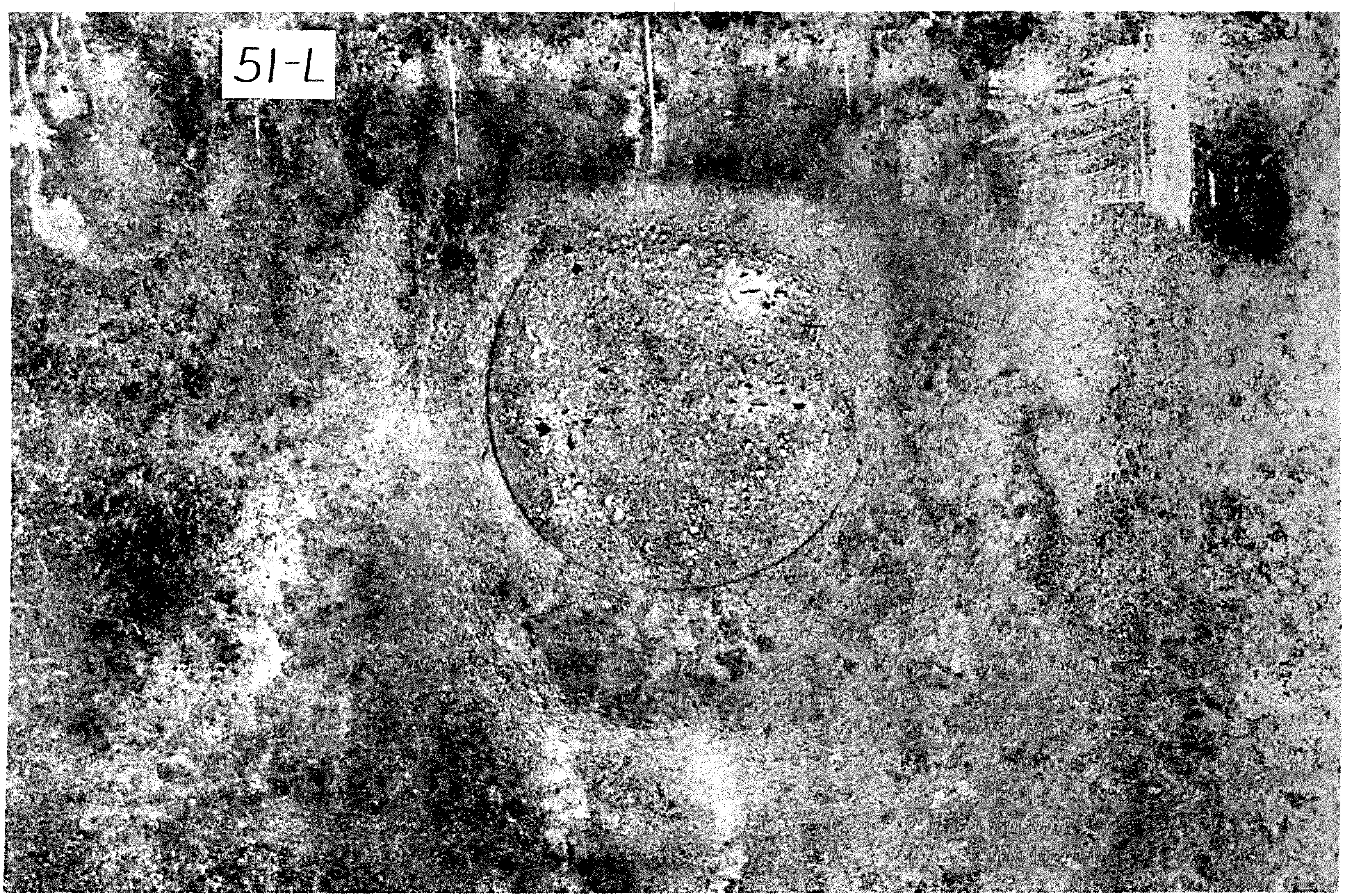
Panel of 2-in. slump concrete cast against lining A by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph. Note good resistance to sandblasting

PLATE 11



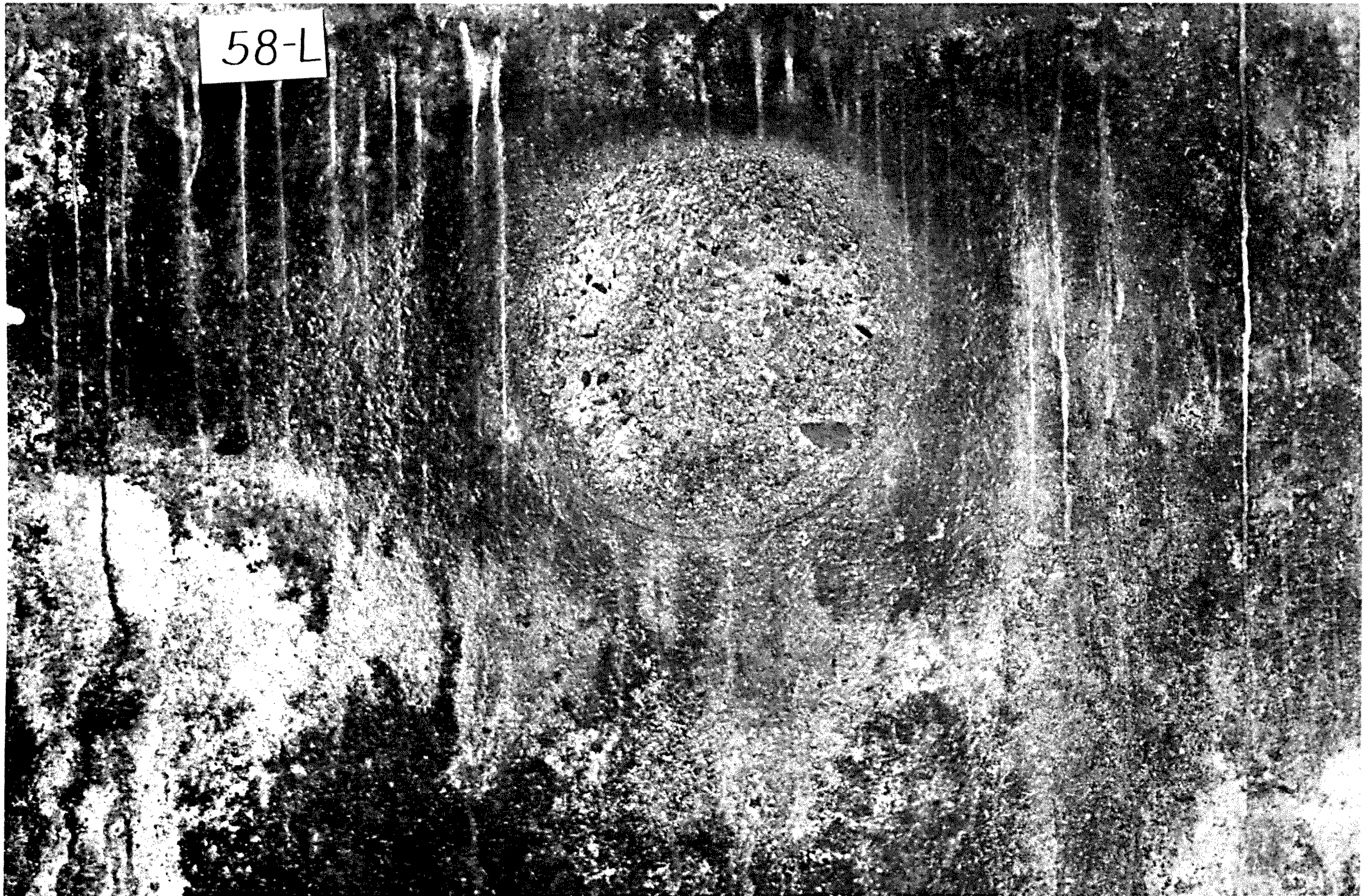
Panel of 2-in. slump concrete cast against lining B by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note good resistance to sandblasting

PLATE 12



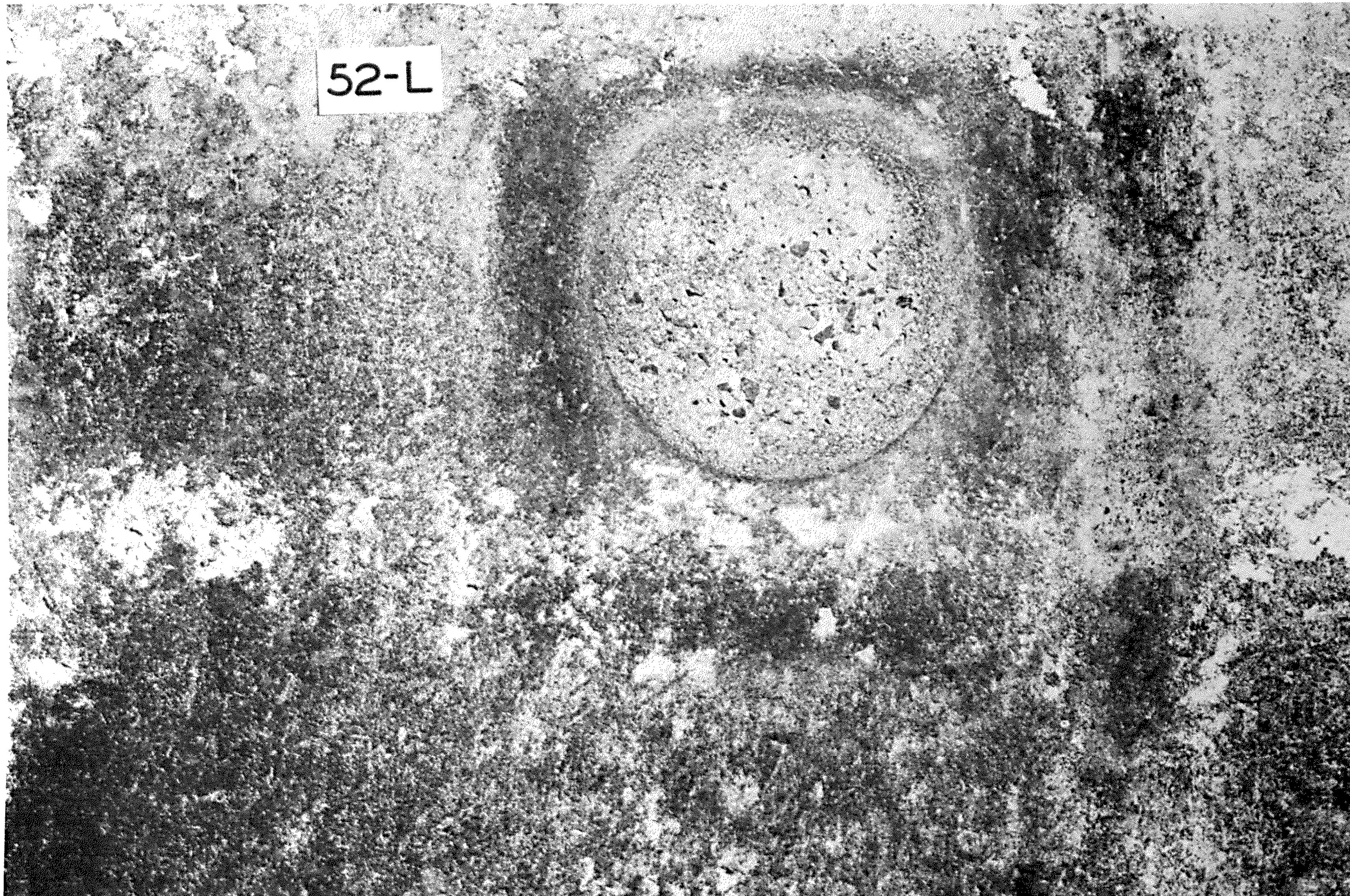
Panel of 2-in. slump concrete cast against lining C(1) by means of prolonged high-frequency vibration after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note good resistance to sandblast

PLATE 13



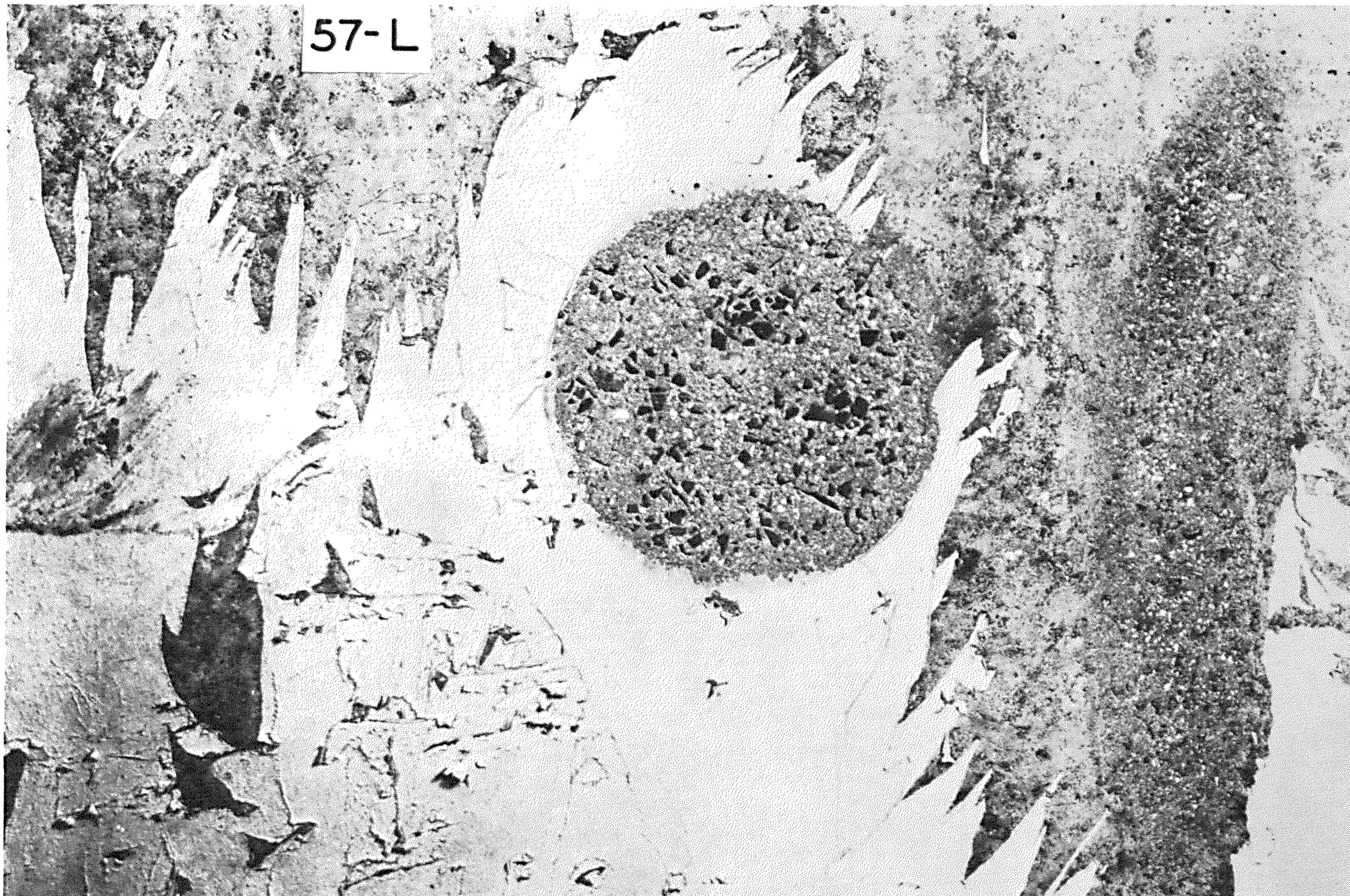
Panel of 2-in. slump concrete cast against lining C[2] by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note the good resistance to sandblast

PLATE 14

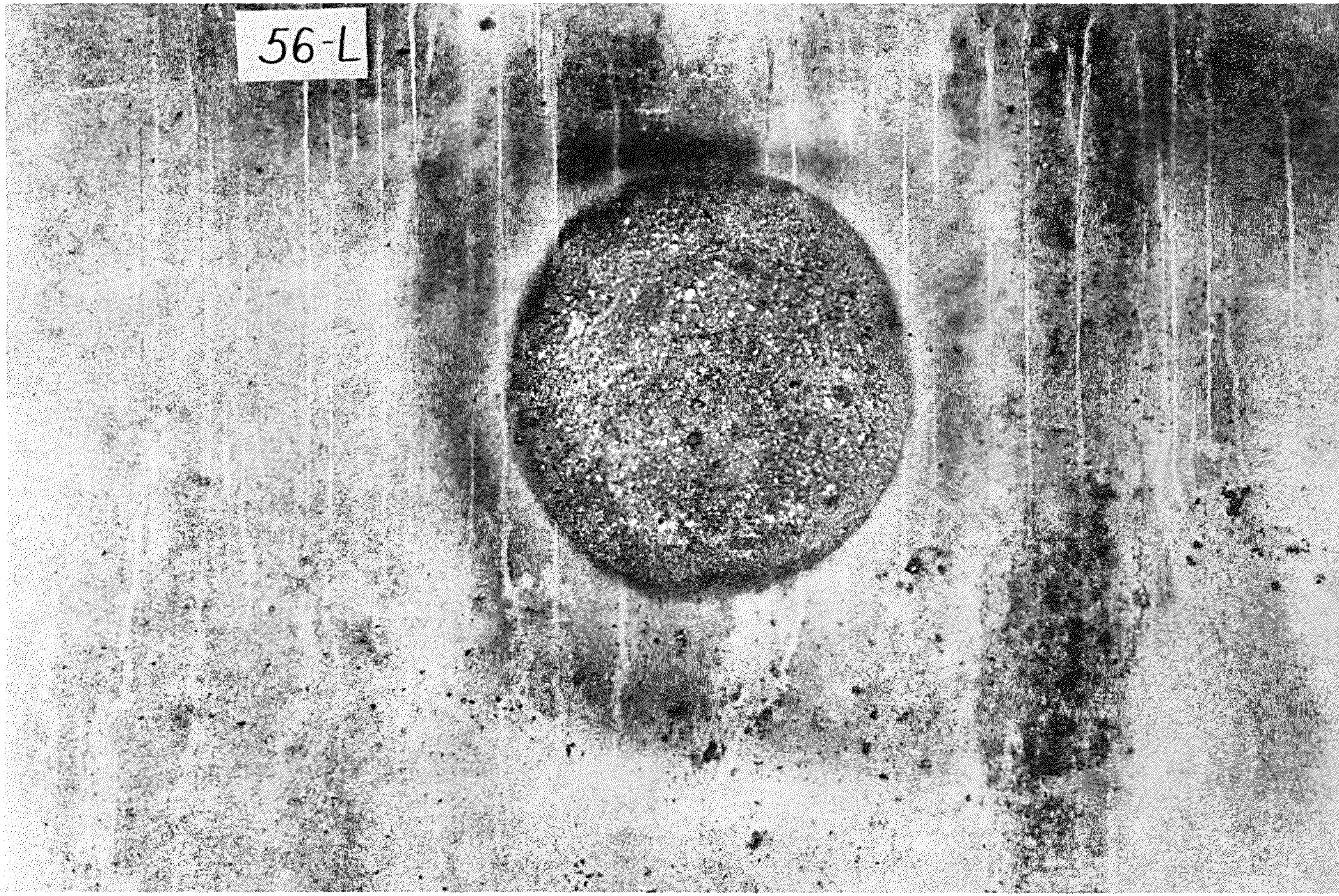


Panel of 2-in. slump concrete cast against lining D by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note good resistance to sandblast

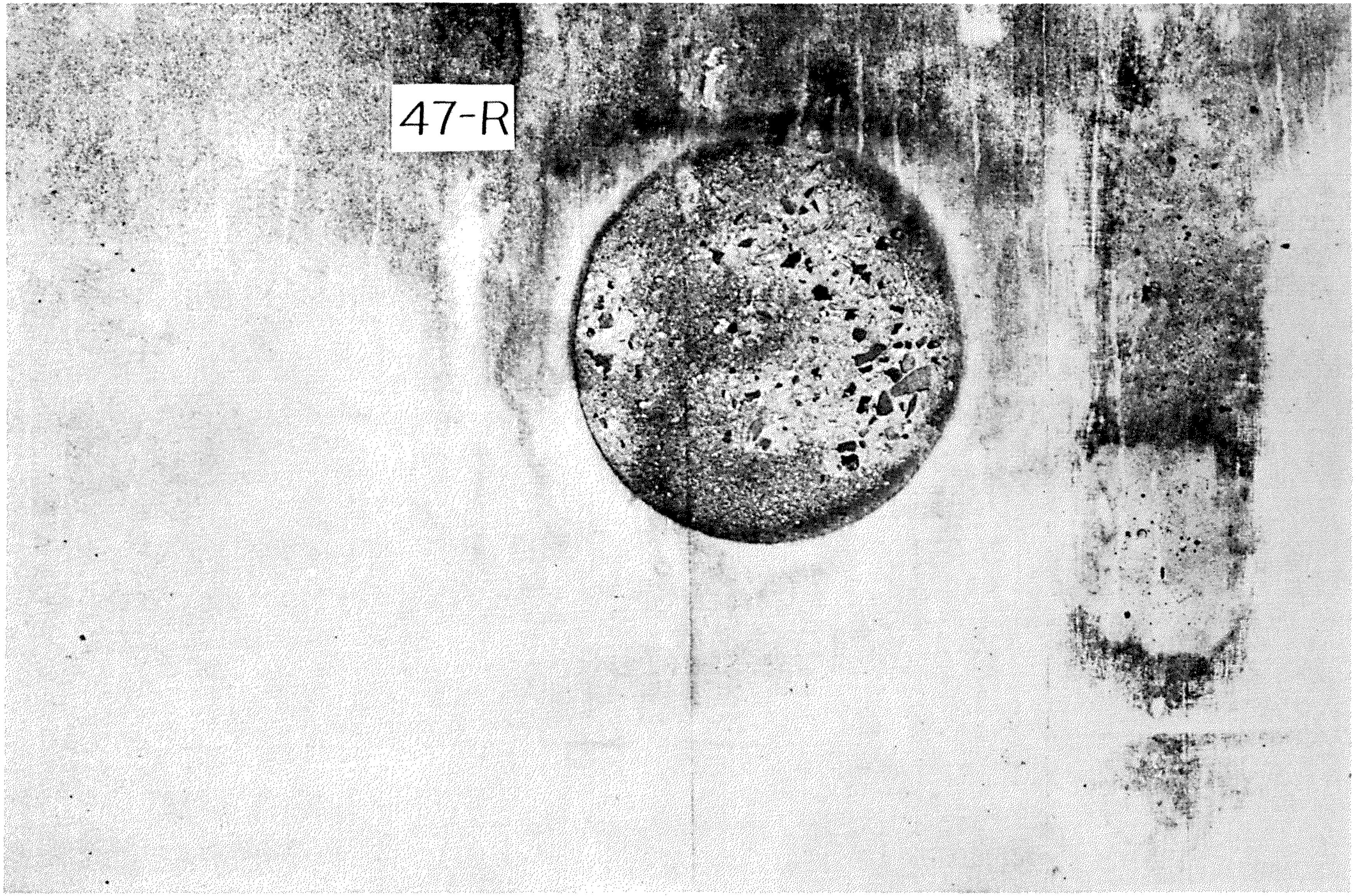
PLATE 15



Panel of 2-in. slump concrete cast against lining E over plywood by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone

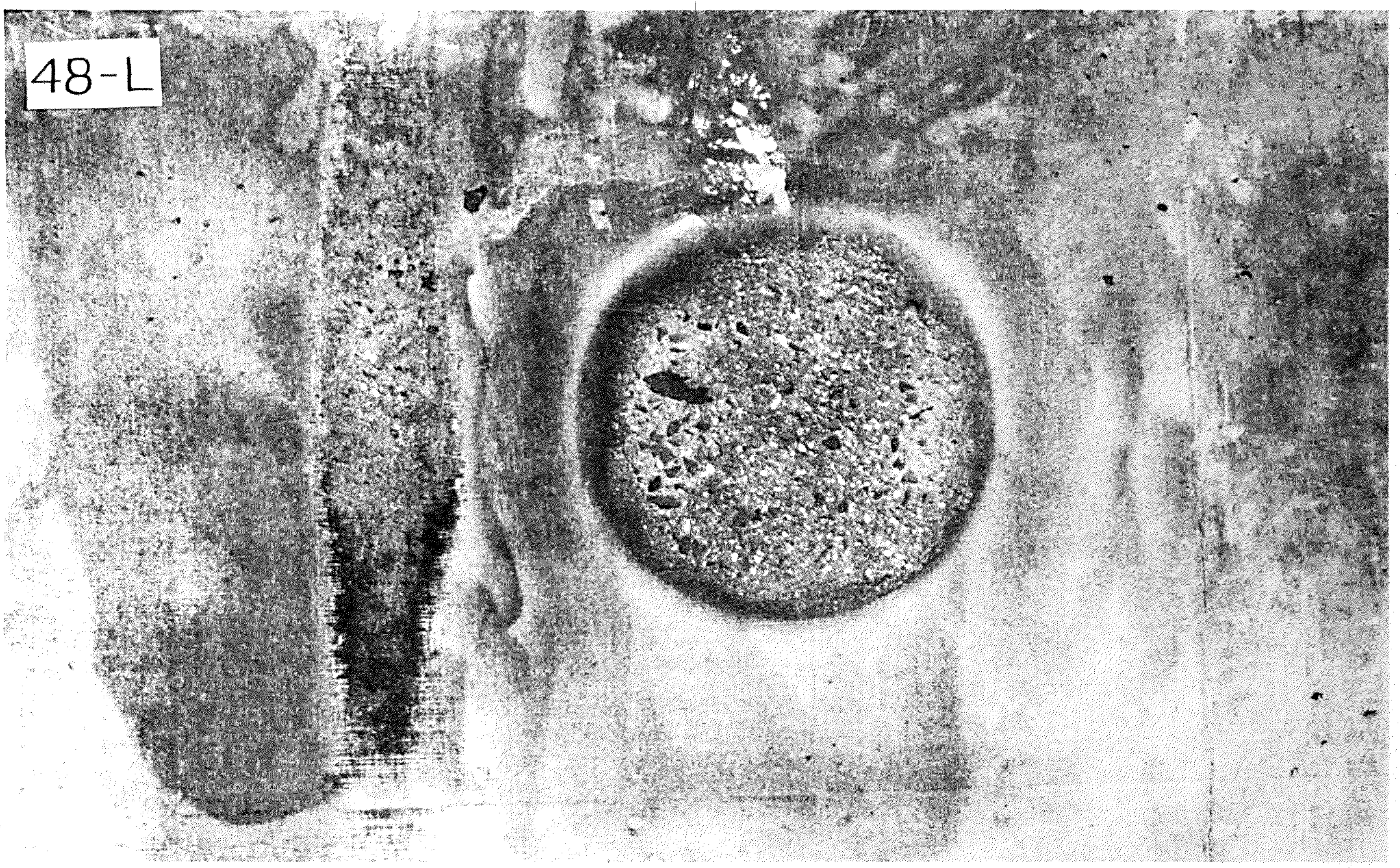


Panel of 2-in. slump concrete formed against lining F over plywood by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note the good resistance to sandblast

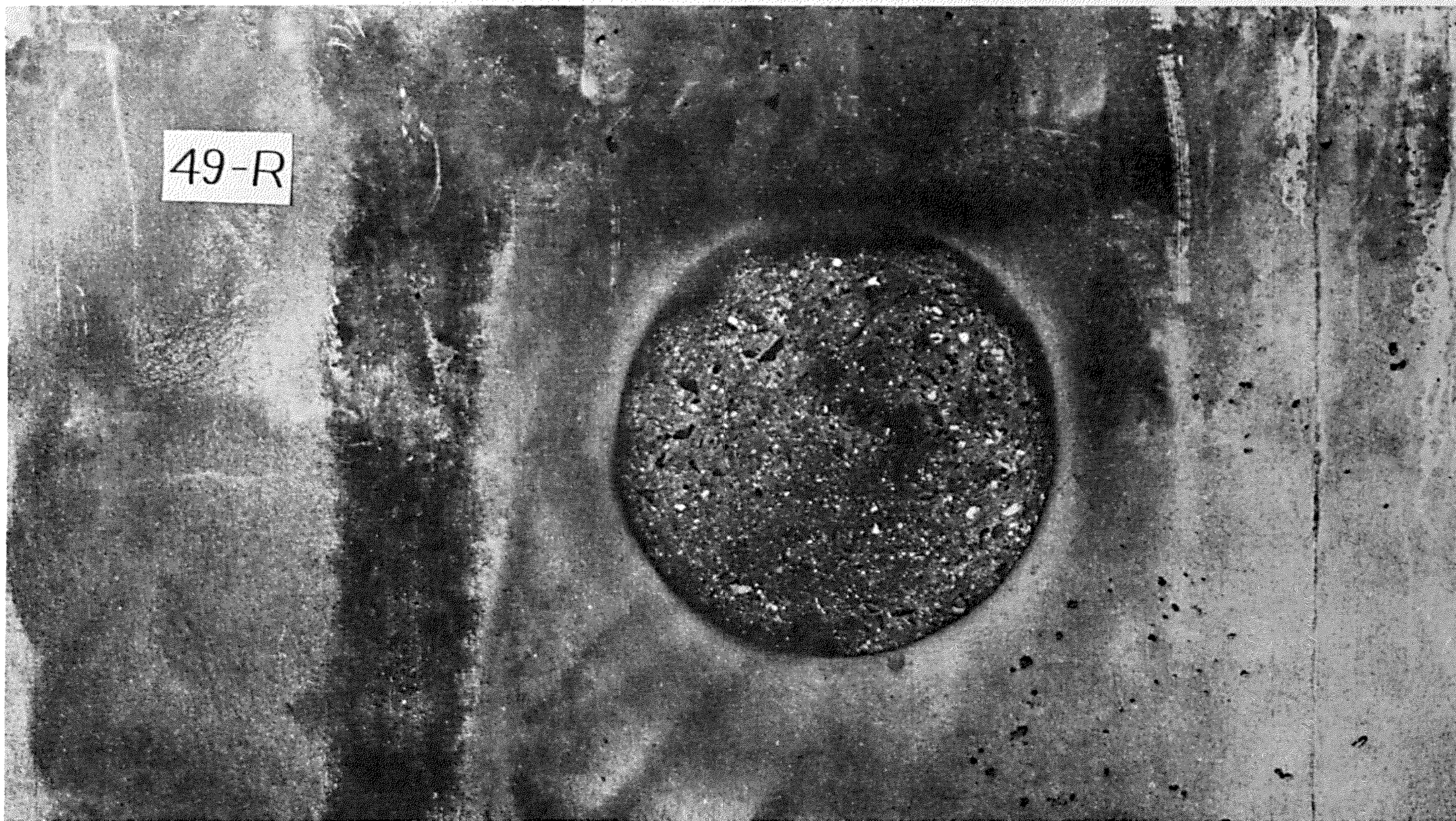


Panel of 2-in. slump concrete cast against lining G over steel by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note good resistance to sandblast

PLATE 18

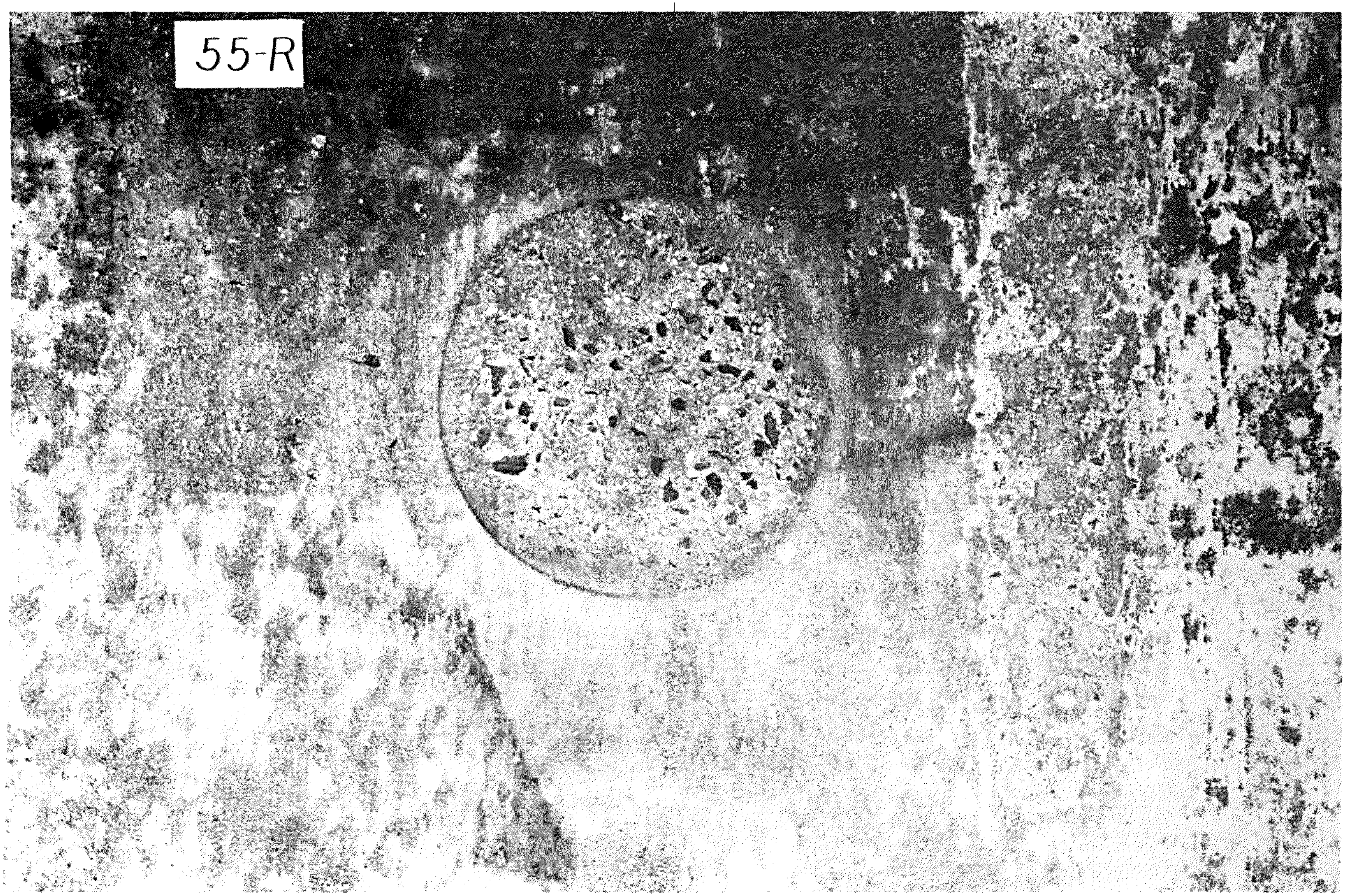


Panel of 2-in. slump concrete formed against lining H over steel by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the left of the photograph with carborundum stone. Note the good resistance to sandblast



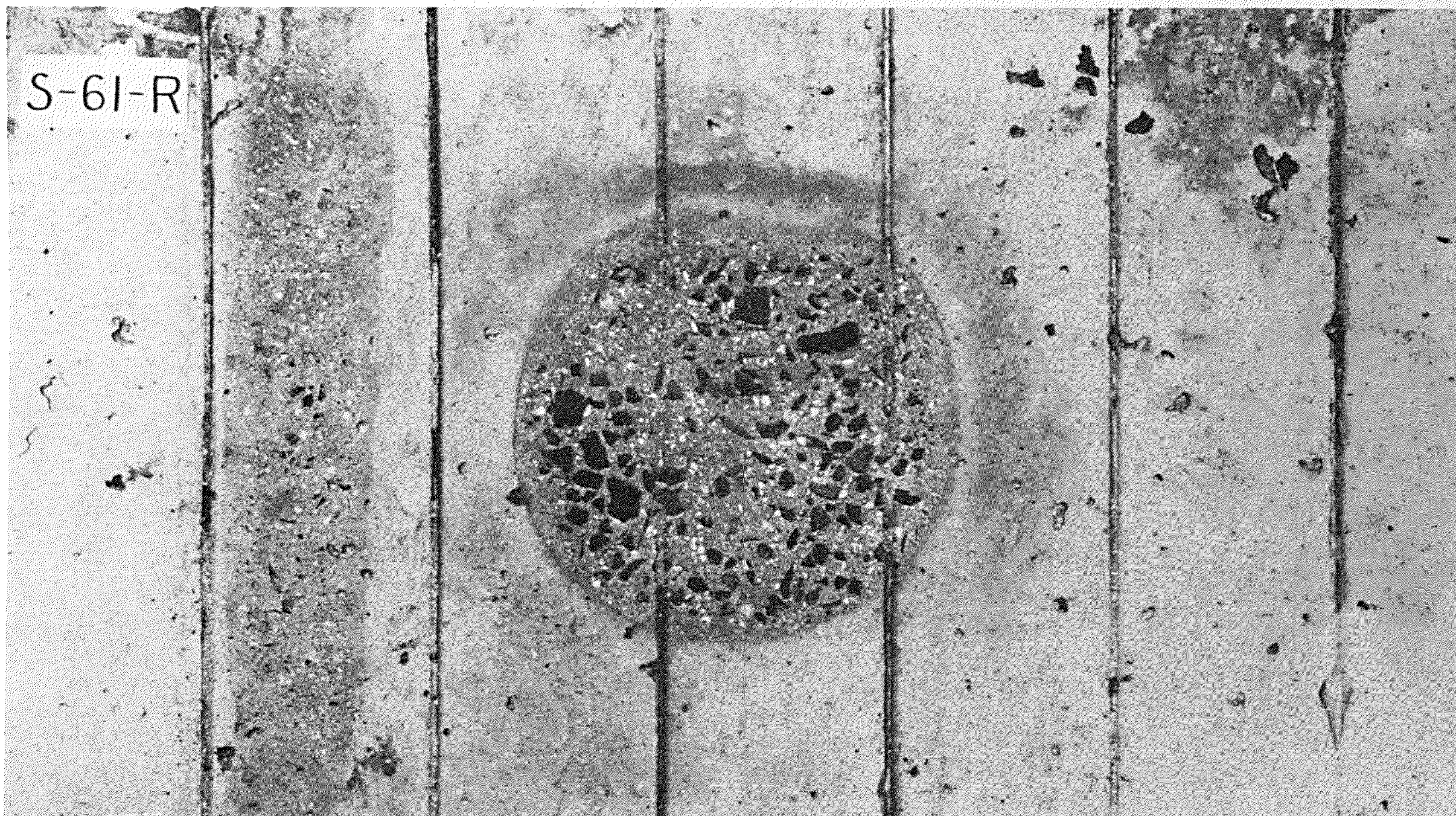
Panel of 2-in. slump concrete formed against lining I over steel by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area to the left of the photograph with carborundum stone. Note the good resistance to sandblast

PLATE 19

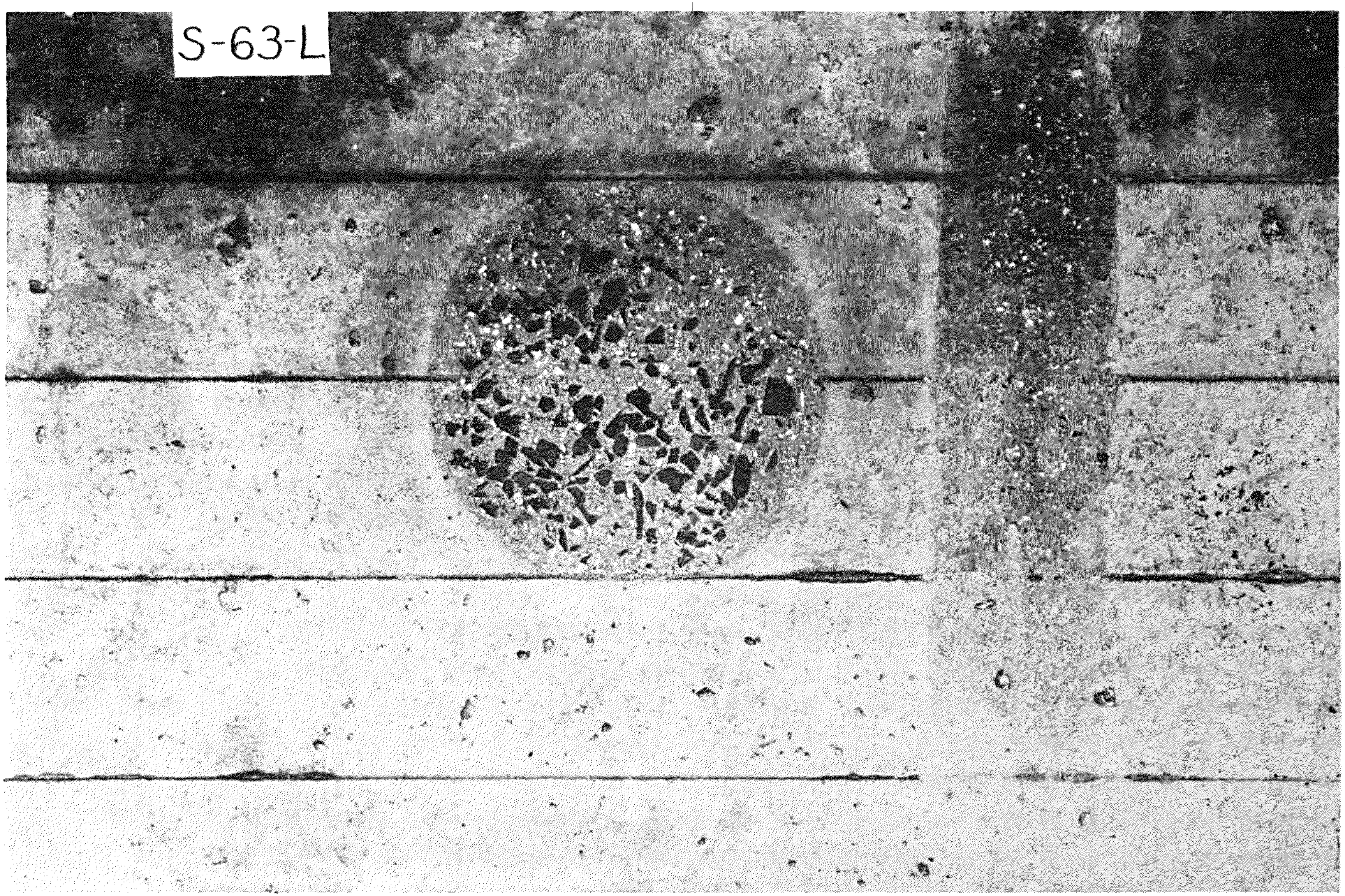


Panel of 2-in. slump concrete formed against lining M over plywood by means of prolonged high-frequency vibration after sandblasting and rubbing of small area to the right of the photograph with carborundum stone. Note the good resistance to sandblast

PLATE 21



Panel of 2-in. slump concrete cast against articulated steel forms with 6-in. channel widths and strips of lining F between the channels, by means of prolonged high-frequency vibration, and after sandblasting and rubbing of the small area to the left of the photograph with carborundum stone



Panel of 2-in. slump concrete cast against articulated steel form with 6-in. channel widths and no lining strips between channels, by means of prolonged high-frequency vibration and after sandblasting and rubbing of small area on the right of the photograph with carborundum stone

APPENDIX A

METHOD OF TEST FOR EVALUATION OF ABSORPTIVE FORM LINING

Scope

1. This method of test describes the procedure for determination of the acceptability of absorptive form lining for use in concrete construction.

Apparatus

2. The apparatus shall consist of the following:

(a) Forms.- Plywood-lined wooden forms for casting concrete panels 3-1/2 in. thick, 16 in. wide and 36 in. high. The forms shall be open at the top, and so constructed as to be easily assembled, sturdy, and capable of frequent re-use. Two forms are required.

(b) Concrete Mixer.- Tilting-drum mixer, capable of mixing thoroughly a batch of at least 1-1/2 cu ft of concrete.

(c) Concrete Vibrator.- Electric-powered, flexible-shaft, internal vibrator, vibrating head 1-1/8 in. x 8 in., revolving free at 7000 rpm.

(d) Scales.- Scales having a total capacity of at least 1000 lb and accurate to 0.5 lb.

(e) Balance.- For weighing 1-ft squares of lining, having a capacity of 5 kg and accurate to 1 g.

(f) Flexible Steel Tape.- Tape having a length in excess of 5 ft graduated to 0.01 in.

(g) Equipment for Abrasion Test.- A device for holding 16 No. 1 Desmond-Huntington Grinding Wheel Dressers, essentially as shown in

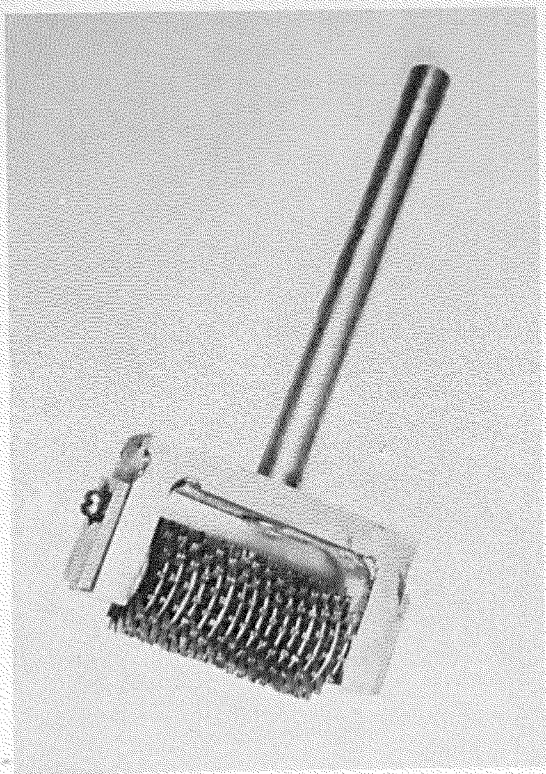


Fig. A1. Abrasion device for chuck or drill press

fig. A1, to be operated in the chuck of a small drill press. A weight of 1000 g shall be suspended on the lever arm of the drill press 5 in. from the center of rotation of the lever for the purpose of exerting a uniform pressure on the specimens during the test. Device prepared for testing is shown in fig. A2.

Preparation of Samples

3. (a) At least 5 pieces of form lining shall be cut 1 ft square for test of absorption.

(b) At least 2 pieces of form lining 16 in. wide by 36 in. long shall be cut for attachment to the faces of the form.

Procedure

4. (a) Flexibility.- The following test applies only to the flexible-type chipboard linings. Four specimens each, 12 in. square, shall be cut from two sheets of the lining, and marked to indicate the longitudinal and transverse directions corresponding to the sheet from which taken. Two specimens representing each orientation and each sheet shall be fitted around a semicylindrical form of 4-in. radius, 12 in. long, with the cloth facing or surface to be applied to the concrete outward. Any failure in the chipboard itself or loosening of the cloth facing from the chipboard should be noted.

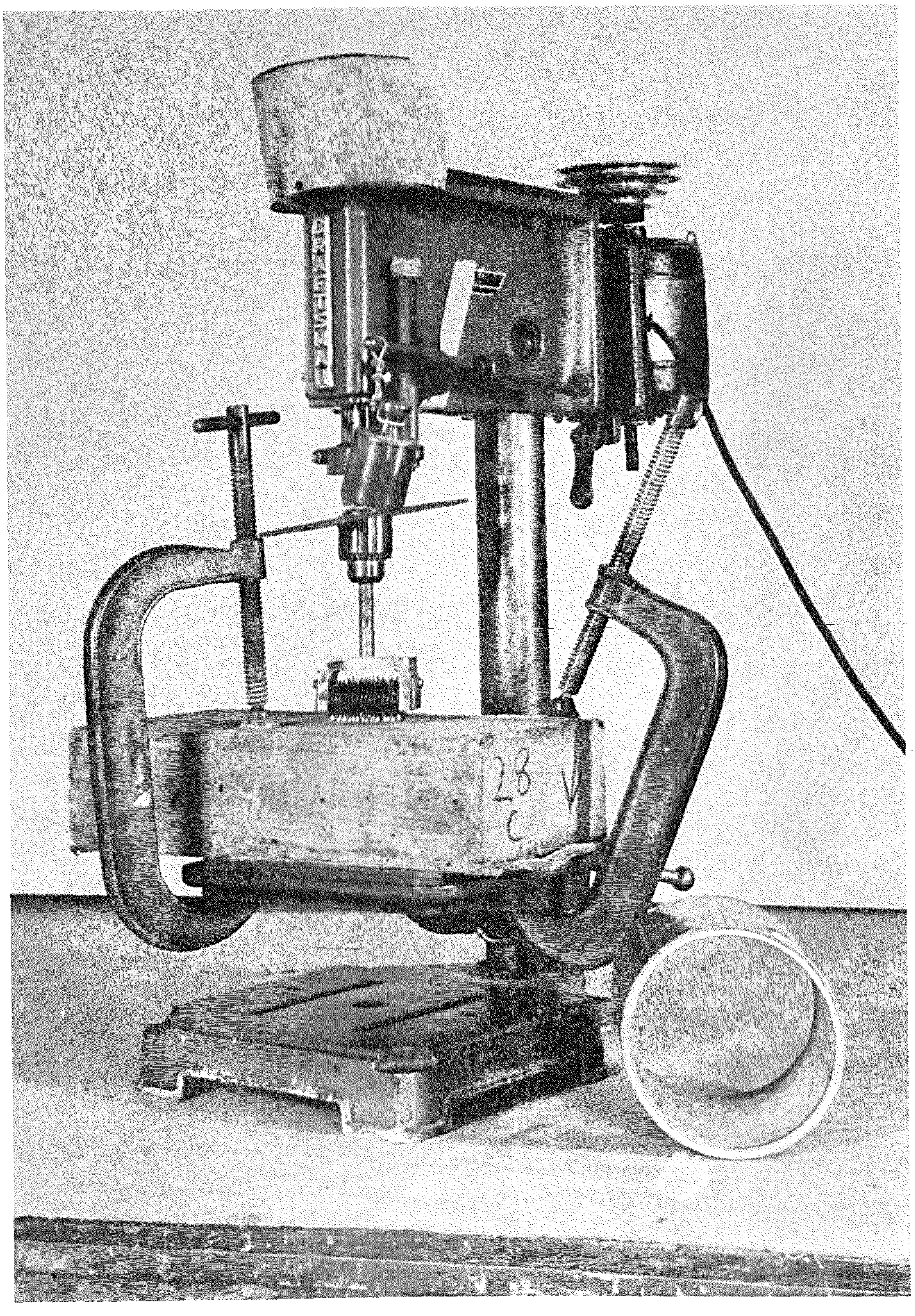


Fig. A2. Abrasion machine and specimen ready for testing

(b) Expansion Due to Moisture.- The following test usually applies only to the semirigid type of linings, but may be applied to the flexible linings if desired. The linear expansion of a lining may be determined by cutting a strip 3 in. wide by 44 in. long from a sheet of lining being tested, with the long dimension parallel with the long dimension of the sheet; cutting another strip of the same dimensions, but with the long dimension of the strip parallel with the short dimension of the sheet, and subjecting the two strips to the following procedure. At each of two spots on the strips, approximately 40 in. apart and on the longitudinal center line, a small area shall be coated with paraffin. A fine cross shall be made with a razor blade on the center line in each of these two areas to serve as a reference point for length measurement. The two strips shall then be stored in a room at 50 per cent relative humidity for 24 hr after which time the distance between the reference points shall be measured, with the steel tape, to the nearest 0.005 in. by use of a magnifying glass. After the original reading the specimens shall be stored in the fog room at 100 per cent relative humidity for 24 hr and read again. The second reading should be made in the fog room or as quickly as possible (within 1 min) after removal therefrom. Specimens should be protected from dripping water during the time they are in the fog room, and so positioned as to permit free circulation of the moist air around them.

(c) Preparation of Concrete Specimen.- Line both faces of one panel form with the lining to be tested; the other form remaining unlined. Assemble the lined and unlined forms. Prepare two 1.3-cu-ft batches of concrete according to the requirements of CRD-C 114, using proportions, materials and gradings specified therein. Cast two panels, one immediately after the other, and consolidate the concrete in each panel in two lifts by internal vibration using identical placing technique. After casting, cover the tops of the panels with wet burlap and allow to stand in the laboratory until time to strip at 24 ± 2 hr, and repeat casting of additional panels on three successive days. Remove lining when forms are stripped. Cure specimens for 14 days.

(d) Inspection for Stains, Sticking, Defects and Voids.- Ease of removal from surface, staining, or other surface defects should be observed and reported in the evaluation of the form lining. The entire area of both 16- by 36-in. faces shall be marked off into 1-in. squares and the surface in each square shall then be examined closely for the presence of voids larger than 1/16 in. in diameter. Voids larger than 1/16 in. in diameter shall be considered objectionable and the number of squares per face containing such voids divided by 5.76 shall be taken as the percentage of surface voids.

(e) Resistance to Abrasion.- Cut an area of the surface from near the middle of each panel cast against the form lining, and from the surface cast against plywood for the control, and subject to abrasion at 21-days age according to the following:

Place abrasion device in chuck of drill press, and clamp specimen securely to the platform of the press. The lever arm shall be adjusted to form an angle of approximately 10^{o} above the horizontal at commencement of the test. The motor shall be started and the device lowered gently until it makes contact with the surface of the specimen, then released so that only the weight on the lever arm holds the abrasion device against the surface (fig. A2). Abrasion shall be continued for two min and the resulting dust shall be collected carefully and weighed to the nearest 0.1 g.

5. The following tabulation of physical requirements may be used as a basis for evaluating a lining material after conclusion of the tests.

Physical Requirements

	Flexible	Semirigid
Wt of fabric facing minimum, lb/sq yd	0.1	---
Thread count of warp and filler of fabric facing, minimum and maximum	40, 80	---
Thickness, in., minimum	---	1/4
Discoloration (observation of concrete test panels)	No staining or discoloration.	No staining or discoloration.
Sticking (as determined by removal of lining from test panels)	*	*
Surface voids, maximum per cent (as counted in the grid marked off on concrete specimen surface)	2	2
Flexibility, visible evidence of rupture as determined by visual observation of bending test around semicylindrical form	None	---
Linear expansion, per cent	0.6	0.6
Abrasion loss, maximum per cent of unlined surface (as determined by test on concrete specimens)	65	65

* Fabric shall be easily removable in strips of minimum 16-in. width.

Report

6. The report shall include the following:

(a) Observations as to tendency of lining to adhere to the concrete at time of stripping, appearance of formed surface relative to staining, bubbles, streaking, percentage of voids on formed surface, etc.

(b) Abrasion loss in grams for both the plain and form-lined surfaces.

APPENDIX B: TESTS OF SPECIAL FINISH MATERIAL

Special Finish Material

1. It has been proposed at various times that instead of using form lining to produce pleasing and more weather- and abrasion-resistant concrete surfaces, the surfaces be given a specially applied finish coat. Such a coat could, if desired, be used to fill the voids that inevitably result from the use of non-absorptive forms; and if a decorative, architectural finish were desired an additional finish coat could be applied.

2. Five slab faces from the basic program were selected for treatment with a proprietary material, supplied to the user as a bond- and finish-coat material to determine the types of finish that could be obtained, how abrasion resistant they would be, and how they would resist natural weathering. A representative of the company furnished the materials and personally applied them to the five slab surfaces.

3. The slab surfaces, the treatment they received, curing, subsequent exposure, and condition after approximately one-and-a-half years exposure to natural weathering are described below:

a. (1) Base panel was of 2-in. slump concrete formed against oiled pressed hardboard.

(2) Treatment consisted of filling the voids, first flushing the surface with water, then troweling a stiff mortar made of 1 part of bond-coat material to 1 part of concrete sand which had been passed through the No. 16 sieve into the voids. After the mortar had set, the slab was placed in the fog room and cured for 7 days, as were all the rest. It was then brought out into the laboratory and allowed to dry for 7 days, after which it was sandblasted in a manner similar to that for the slabs described in the main report. The filler material remained tightly bonded to the slab during the sandblasting. The old sandblasted area,

which was partially treated with bond-coat mortar, is visible to the left in plate B1; the newly blasted area may be seen at the right.

(3) Condition. After approximately 18 months of outdoor exposure the condition of the slab surface was good with slight crazing evident on the surface when water was dashed over it. The back side of this panel, which had been formed against lining C(2) also showed slight crazing.

b. (1) Base panel was of 2-in. slump concrete formed against articulated steel channel forms with 6-in. channels containing strips of lining F between channels.

(2) Treatment consisted of filling the voids. This was accomplished by first flushing the panel face with water, then troweling with a steel trowel a stiff mortar made of 1 part bond material to 1 part concrete sand prepared by passing it through the No. 16 sieve. After curing and drying the slab was sandblasted. The filler material remained tightly bonded to the concrete. The panel after treatment and sandblasting is shown in plate B2.

(3) Condition of the panel surface was fair after approximately 18 months outdoor exposure, with crazing evident over the whole area when water was dashed over the surface.

c. (1) Base panel was of 2-in. slump concrete formed against articulated steel forms with 6-in. vertical channels and no lining strips between the channels.

(2) Treatment consisted of removing the fins between channels, and flushing the surface with water, after which a bond coat was applied by means of a steel trowel and rubber float to a thickness of approximately 1/16 in. The following day a finish coat consisting of 1 part finish-coat material to 1.5 parts of -No. 16 sand to a depth of about 1/16 in. was applied and steel troweled to a slick finish. It was sandblasted after curing and drying. The finish resisted sandblasting very well, the base coat material appearing to be more resistant to abrasion than the finish coat. The panel is illustrated in plate B3.

(3) Condition of the panel surface, after approximately 18 months outdoor exposure, was fair with crazing of medium-size pattern (lines about 1 in. apart) over the entire surface evident when water was dashed over it.

d. (1) Base panel was of 2-in. slump concrete formed against oiled tongue-and-groove lumber.

(2) Treatment consisted of flushing the surface with water then applying a bond coat one day and a finish coat with a cork float finish the following day. After curing and drying it was sandblasted (see plate B4). The resistance to sandblast abrasion offered by the special finish was better than that of the original concrete.

(3) Condition of the treated panel surface after approximately 18 months exposure was fair with large-pattern crazing (lines approximately 1-1/2 in. apart) evident when water was dashed over the surface. The reverse side which had been formed against lining A was also slightly crazed.

e. (1) Base panel was nominal 2-in. slump concrete formed against oiled plywood.

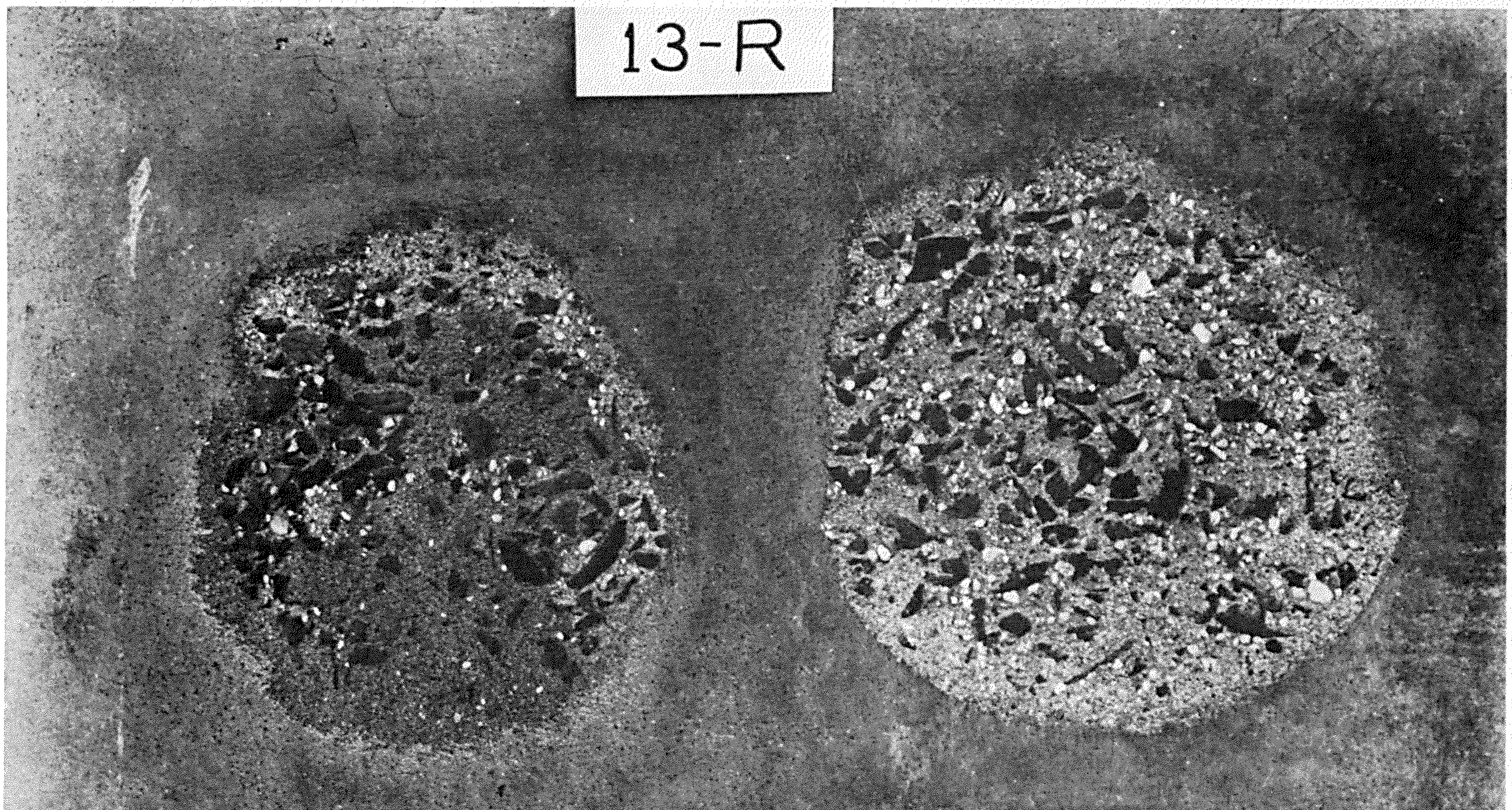
(2) Treatment consisted of bond coat and finish coat applied, cured, dried and sandblasted as the other slabs. The panel is shown in plate B5 after treatment and sandblasting. The abrasion resistance was good.

(3) Condition of the panel after approximately 18 months outdoor exposure was fair, but the entire surface was covered with small-pattern crazing (lines about 3/4 in. apart), evident when water was dashed over the surface. The reverse side which had been formed against lining C(1) was also crazed.

Conclusions

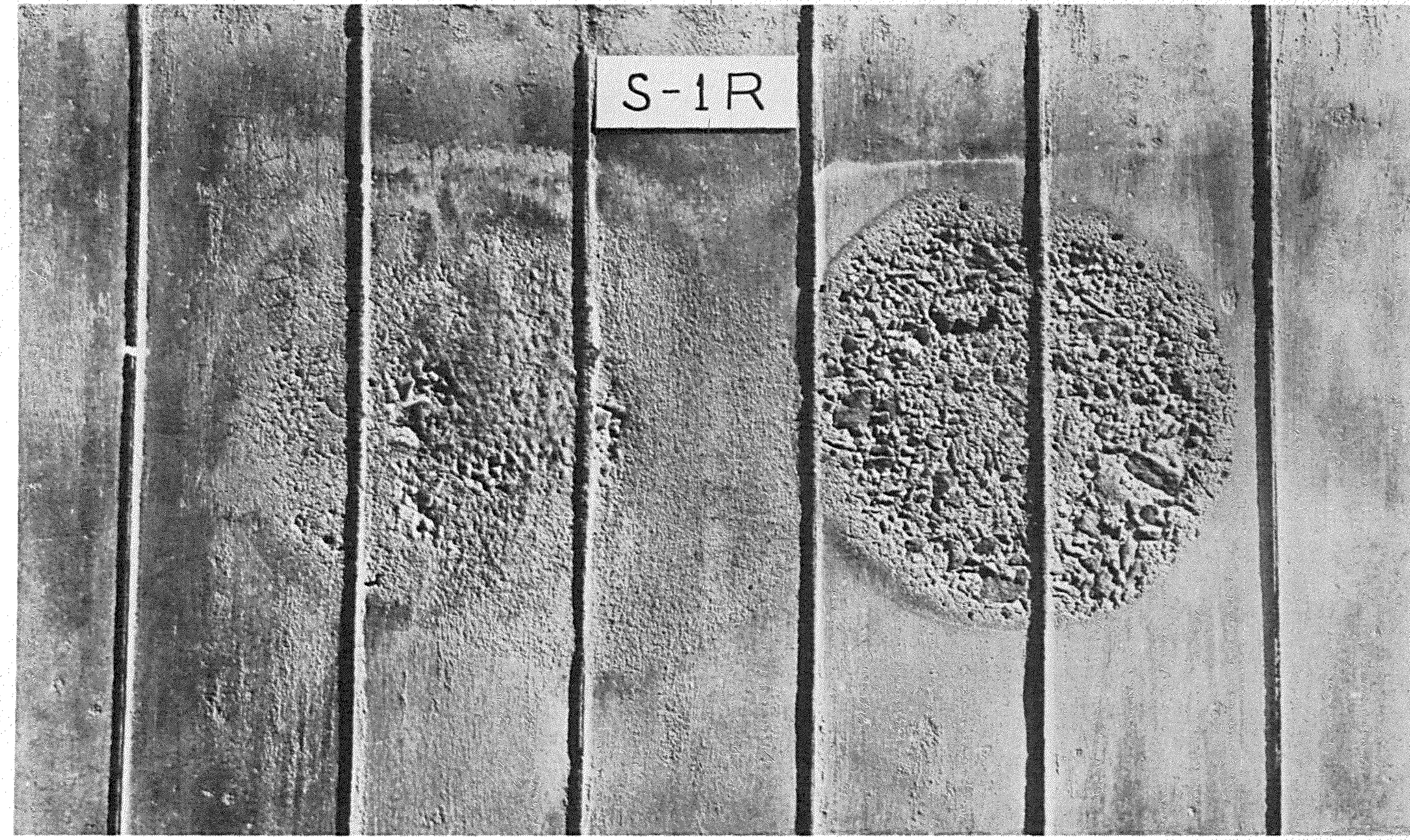
4. The finish coat does an efficient job of void filling with a material that appears to adhere firmly. The two-course work is very attractive in appearance and quite abrasion resistant. Some crazing developed in both the base surfaces and in the finish applied over them.

PLATE B-1

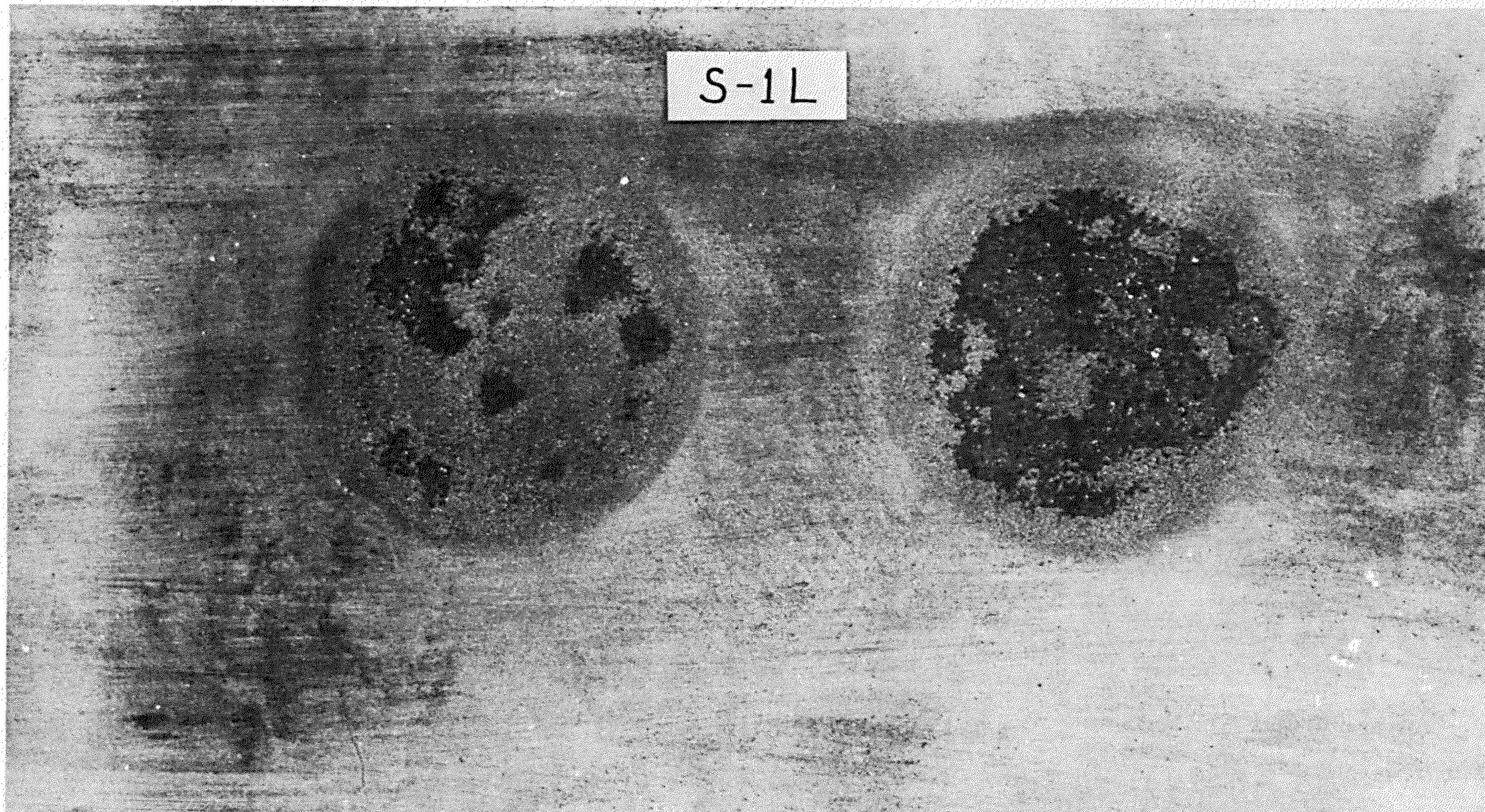


Panel of 2-in. slump concrete formed against oiled pressed hardboard, after filling voids with special finish bond coat. Old sandblasted area, partially plastered, is shown at the left of the photograph; newly blasted area is to the right

PLATE B-2



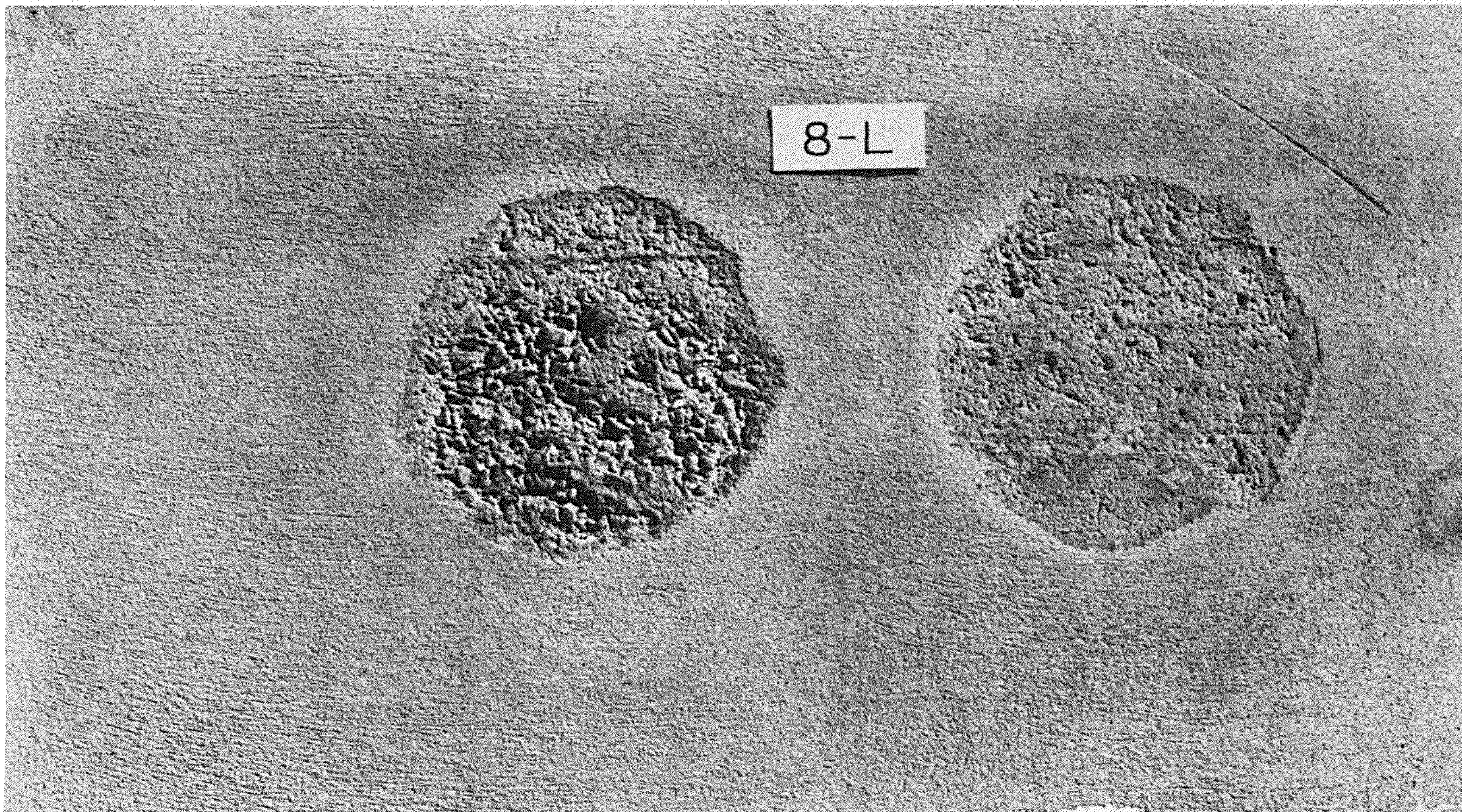
Panel of 2-in. slump concrete formed in articulated steel forms, after filling of voids with special finish bond coat. Old sandblasted area, partially plastered, is shown to the left of the photograph; newly sandblasted area is to the right



Panel of 2-in. slump concrete formed in articulated steel form, with fins knocked off before treatment with bond coat and steel trowel finish coat. Both abraded areas shown were plastered and sandblasted. Finish had good abrasion resistance

PLATE B-3

PLATE B-4



Panel of 2-in. slump concrete formed against oiled tongue-and-groove lumber, given base coat and cork-float finish coat. Old sandblasted area, partially plastered, is shown to the left of the photograph; new sandblasted area is to the right. Finish had good abrasion resistance

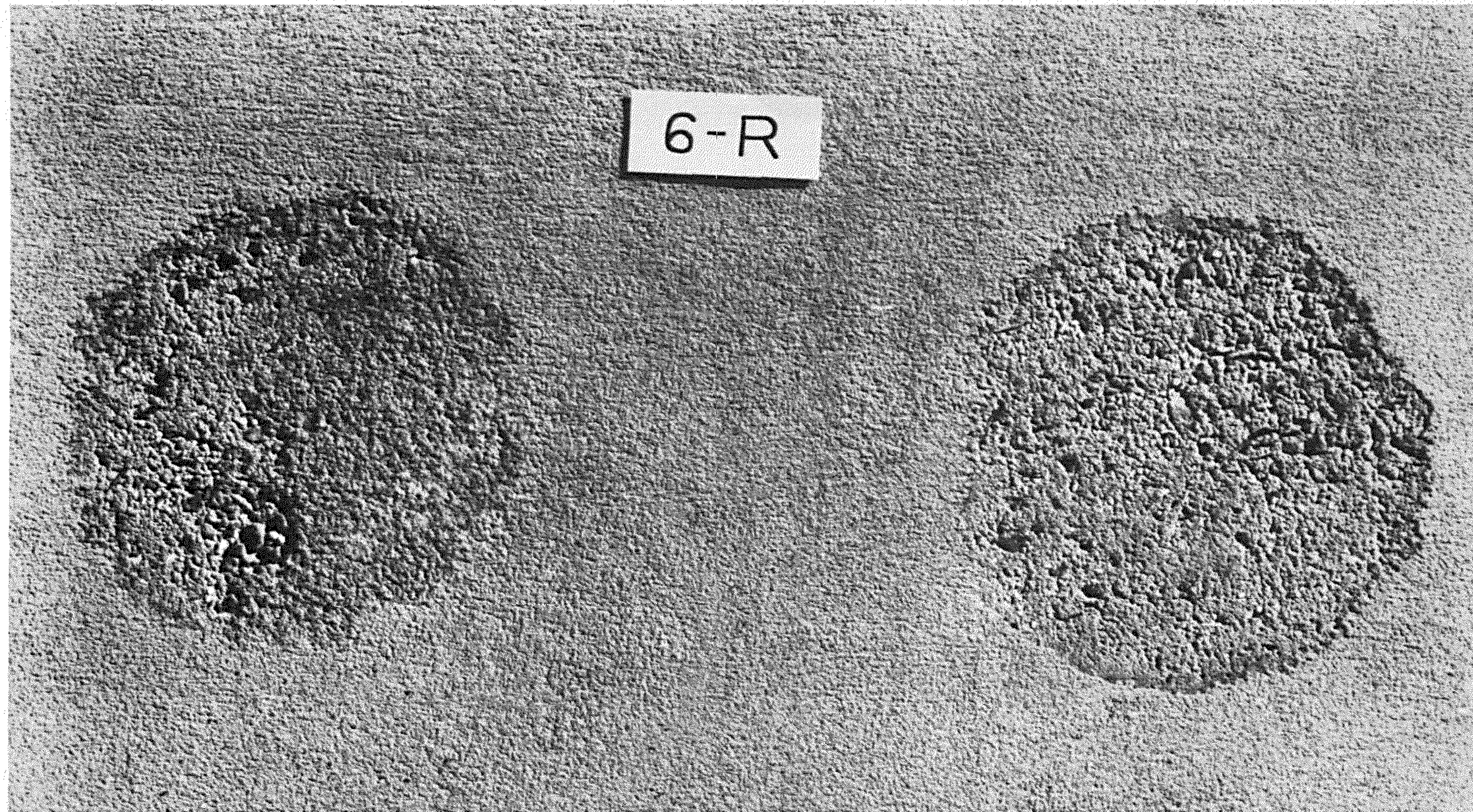


PLATE B-5

Panel of 2-in. slump concrete formed against oiled plywood, and given base coat and finish coat applied with cork float. Old sandblasted area shown on left, was special-finished and reblasted; new sandblasted area is shown on right. Finish exhibited good abrasion resistance