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Synopsis

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Based on field observations and laboratory tests, it is concluded that dusting may result from the first use of wood forms that have been exposed to the weather for several weeks in advance of pouring concrete. Dusting is not likely to occur on subsequent use of the form. It is due to unknown changes that take place in the wood upon exposure to the weather but which do not develop under ordinary covered storage. It is indicated that dusting may result from the use of wood forms other than Douglas fir plywood. Form oil is not responsible for the condition but, on the other hand, the type of form oil customarily used is ineffective in nullifying the causes of dusting.

Dusted surfaces harden satisfactorily upon removal of the forms, after a few days curing under moist conditions. Rather than attempt to prevent dusting from occurring it is believed to be more practical to correct the condition by subsequent curing with water in a spray fine enough not to erode the soft surface.

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SURFACE DUSTING OF FORMED CONCRETE

SYNOPSIS

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Based on field observations and laboratory tests, it is concluded that dusting may result from the first use of wood forms that have been exposed to the weather for several weeks in advance of pouring concrete. Dusting is not likely to occur on subsequent use of the form. It is due to unknown changes that take place in the wood upon exposure to the weather but which do not develop under ordinary covered storage. It is indicated that dusting may result from the use of wood forms other than Douglas fir plywood. Form oil is not responsible for the condition but, on the other hand, the type of form oil customarily used is ineffective in nullifying the causes of dusting.

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INTRODUCTION

During the summer of 1952 reports were received in the Laboratory of an unsatisfactory condition of the surface of concrete which was observed upon removal of plywood forms on two structures which were parts of freeway construction in Los Angeles County. The structures involved were the Colorado Street Arch, VII-L.A-161-Pas, Contract 51-14VC16 and Bronson Avenue Overcrossing, VII-L.A-2-L.A, Contract 51-14VC21-F.

On the Colorado Street Arch it was reported that surfaces in contact with certain plywood forms were "burned", that is, upon removal of the forms a soft, chalky surface extending to depths up to 1/4 inch was observed. Where this condition existed, the surface could be abraded readily with the bare fingers. Adjacent areas, in contact with other plywood boards were found to be hard and entirely normal. Similar conditions were observed on the Bronson Avenue Overcrossing, however, on this structure the affected areas were more extensive and were located where they would be conspicuously in view of passing traffic.

In the remainder of this report, the condition of a soft, chalky surface will be referred to as "dusting" since this term has been used by other investigators.

Both structures were visited and the resident engineers and assistants were interviewed as to conditions surrounding the occurrences. The following information now appears to be pertinent. Dusting has occurred only during the first use of plywood forms. Where dusting occurred the forms had been erected several weeks in advance of pouring the concrete. The

effect of exposure to the weather was well illustrated on the Bronson Avenue Overcrossing, a box girder design. The outer forms were placed completely except for two 4' x 8' boards to provide an opening during the placing of reinforcing steel and interior form work which required about six weeks time. Just before the concrete was poured the two remaining boards were put in place. Upon removal of the forms both vertical surfaces of the girder were dusted with the exception of the area in contact with the two boards placed just before pouring. The contrast in surface was readily visible from a distance of 50 to 100 feet. In order to make the difference in texture less conspicuous the sound areas were sand blasted.

The grade of plywood used on these structures normally is Douglas Fir "Plyform", exterior type, grade B-B. This grade is oiled both sides and edge-sealed at the mill before shipment and is intended to be used the first time without additional oiling. However, a number of sheets of exterior plywood grade-marked "A-A" or "A-B" were noted in the stock of the contractor on the Colorado Street Arch. These grades are not oiled at the mill. It was the practice of the contractor on each structure to apply a coat of form oil by spraying just before erection to the plywood sheets regardless of previous oiling at the mill. The type of form used is known as "100 pale oil", a petroleum product manufactured by major oil companies. Oil of different manufacture was used on the two contracts. The oil reportedly used by the plywood mills is of the same type. As

will be discussed later, it does not appear that the form oil was in any way directly responsible for the dusted condition.

A further observation on the work that is pertinent to the laboratory study is that a severely dusted area on a pier of the Colorado Street Arch hardened normally after it became thoroughly wet during a subsequent period of rain.

PRELIMINARY LABORATORY TESTS

A large number of tests were made in the laboratory during the early stages of the investigation in an effort to find clues as to the basic causes of the distress. These tests were not well co-ordinated and will be mentioned in part only.

A sample of board from a dusted area of Colorado Street Arch cut from an elevation above the top of the concrete pour was sent to the laboratory. Mortar pats cast against this board dusted at the surface of contact. Pats cast against samples from other boards that did not cause dusting on the work were sound at the surface of contact.

A full (4' x 8') sheet of 5/8" plywood, (exterior Plyform, Grade B-B) was secured from the jobber in Los Angeles who supplied plywood to both contractors. Portions of this board were retained by H. R. Lendecke, Resident Engineer, Colorado Street Arch, the balance was sent to the laboratory. Samples coated with form oil and exposed on the roof of the laboratory for two weeks yielded dusted pats. Other samples coated with form oil and with mortar cast against them the following day gave sound specimens. Glass plates coated with form oil then exposed on the roof for two weeks gave sound mortar pats.

TESTS ON THE JOB

H. R. Lendecke, using portions of the plywood sheet described above and subjected to various exposure treatments, cast 1:2 mortar pats which were cured wet for 7 days. Upon removal of the plywood the following results were observed and usually confirmed by tests on the opposite face of the board.

Surface Treatment	Exposure	Condition of Mortar
Mill oiled only	None	Sound
Mill oiled plus one coat of job oil	None	Sound
Mill oiled only	38 days	Dusted
Mill oiled plus one coat of job oil	38 days	Dusted
Mill oiled only	62 days	Dusted
Mill oiled plus one coat of job oil	62 days	Dusted
Mill oiled only	Face down outdoors for 69 days	Sound
Mill oiled plus one coat of job oil	Same as above	Sound

Several of the dusted surfaces after soaking in water for 7 days became hard and sound.

REPORT BY DOUGLAS FIR PLYWOOD ASSOCIATION

In response to our inquiry, Thomas H. Moran, Research Engineer, Douglas Fir Plywood Association, Tacoma, Washington, gave an extensive summary of job experiences with dusting associated with plywood forms which is abstracted in the following

paragraph.

Dusting was experienced during construction of buildings at the College of Agriculture, Davis, California. The results in general paralleled our experience. Dusting occurred on the surface of concrete in contact with forms or portions of forms that had been exposed for some time to the weather. Fresh forms or portions of forms that had been protected against exposure during previous use gave sound surfaces. When dusting occurred it seemed to become progressively worse as the forms were reused. (Reported results from our work do not agree with this experience.) Proprietary sealers of lacquer or synthetic resin types may minimize dusting but they may also introduce difficulty in stripping the forms. A construction foreman stated that dusted surfaces if left strictly undisturbed for several months become firm and can then be painted without difficulty. Information was quoted from the Portland Cement Association, Chicago, to the effect that dusting is the result of excess oil on the forms and the consequent accumulation of dirt. The letter concluded with an expression of opinion that the glue used in either interior or exterior plywood would not be likely to come in contact with the surface of the concrete and therefore should not be a factor in causing dusting.

LABORATORY TESTS

Indications of the preliminary tests and information gained through correspondence led to three series of tests in which mortar was cast against the faces of conditioned test

panels. After the mortar had hardened into blocks, they were removed and the surface in contact with the test panel was examined for hardness.

The test panels were 4" x 4" squares cut from sheets of plywood or window glass. Test panels that were oiled in the laboratory were given brush applications of "Union 100 form oil". This oil dried within 24 hours to a non-tacky film.

In some cases the test panels were exposed, either before or after oiling, to outdoor weathering or to simulated weathering under infra-red lights. Outdoor weathering was on the roof of the laboratory. The panels were in a vertical position with one side facing south. Duplicate specimens were exposed so as to provide south exposure to each of the faces. Infra-red exposure was on horizontally revolving tables in which the panels were at a temperature of about 140°F. Only one face was exposed to the light but duplicate specimens provided exposure of the opposite face. Outdoor exposures were for periods of two weeks during May and June, 1953. Although the percentage of sunshine was high during this period, the effects in causing dusting of the mortar did not seem to be more severe than resulted from two-week exposures during the winter months in preliminary tests. Infra-red exposure was for a period of 48 hours continuous operation. This exposure is not considered to be particularly accelerated other than by providing continuous exposure to light rays and warmth.

Since the accumulation of dust on the panels was

considered to be a factor of considerable importance they were examined carefully at the end of the exposure period. Accumulations were light and were chiefly of linty character. They were heavier on the side facing north. No indication of flushing of oil to the surface was noted.

Treatments and exposures of a given series were scheduled so that all would be completed on the same day. The panels were then mounted vertically in a long 4" x 4" box with a clear space of 1-1/4 inches between faces of adjacent specimens. A single batch of 1:2½ Perkins sand mortar was used to fill the spaces and thus form a series of 4" x 4" x 1-1/4" blocks. The mortar was cured damp for 3 days and the blocks were removed for examination. The faces of the mortar blocks were identified with the particular plywood specimen with which they had been in contact.

In addition to informal classification of surface condition such as by appearance, scratch hardness or finger abrasion, the two faces of each mortar block were subjected to the abrasion of 1000 grams (500 grams in Series 2 and 3) of steel shot falling a distance of about 42 inches through a 1-inch tube. The abrasive effect was sufficient to remove all soft mortar within a circle about 1 inch in diameter but mortar that had hardened normally was scarcely affected by the shot. In general, each surface could be classified definitely as "sound" or "dusted". Degrees of dusting were classified as slight (1/32"), moderate (1/16"), or severe (1/8"). Figure 1 shows two specimens with "severe dusting",

Nos. 6X and 21A, each with two abraded areas. The remaining three specimens are sound. No. 26 was cast against an oiled glass plate.

SERIES 1

Panels in this series consisted of 4" x 4" squares cut from:

(a) The previously mentioned sample of 5/8 inch exterior "Plyform" (mill-oiled) furnished by a Los Angeles jobber,

(b) A sheet of 3/4 inch exterior type plywood, Grade A-B (not mill oiled), purchased locally

(c) Window glass.

Laboratory oiling consisted of:

(1) A light brush application of form oil to both faces 24 hours ahead of exposure or 24 hours ahead of casting mortar when the panels were not exposed, or

(2) Two heavy coats of form oil to both faces 48 and 24 hours respectively ahead of exposure or casting.

Outdoor exposure was for two weeks, infra-red exposure for 48 hours. The condition of the mortar after hardening in contact with the panels is shown in Table I.

TABLE I

Data from Series 1 showing oil treatment applied to test panel, type of exposure to weathering and condition of mortar after hardening in contact with panel

No. of Laboratory Coats of Form Oil	Type of Exposure	Side Facing South or toward light	Degree of Dusting		
			Plyform B-B	Plywood A-B	Glass
None	None		None	None	
1	None		None	None	None
2	None		None	None	None
1	Outdoor	X	Severe	Severe	None
1	"	Y	Severe	Severe	
2	"	X	Severe	Severe	None
2	"	Y	Severe	Severe	
None	Outdoor	X	Severe	Severe	
None	"	Y	Severe	Severe	
1	Infra-red	X	Slight		
1	" "	Y	Slight		
2	" "	X	Slight		
2	" "	Y	Slight		

Note: The effect of outdoor weathering on the side facing north was the same as on the side facing south in all cases. In infra-red weathering the side not exposed to the light yielded sound mortar.

After the shot abrasion tests were made the specimens remained in the laboratory for about a week. They were then immersed in water for 24 hours and stored in the fog room for about a week. After this treatment all dusted surfaces were found to have become hard and "sound".

SERIES 2

The panels in this series consisted of those of Series 1 that had been exposed outdoors and which caused dusting of the

mortar. Two groups of six similar panels each were selected. In one group both sides were cleaned carefully, one coat of form oil was applied and they were exposed outside. A similar procedure was followed with the other group but the panels were not cleaned before oiling. After outside exposure for two weeks, mortar was cast against the faces of the panels in the manner described previously.

None of the mortar blocks showed more than very slight dusting. The panels that were not cleaned before oiling and exposure possibly caused slightly more dusting than the cleaned panels but in no case was the dusting comparable in severity to that resulting from the first use of the panels.

SERIES 3

The panels of this series were cut from the 3/4 inch sheet of exterior plywood used in Series 1 and from scraps of interior plywood from the carpenter shop. A piece of 1-inch pine board was also included. Each piece of interior plywood was selected from stock of different thickness primarily to assure that each was from a different sheet. The thicknesses were 3/4", 1/2", 3/8" and 1/4". None was mill oiled.

The panels were exposed outside, without oiling for 0, 3, 7 and 14 days. After the exposure, one side was oiled and allowed to dry for 24 hours. The panels were then mounted vertically in a box frame and mortar was placed in the spaces between

panels.

The effect of panel weathering on dusting of the mortar was substantially the same with all of the plywood sheets tested, and the pine board as well. The results can be reported for each group without reference to individual panels of the group.

The duration of exposure to outside weathering was found to have an important effect on the degree of dusting produced on the mortar. For the exposures involved the results were as follows:

Length of Exposure	Degree of Dusting
None	None
3 days	Very Light
7 days	Light
14 days	Moderate

Treatment of the panels with a coat of form oil after exposure and 24 hours ahead of casting the mortar had no observable effect on dusting. The above tabulation applies equally well to the sides of the panels that were oiled as well as those that were not.

Figure 2 shows rather imperfectly, the appearance of part of the mortar blocks after the sand abrasion test. The vertical rows from left to right are of mortar blocks cast against panels exposed for 0, 3, 7 and 14 days respectively.

DISCUSSION

In Series 1, the tests with glass plates indicate strongly that the form oil itself is not direcly responsible for dusting regardless of whether it is applied liberally or sparingly. The glass adhered tightly to the hardened mortar and could not be removed without breaking the glass into small pieces. The oil was likewise found to be harmless when it was applied to plywood which was not subsequently exposed to weather. On the other hand, the oil was unable to nullify the dusting that was brought about by exposure of the wood panels to the weather. Series 3 shows the ineffectiveness of the oil when it was applied after outside exposure.

The data indicate strongly that it is the wood itself that causes dusting. The nature of the changes that take place in the wood are not known but it is evident that they do not take place during ordinary covered storage. It is evident that the dusting effect is not confined to a particular piece of plywood because it was found to occur with each of the six pieces used in the tests. Two of these were of the exterior type and four were interior. The same results were obtained with the single piece of pine lumber. It is probable therefore that dusting can be caused by a number of species of wood. Dusting increased in severity with increased length of outdoor exposure up to two weeks which was the limit of the tests. Job experience indicates that longer exposure may cause deeper dusting.

Direct exposure to the sun is not necessary to bring about the changes necessary to cause dusting because the result was the same with surfaces facing north as with those facing south.

It does not appear that accumulations of dust in the usual sense are a factor because accumulations were very light on the test panels. They were somewhat heavier on the sides facing north but this did not increase the severity of dusting measurably. The observable dust was of a light, linty character, spider webs, plant down, etc. It seems probable that such material was removed during subsequent application of the form oil in Series 3.

Series 1 panels which were exposed during May caused more severe dusting than Series 3 panels which were exposed a month later, during June. Series 1 panels received less sunshine and this suggests the possibility that dew may have been a factor.

In view of the results of these tests it appears that wood forms are potential causes of dusting whenever they are exposed to weather for prolonged periods before concrete is placed in them. The fact that dusting has not been reported more frequently may be due to a general acceptance of minor dusting as a matter of course and that only the more severe cases have occasioned comment.

SUGGESTED REMEDIES

It is difficult to suggest a practical means of prevention when construction conditions are such as to make form

setting far in advance of pouring a virtual necessity. It is possible that a type of form oil other than that customarily used would offer protection.

In the final analysis, dusting affects the appearance more than the structural integrity of the concrete. As noted by Lendecke, and as found in Series 1 of the laboratory tests, dusted surfaces harden rather rapidly if kept moist.

It is suggested that, rather than attempt to employ inconvenient methods of preventing dusting, final results will be satisfactory if affected areas are subsequently cured for a few days with water in a spray fine enough not to erode the soft surface.

- Bailey Tremper
Supervising Materials and
Research Engineer

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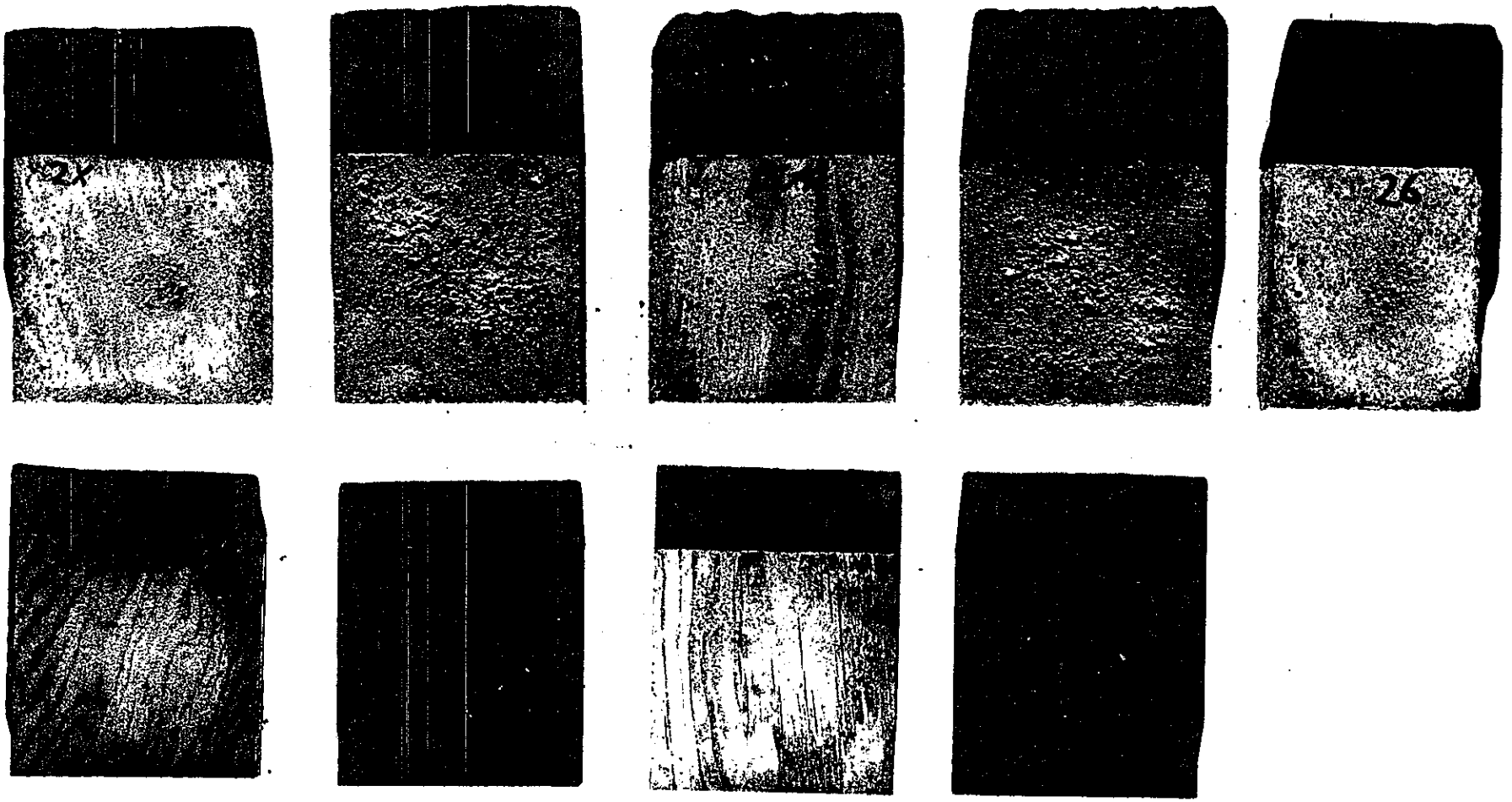
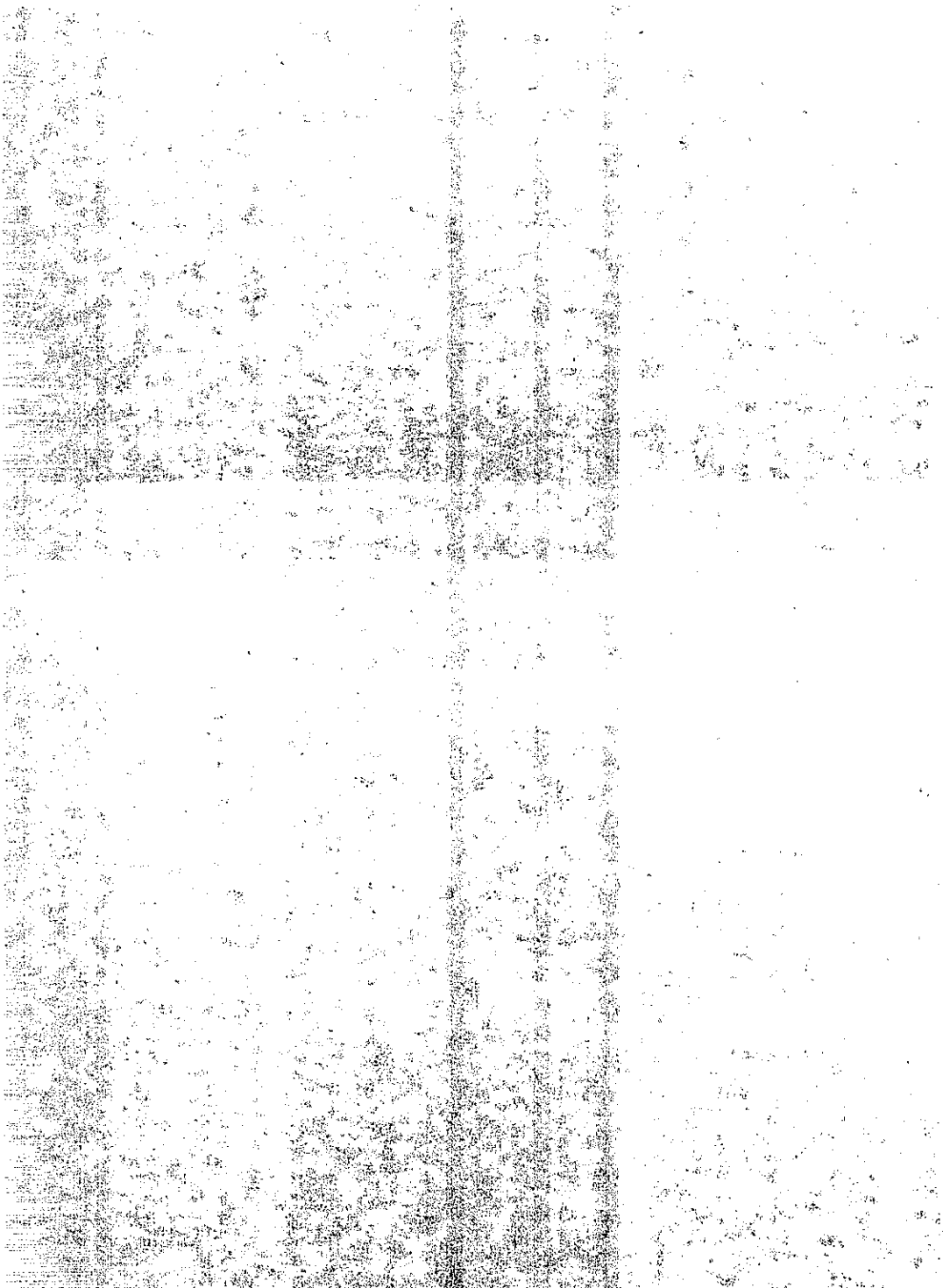


Figure 1.



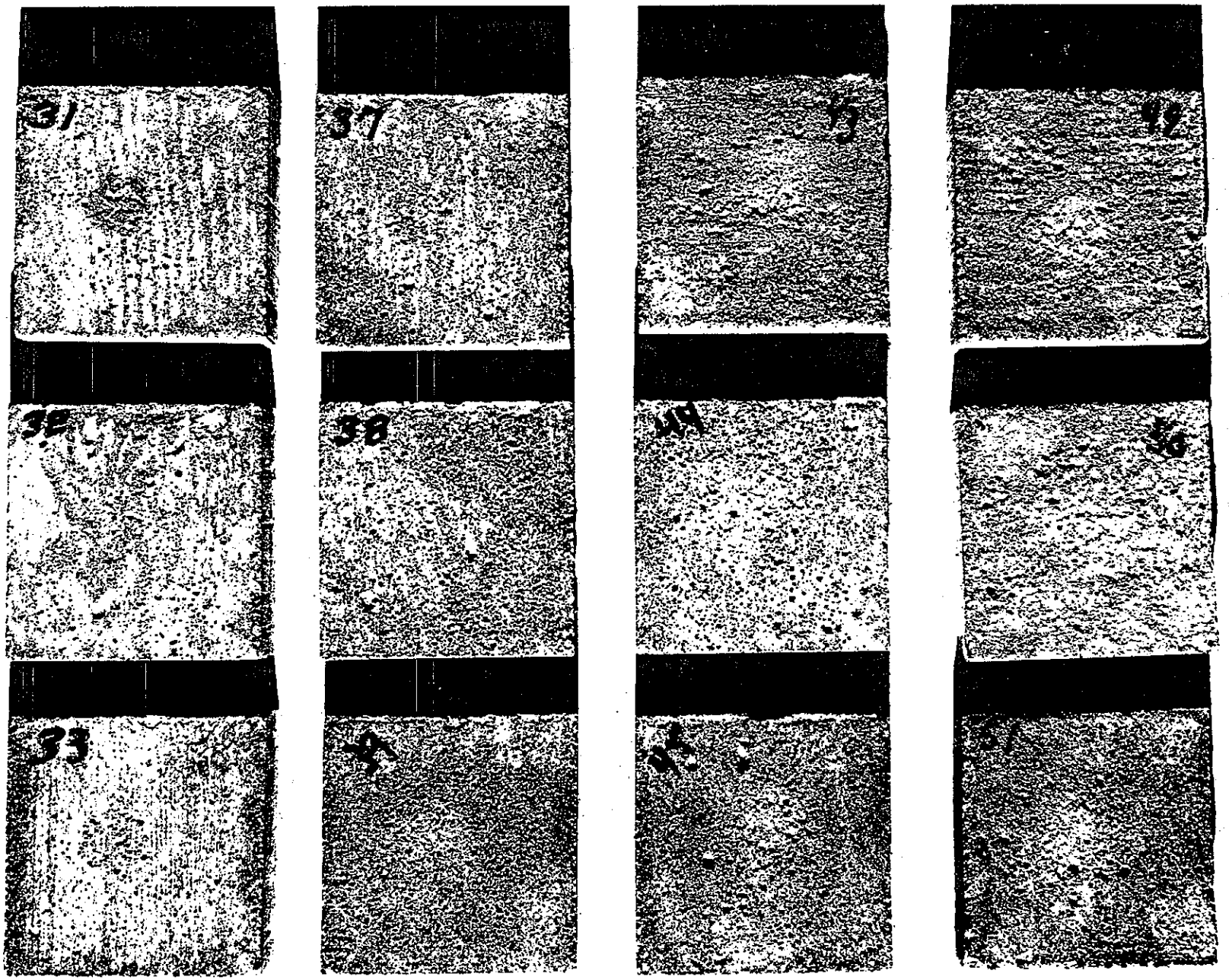


Figure 2.