8009

NATIONAL BUREAU OF STANDARDS REPORT

8009

SECOND PROGRESS REPORT

ON

BONDING TO TREATED CONCRETE SURFACES

by

Winthrop C. Wolfe

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and the Central Radio Propagation Laboratory Ionospheric Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT | **NBS REPORT**

1004-12-10449 | 30 June 1963 | 8009

SECOND PROGRESS REPORT

ON

BONDING TO TREATED CONCRETE SURFACES

by

Winthrop C. Wolfe

Organic Building Materials Section
Building Research Division

Sponsored by

Office of the Chief of Engineers
Department of the Air Force
Bureau of Yards and Docks

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

SECOND PROGRESS REPORT

ON

BONDING TO TREATED CONCRETE SURFACES

1. INTRODUCTION

The subject of bonding to treated concrete surfaces is a broad one. Concrete can be treated with curing and parting agents, chemical "hardeners", sealers, and other treatments. The concrete surface can be finished with a variety of organic coatings and coverings. The present work was mostly on vinyl asbestos tile, laid with asphalt cutback or asphalt emulsion adhesive on concrete treated with curing and parting agents. Parting agents are used with lift-slab and tilt-slab construction and are not of great importance at present. The term "curing agents" generally refers to organic coatings applied to fresh concrete to seal in the moisture and allow the concrete to cure. The main problem to be investigated was the adhesion of vinyl asbestos tile, applied with asphaltic adhesive, to concrete floors. Specifically, it is important to know how to lay tiles on old floors and how to treat new floors so that tiles can be applied. The problem with old floors is to determine what treatment, if any, is necessary to enable tile to be laid satisfactorily. In the case of new floors, specifications should be written such that the floors will be suitable to receive tile.

Resilient floor coverings are not suitable or necessary for some purposes and some buildings are constructed with the intention of leaving concrete floors bare or painted. In such cases, oily or waxy curing agents may be left on the floor, the floors may have been painted, waxed, or both, or there may be an accumulation of oil, grease, and dirt on the floors. Materials such as oils and waxes on the floor are known to cause poor adhesion of resilient tiles. The problem would be simpler if the previous history of each surface were known, but this is not always the case. In the past, specifications have banned application of resilient floor coverings if oily or waxy materials or any membrane curing compounds had been applied to the floor. Apparently the only remedy was costly grinding or refinishing. It would be desirable to have a field test to determine whether a floor was suitable to receive resilient tiles and what, if any, treatment was necessary. This might be a test for adhesion of tiles or an analysis of the surface coating.

As already mentioned, membrane curing compounds in general have been prohibited on concrete floors which are to receive resilient floor coverings. This attitude is gradually changing as reliable products become known and progress is made in the relatively new field of membrane curing. Accordingly, specifications are in the process of change.

The work reported here was undertaken with the above considerations in mind. An attempt was made to develop a field test which would be simple, reliable, and as rapid as possible. A good field test could be used to determine whether tile can be laid satisfactorily on a concrete floor and also as a part of specifications for membrane curing compounds and for concrete work. Some work was done on the analysis of concrete surfaces for oils and waxes and an attempt was made to evaluate concrete surfaces for wettability. Several widely used commercial curing and parting agents were analyzed and further information on the composition of such materials obtained from the Bureau of Public Roads. This provided information about the kind of materials currently used for this purpose. Analytical data was used to prepare known formulations which were tested along with commercial curing agents. Although a suitable field test has not been developed, some progress has been made towards a laboratory test which might be used as a basis for a qualified products list. Also, knowledge has been gained from the tests to enable more satisfactory decisions regarding the tiling of old concrete floors.

2. FIELD INSPECTIONS

Manufacturers of curing compounds have cited a large number of cases in which their products were used to cure concrete floors with subsequent satisfactory installation of resilient tile. As mentioned in the previous report, a number of buildings were inspected, the concrete floors of which had been cured with "West Concrete Floor Treatment", then successfully tiled. Another large building in Washington was inspected two days after the ground slab was poured. The floor appeared yellowish gray and had a dull sheen, obviously from a transparent coating. There were some unopened drums of "West Concrete Floor Treatment", which the superintendent said was part of a shipment which had been used to coat the floors. Construction work was proceeding on the "green" slab. A year later the completed building was inspected. In the meantime, asphalt tile had been applied, using bentonite clay type asphalt emulsion adhesive. The tile appeared to be in perfect condition and the maintenance staff said that there had been no loose tiles or other complaints about the flooring.

A small building in Washington was inspected while the ground slab was poured and hard troweled and "Toch RIW Seal Cure" applied, using a lamb's wool applicator. The completed building was inspected a year later. Vinyl asbestos tile had been applied, with asphalt emulsion adhesive. The tile installation appeared to be satisfactory with no loose tiles.

A building in Arlington was erected by the lift-slab method, using Thompson's Water Seal as the parting agent. After about six months, the uneven first floor was refinished with a terrazzo grinder. About 10 percent of the upper three floors was refinished with a grinder. Asphalt tile was laid on the floors, using asphalt emulsion adhesive. After about a year, the building was inspected again. The tile installation was reported to be satisfactory throughout. Adhesion of tiles was so good that it was difficult to remove damaged tiles.

3. LABORATORY ADHESION TESTS

A number of qualitative adhesion tests were run on panels and slabs of concrete, 1/2 to 5/8 inch thick, made from 2 parts portland cement, 6 parts of concrete sand, and 1 part of water, by weight. Sometimes slightly more water was added to make the mix workable, depending on the water content of the sand. This proportion was used in tests described by Percy A. Sigler and Robert I. Martens, Building Materials and Structures Report BMS 59, National Bureau of Standards, September 19, 1940, "Properties of Adhesives for Floor Coverings". Most of the panels were 4-1/2- by 9-inches or half the size of a standard 9- by 9-inch vinyl asbestos tile. Some of the panels were 6- by 6-inches and a series of seven 27- by 28-inch slabs was prepared for nine 9- by 9-inch tiles each, leaving a 1- by 27-inch strip for marking. One of the 27- by 28-inch slabs or a set of eighteen 4-1/2- by 9-inch panels weighed about 29 pounds.

The object of the tests was to evaluate various concrete curing agents for adhesion of floor covering cement and to devise a suitable test method for evaluation. According to the "Bond Test" on page 34 of Technical Data, 1962-63, Armstrong Cork Company, 3- by 3-ft. panels of the flooring material to be used are installed approximately 50 feet apart on the floor. Panels are checked for bonding or adhesion after two weeks. In NAVDOCKS Specification 13Yf, December 1960, p. 12, under 2.13.7, Liquid chemical compound, a simple, quantitative adhesion test is described. In this test, concrete slabs are prepared, cured, dried, and floor covering applied in the normal manner. After the adhesive has set, cuts, an inch apart and 6 to 10 inches long, are made, forming strips to one end of which a calibrated spring balance or other device is attached. The strips are peeled off at a rate of 2 to 10 inches per minute. Adhesion to concrete treated with curing agent must be at least 90 percent of adhesion to the same concrete untreated.

The test method used in the present work was to first apply curing agents to the "green" or fresh concrete in a manner similar to that which would be used on actual floors. In similar tests performed elsewhere, precast concrete blocks are sometimes used and the blocks are soaked in water for

24 hours before applying curing agents. Untreated panels were steam cured for 28 days. Treated panels were placed in a constant temperature, constant humidity room at about 73°F., 50% relative humidity. Before applying floor coverings, the steam cured panels were allowed to dry in an ordinary room for several days. After curing, the panels were coated with suitable adhesive cements and appropriate floor covering materials applied. Most of the tests were made with vinyl asbestos tile, using asphalt cutback and asphalt emulsion adhesive. Some tests were performed using linoleum and linoleum paste. Since tests with floor coverings are slow, an attempt was made to devise a quicker test, using cotton gauze strips in place of floor covering. It was thought that the cement would dry faster and simulate a longer period of time.

The gauze strip test was based on a method for testing the adhesion of paint films, reported on page 176 of Henry A. Gardner and G. G. Sward, "Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors", Henry A. Gardner Laboratory, Bethesda, Md., 11th ed., 1950. This method is called the "Gardner Laboratory Adhesion Method". Figure 266 in this book shows the "Gardner-Parks tensile strength meter adapted for quantitatively determining the adherence of films". Apparently this refers to the "Gardner Tensile Strength and Elongation Apparatus", Catalog No. TG-1500, Gardner Laboratory, Inc., P. O. Box 5728, 5521 Landy Lane, Bethesda 14, Md., priced at $603.75. The test method was based on preliminary work by a committee of the ASTM. A film of the coating material is applied by any suitable method to a panel about 3- by 5-inches. A piece of silk cloth is then placed upon the film while it is still in a tacky condition and pressed firmly in contact with the base panel by means of a broad, flat spatula. After further drying for any desired period of time, the surface is cut up into areas 1 cm. wide by means of a sharp razor blade. Each test panel is then fastened into the tensile strength apparatus as shown in the illustration and one of the strips is partly removed at the top of the panel in order to form a grip for the machine. By applying the load, the strip is slowly and gradually removed from the coated panel. The load usually is constant for the entire length of the panel, thus showing that the adhesion is the same over the entire surface where normal conditions obtain.

In the gauze test for flooring adhesives, 1-inch wide cotton gauze was used in place of silk cloth. Adhesive coatings are thicker than paint films and a more open fabric seemed more likely to shorten drying time and to "key" better with the adhesive. Adhesives were spread as thin as possible with a putty knife, which was also used to coat the gauze and press it into the adhesive.

No quantitative measurements were made in tests with flooring materials or with cotton gauze. Adhesion was judged mainly by the amount of adhesive remaining on the concrete surface after the strip of material was removed, although ease of removal was also taken into account. Flooring materials applied to the 4-1/2- by 9-inch and 6- by 6-inch panels were cut into 1-inch wide strips at various intervals of time and the strips pulled back manually. Sometimes it was necessary to pry up the strips with a putty knife. The 27- by 28-inch slabs were covered with standard 9- by 9-inch tiles, which were removed at intervals. Tests were completed and all material removed after three months.

The gauze strips were removed beginning in 1 to 2 days, the idea of the test being to develop a rapid method. However, results of this test were inconsistent both as to time and as to materials, as reported earlier. Earlier reports also mentioned that tests with flooring materials were variable and only general conclusions could be drawn. Adhesion was poor to concrete surfaces treated with oils and waxes, but even in such cases, satisfactory results were achieved by using asphalt cutback adhesive or asphalt primer.

Photographs at the end of this report show tests on the 27- by 28-inch concrete slabs and on the corridor on the fourth floor of the Industrial Building, National Bureau of Standards. No oozing between tiles was noted, even with oily and waxy materials, such as Thompson's Water Seal. Light sanding of a slab treated with paste wax improved adhesion to asphalt emulsion adhesive cement.

It was found that adhesion of tile cement was not always good to untreated or steam cured panels. A good example is an untreated 27- by 28-inch concrete slab which had been steam cured for 28 days. After curing, the surface had a whitish appearance, suggesting efflorescence. After air drying for several days, half of the slab was coated with asphalt cutback adhesive cement and half with asphalt emulsion adhesive. Nine 9- by 9-inch vinyl asbestos tiles were laid on the slab. Some of the tiles were removed after a month and the rest after three months. The tiles were pried up, in each case, with moderate difficulty. About half of the concrete surface was bare on each half of the slab. Judging from the appearance of the concrete surface, adhesion would be considered fair to poor. However, the concrete surface appeared "dusty" and the underside of the adhesive remaining on the tiles was whitish in appearance, as can be seen from the photograph. Apparently, due to the composition of the concrete mix and the manner of finishing, there was considerable laitance or a layer of loose material which prevented good adhesion. Another difficulty with

the test method is that sometimes the bond between the adhesive and the concrete surface is so good that when the tile is removed, concrete is torn from the surface and bare spots result.

The results were too variable for quantitative evaluation of curing and parting agents or to serve as a basis for specifications. However, from a large number of tests, the following tentative conclusions and recommendations are offered:

(1) Curing, parting, and other concrete treatment agents should not contain oils or waxes if resilient flooring is to be laid on the concrete floor so treated. A specification such as CRD-C-300-55, requiring drying time to touch in not more than 4 hours, should be sufficient to exclude oily and waxy curing agents. It might be better to add a simple test such as described in Method 4061 (May 15, 1958), "Drying Time (Varnishes, Lacquers and Enamels)", Federal Test Method Standard No. 141. The test is to touch the tip of a finger lightly to the coating, then touch the finger tip immediately to a piece of clean, clear glass, observing whether any of the coating is transferred to the clean piece of glass. Since concrete is porous and oils and waxes may soak into the mass of the material, this might not be suitable as a test of a coating already applied, but as one applied to a metal panel. This could even be done in the field, sampling the curing agent before application.

(2) Some commercial curing agents have been shown to be satisfactory as a substrate for vinyl asbestos tile. Known formulations shown to be satisfactory include butadiene styrene copolymer or petroleum hydrocarbon resin dissolved in xylene or other suitable hydrocarbon solvent, such that the resin content is about 25-30% and the drying time approximately that of xylene. The product should dry to a hard film in 4 hours.

(3) Old concrete floors which have been treated with any oil or wax, such as paraffin wax, kerosene, floor wax, etc., or the previous history of which is unknown, can generally be tiled using asphalt cutback adhesive cement. Such floors can also be coated with asphalt primer. Light sanding should improve adhesion.

(4) It is unlikely that oozing between tiles is caused by curing or parting agents or by products containing oils or waxes.

(5) All parting agents that we have analyzed contain non-volatile oils or waxes or both. Floors constructed by the lift-slab method may cause trouble with resilient flooring installations.

(6) Adhesion of resilient flooring to water cured concrete depends on the composition and finishing of the concrete. Adhesion varies considerably on the surface of a concrete slab. In performing any adhesion tests, enough observations must be made so that the results will be significant. In laboratory tests, it might be better to use as a standard a concrete surface treated with a known membrane curing agent.

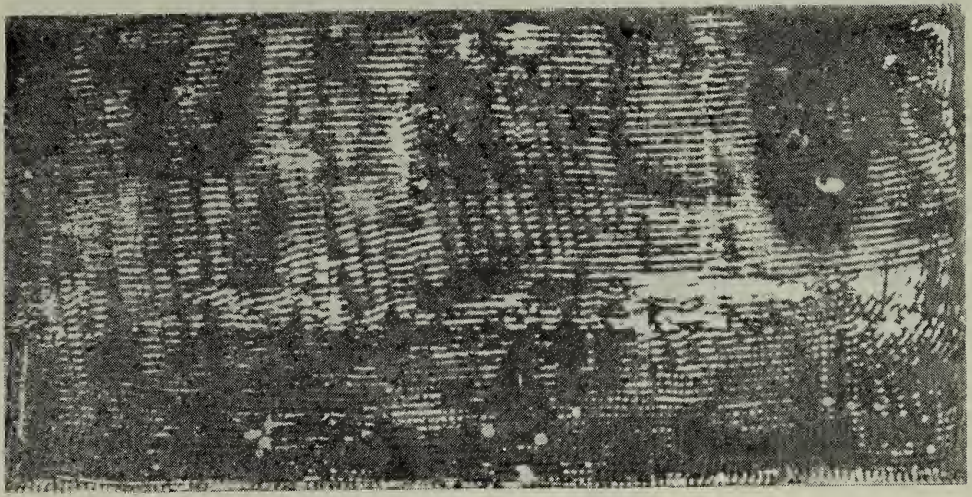
4. PLANS FOR FUTURE WORK

It has been mentioned already that the appearance of the concrete surface after removal of flooring material is not a perfect criterion of adhesion. Perhaps a better property for testing adhesion is the force required to break the bond between the concrete surface and the adhesive. Tests on linoleum along these lines were reported in BMS 59, previously mentioned in this report. Tests described in BMS 59 were performed with concrete blocks and panels cast with steel pins running through them and made to fit special yokes. These yokes were made to fit in the jaws of a Scott tester.

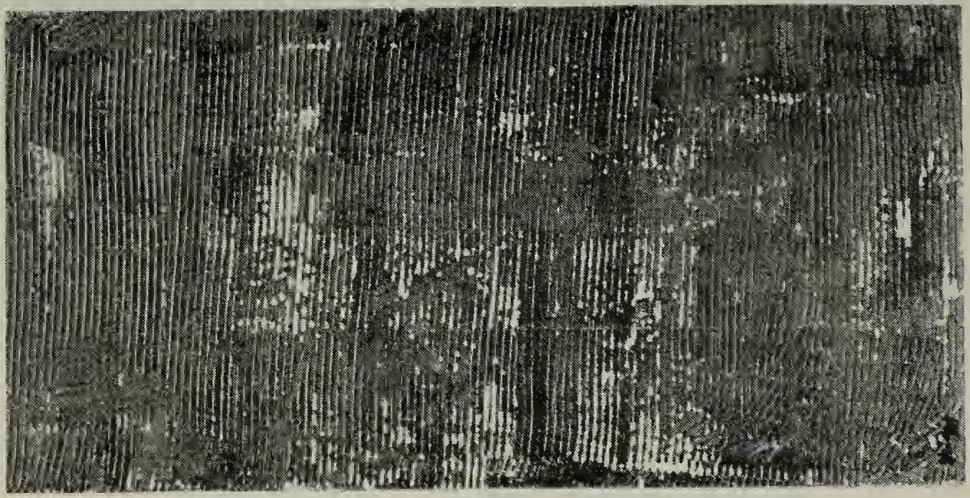
The yokes described in BMS 59 were obtained for use in pull tests or as a basis for designing new yokes. Concrete blocks and panels similar to those used in BMS 59 were cast. The blocks were 2-inch cubes, designed to be used in straight or 180° pull tests. A 2-inch square of flooring material is applied to one surface of a cube and a wooden block cemented on top of the flooring material. A steel pin is run through the wooden block, made to fit in a yoke which fits in one of the jaws of a pull testing machine. The concrete panels were 2- by 6- by 3/4-inch and were designed for stripping or 90° pull tests. The yoke fits in one jaw of a testing machine and the flooring material is placed in the other jaw. It is planned to use an Instron tester in place of the Scott tester, which is now obsolete. The Instron tester gives more complete and precise information.

Some concrete panels, 3- by 5- by 1/2-inch were cast to be used in further exploratory tests. For example, it would be desirable to test a concrete surface for the presence of oils and waxes. One possibility would be to press a piece of filter paper on the surface with a hot iron.

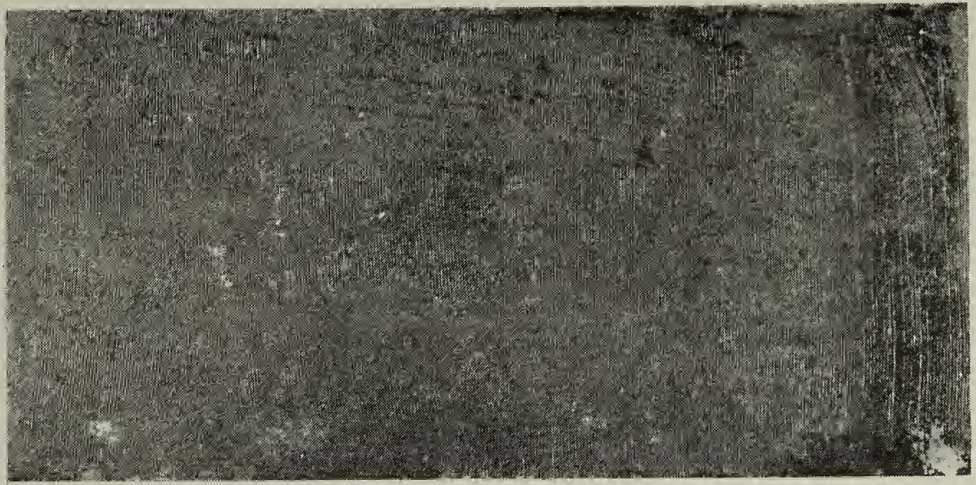
The Organic Coatings Group has been consulted with the idea of collaborating in testing adhesion of paints to concrete surfaces.



TILES LAID ON ASPHALT EMULSION CEMENT

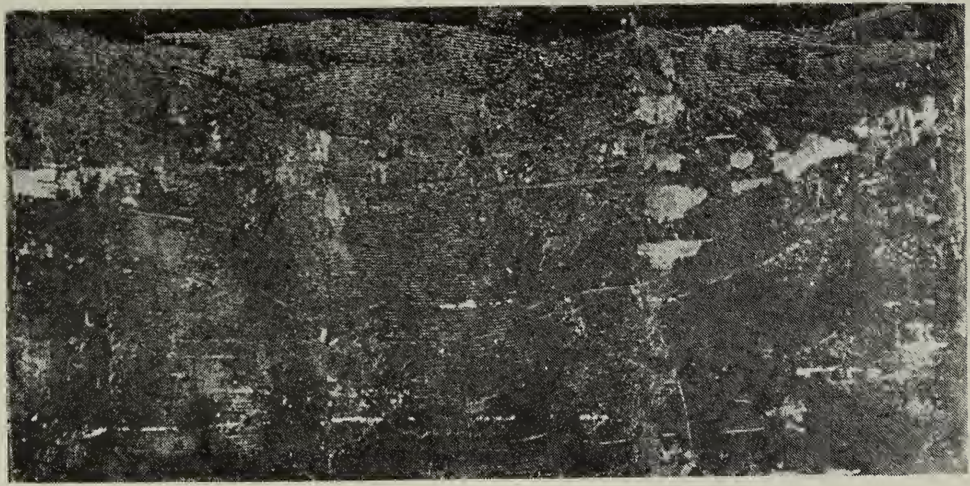


ASPHALT EMULSION



ASPHALT CUT-BACK

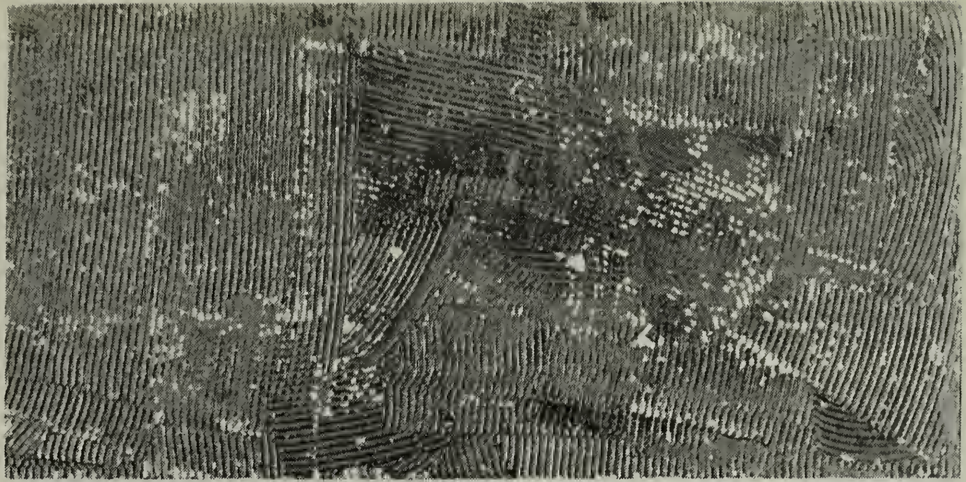
CURING AGENT - THOMPSON'S WATER SEAL



ASPHALT CUT-BACK

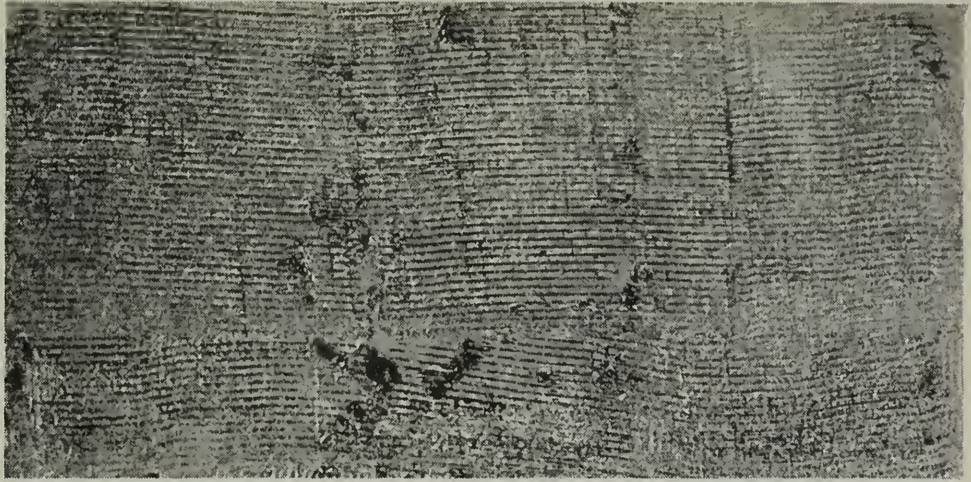
PARAFFIN WAX IN KEROSENE

ADHESION OF VINYL ASBESTOS TILES TO CONCRETE TEST SLABS

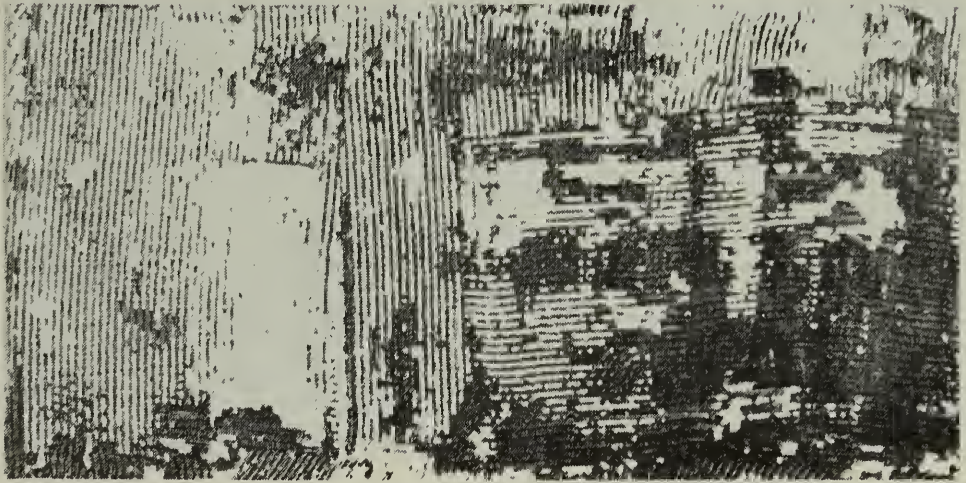


SLAB WAXED AND SANDED

TILES LAID ON ASPHALT EMULSION CEMENT



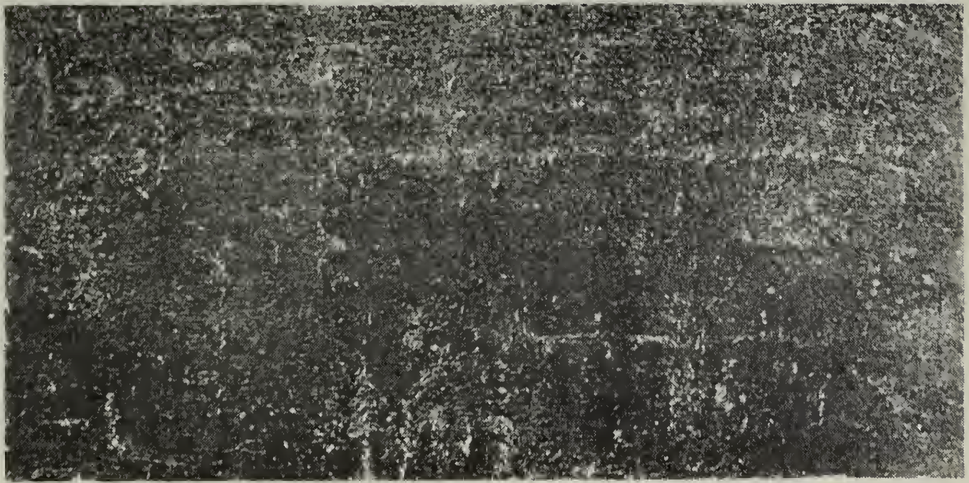
TILES LAID ON ASPHALT EMULSION CEMENT



SLAB WAXED

TILES LAID ON ASPHALT EMULSION CEMENT

CURING AGENT - PARAFFIN WAX IN KEROSENE

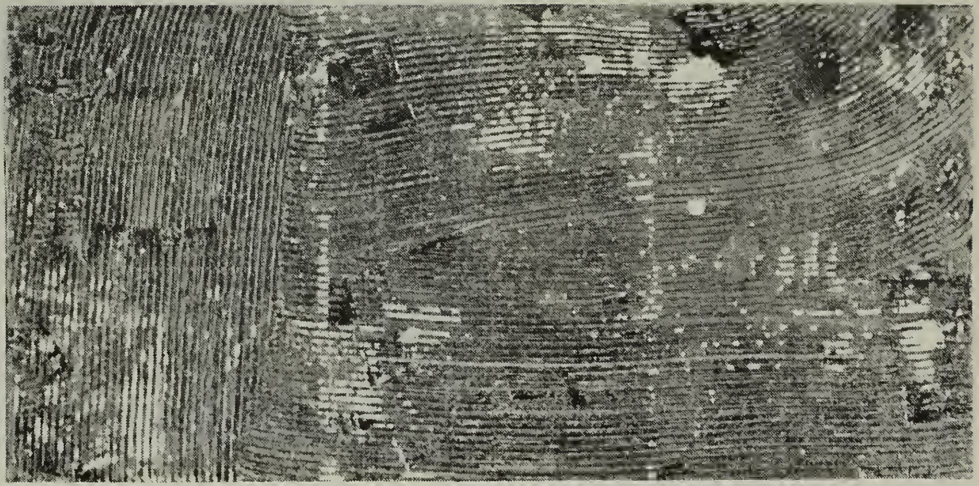


TILES LAID ON ASPHALT CUT-BACK CEMENT

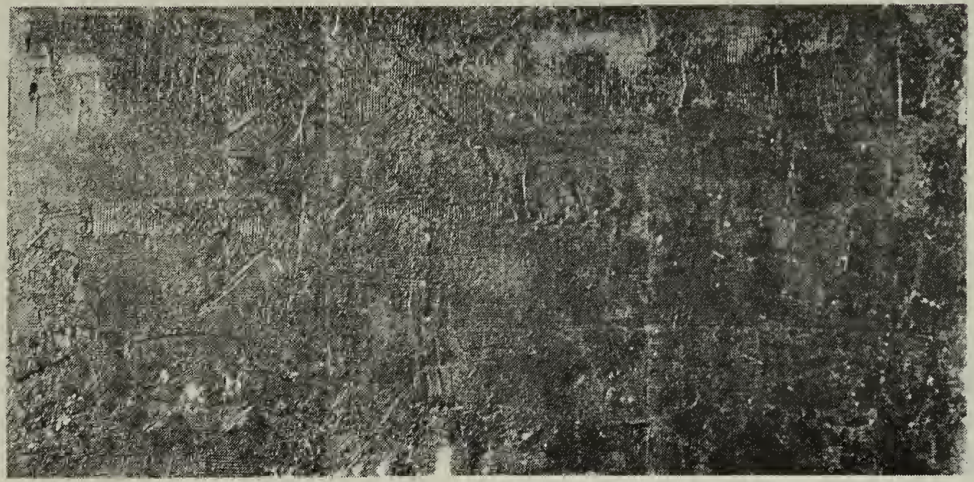
CURING AGENT - BUTADIENE-STYRENE COPOLYMER

ADHESION OF VINYL ASBESTOS TILES TO CONCRETE TEST SLABS

TILES LAID ON ASPHALT EMULSION CEMENT



ASPHALT EMULSION



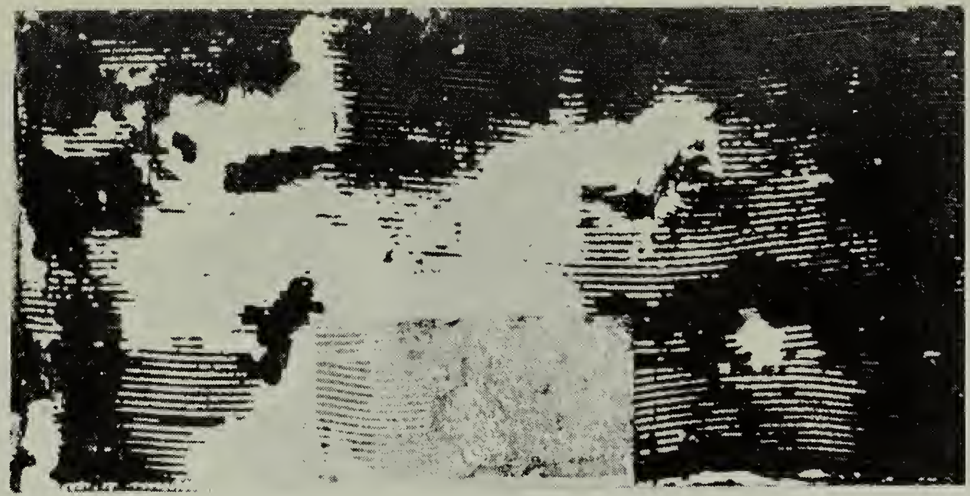
ASPHALT CUT-BACK

CURING AGENT - PETROLEUM HYDROCARBON RESIN

ASPHALT CUT-BACK

CHLORINATED RUBBER

ADHESION OF VINYL ASBESTOS TILES TO CONCRETE TEST SLABS

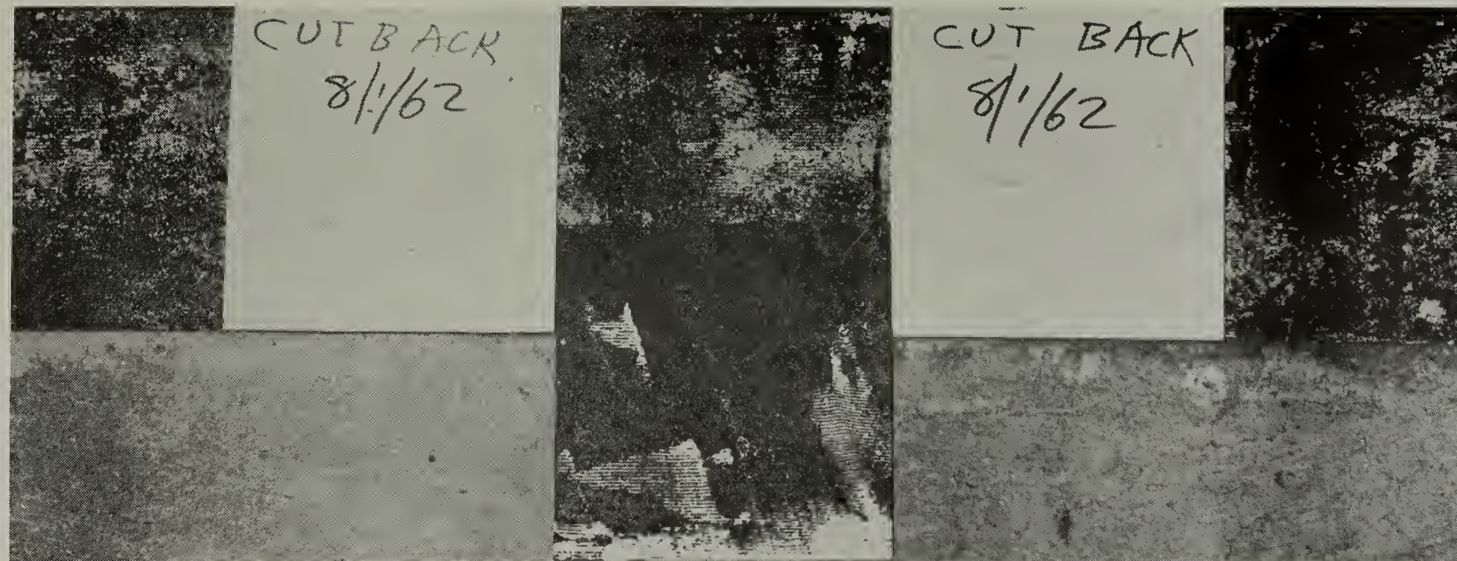


TILES LAID ON ASPHALT EMULSION CEMENT

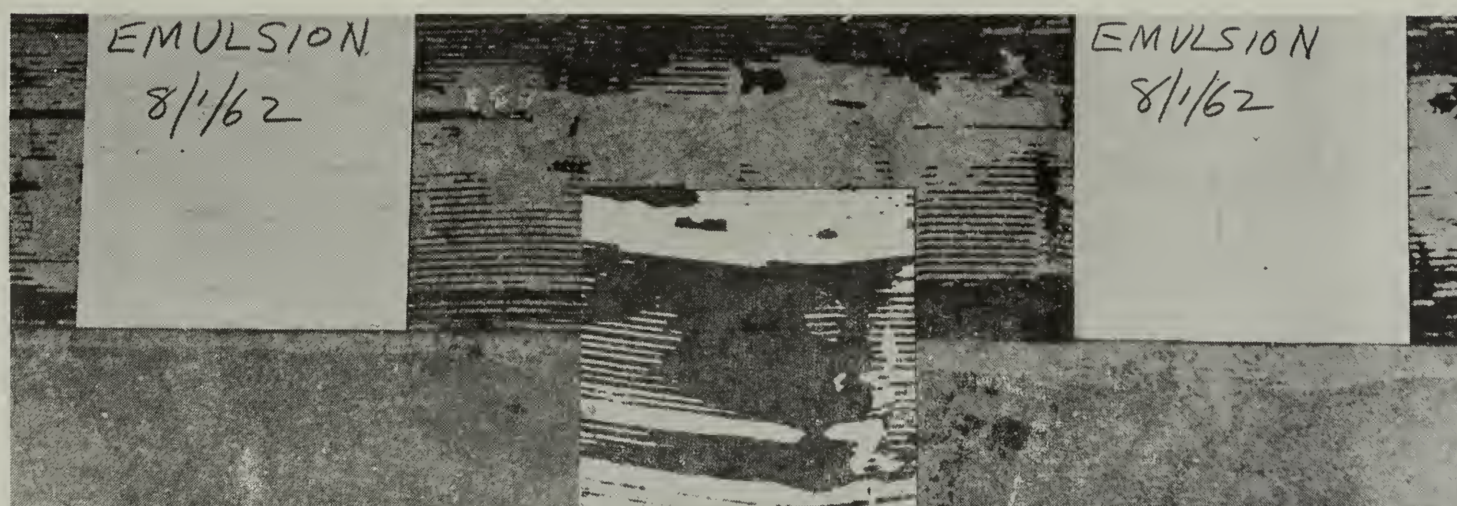
TILES LAID ON ASPHALT CUT-BACK CEMENT

STEAM CURED SLAB
SHOWING UNDER SIDE OF TILE

ADHESION OF VINYL ASBESTOS TILES TO CONCRETE TEST SLABS



TILES LAID ON ASPHALT CUT BACK CEMENT



TILES LAID ON ASPHALT EMULSION CEMENT

ADHESION OF VINYL ASBESTOS TILES TO WAXED CONCRETE FLOORS

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Troposphere and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Standards Physics. Frequency and Time Disseminations. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Microwave Physics.

Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics - NBS Group (Univ. of Colo.).

NBS