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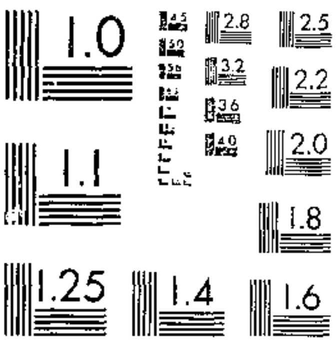

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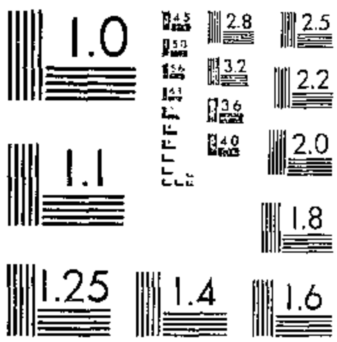

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NATIONAL BUREAU OF STANDARDS-1963-A

PERFORMANCE OF FLOOR SLABS MADE FROM WOOD AND WOOD PRODUCTS

Technical Bulletin No. 1543

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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The floors described in this publication were installed in 1963 and are still functioning satisfactorily. The data reported were collected during 1963–71.

Washington, D.C. Issued October 1976

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PERFORMANCE OF FLOOR SLABS MADE FROM WOOD AND WOOD PRODUCTS

By JERRY O. NEWMAN, *agricultural engineer, Agricultural Research Service, U.S. Department of Agriculture, Clemson, S.C. 29631*

ABSTRACT

Three-layer floors consisting of an asphalt-tile wearing surface, a pressed-hardboard underlayment, and subfloors of white-pine sheathing, pressed paperboard. or asphalt-impregnated fiberboard performed well during a 9-year test under simulated housing conditions in a moderately wet climate. Placed directly on earthfill, the floors remained relatively level and, owing to grading and ditching, dry. Although the floors cost about the same as a conventional concrete slab. they were superior in comfort and as easily installed. Further testing of the floors is indicated before they can be recommended for use in more severe climates.

INTRODUCTION

A large percentage of the rural population in the United States must live on a low or fixed income. As living costs continue to rise, the portion of family income available for housing continues to decrease, and the need for low-cost housing becomes more urgent.

This publication presents the latest research on low-cost floor slabs constructed of wood and wood products. Traditionally, slabs used for floors at grade level have been made of concrete. Concrete slabs became popular because they are durable and resistant to attack by insects, fungi, and bacteria. On the other hand, concrete slabs leave much to be desired from the standpoint of heat transfer, resilience, and comfort for the home occupant.

Wood and wood products offer the possibility of well-insulated, resilient, and low-cost floors at grade level, but the problems of insects and decay, and that of moisture, which promotes the growth of destructive organisms in wood, must be overcome if these floors are to remain durable for an acceptable number of years. The Farmers Home Administration (FmHA) provides reasonable guidelines for durability. Since FmHA loans have a maximum span of 33 years, the minimum life expectancy of any part of a house should be at least that long.

This study attempts to evaluate (1) the materials and the construction techniques for installing wood and wood-product flooring systems, (2) the methods of protecting these floors from excessive moisture, and (3) the physical stability of the test floors.

Three flooring systems were designed for the study, each of which used wood and wood products placed directly at grade level. These floors were installed in a pole-frame structure at Beltsville, Md. (moderately wet climate), and thereafter subject to conditions similar to those expected in ordinary housing. Each floor was observed during and after installation. A moisture protection system was designed and installed to divert ground water away from the test floors and to form a moisture barrier between the test floors and the soil. Moisture contents were recorded at strategic points in the flooring materials and in the soil under the floors to monitor changes in moisture concentrations. Elevation readings were taken at several locations on each floor to determine its contour at the time of installation, and subsequent readings were made to ascertain changes in contour or elevation.

MATERIALS AND CONSTRUCTION TECHNIQUES

Procedure

Evaluation of each of the three flooring systems included the following variables: materials used, methods of installation employed, problems encountered both before and after installation, and preventive action taken as these problems occurred. A complete record of the variables was made for each installation.

Each of the three floors consisted of three layers of materials: a subfloor, an underlayment, and a wearing surface. A profile of the three flooring systems is shown in figure 1. The wearing surface for all three floors was asphalt tile, and the underlayment was pressed hardboard in every case. The materials used in the three floors differed only in the subfloor.

For floor No. 1, the subfloor consisted of 1-inch, dressed, white-pine sheathing in 12-inch widths. The lateral spacing between these boards varied from 4 to 8 inches. For floor No. 2, the subfloor consisted of ½-inch pressed paperboard. For floor No. 3, the subfloor was ½-inch asphalt-impregnated fiberboard.

Observations

Floor No. 1.—Floor No. 1 was installed during June 1963 and then evaluated over a 9-year period. The 1-inch-sheathing subfloor was easily installed by placing it over the prepared subgrade. Fastening the hardboard underlayment to the ¾-inch lumber was the most time-consuming phase of construction, but the entire installation took less time than most conventional floor installations. Hardboard fastened with serrated nails placed 8 inches on center held securely, and the nails had no tendency to pop up. For hardboard fastened with wood screws placed 16 inches on center along the outer edge of the 4- by 8-foot sheets, the distance between screws was too great, and the hardboard bowed up as a result of expansion, thereby creating a spongy floor.

Immediately after installation, floor No. 1 had a tendency to tip when loads were applied near its edges. After the floor had settled for several days, this kind of nonuniform support was no longer noticeable. Walking on the part of the floor where sheathing boards had been placed 8 inches apart was uncomfortable, however, because loads applied to the hardboard in these areas caused excessive deflection. Otherwise,

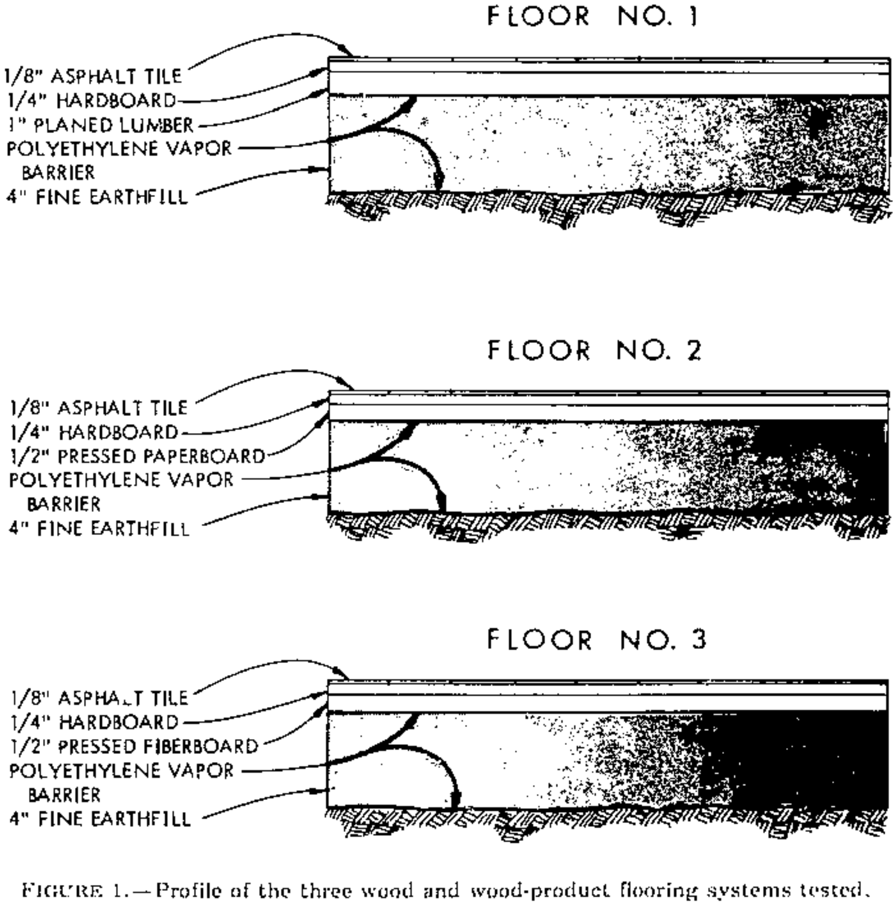

FIGURE 1.—Profile of the three wood and wood-product flooring systems tested.

the floor was comfortable and more resilient than concrete.

Floor No. 2.—Floor No. 2 was also installed during June 1963 and evaluated over the next 9 years. The ½-inch pressed-paperboard subfloor and the hardboard underlayment were glued together with asphalt mastic in one easy operation. A stronger glue or an underlayment with less tendency to warp along the edges when wet by mastic would have improved this installation. Floor No. 2 was more resilient and comfortable to walk on than the first test floor, and there were no spongy areas or soft spots.

Two large holes were cut in floor No. 2 to determine its repairability. Each layer of material was stepped down 3 inches to give the overlying layer a solid bearing around its perimeter (fig. 2). The patch was successful, but because of local warpage in the hardboard, the layers of materials tended to delaminate.

On the day after the asphalt tile had been placed on floor No. 2, a raised line appeared along one edge of the slab, indicating that the bond between the hardboard and the pressed paperboard had broken. Weights were applied to the joint in an effort to reglue the two layers. After several attempts had failed, a number of the asphalt tiles were removed, and additional mastic was applied. Weights were then reapplied, but when these were removed several days later, it was discovered that the hardboard had warped again. The curled edge was finally held down by wood screws spaced 8 inches on center along the edge of the hardboard.

Floor No. 3.—Floor No. 3 was installed during July 1963 and examined periodically during the next 9 years. This floor was easy to install, but nonetheless required more time than floor No. 2. The tile was not applied immediately so that the hardboard underlayment could be observed for a time. After a few days, the hardboard that had been fastened to the pressed fiberboard with mastic began to curl up at the edges. Part of the hardboard was then removed, cut into 2-foot by 2-foot sheets, and relaid. Contrary to expectations, the warpage of the hardboard was more severe with the 2-by-2 sheets than with the 4-by-8 sheets.

The 2-by-2 hardboard sheets were then fastened to the subfloor with one ¼-inch wood screw in each corner. Although the pressed fiberboard did not have much screw-holding strength, when

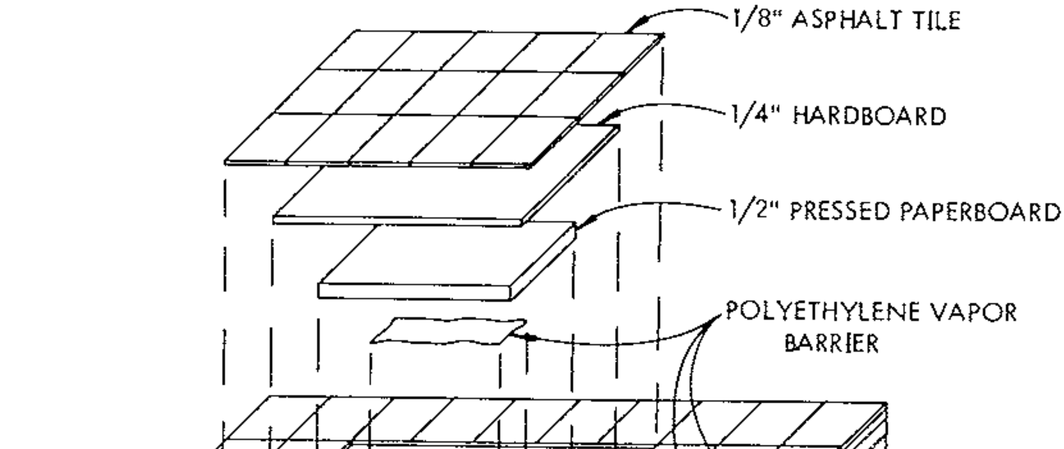

FIGURE 2.—Stepdown pattern used for patching slab floors made from wood and wood products.

screws were placed every foot around the edge of a 4-by-8 sheet of hardboard, and two screws spaced at third points along the longitudinal center line, buckling was prevented and a desirable floor deck was maintained.

This deck provided the most comfortable and stable installation, and it did not show any defects after the asphalt tile had been laid. Recently developed structural adhesives may be far superior to the mastic and screw methods of fastening used in this installation.

Discussion

The installation of all three flooring systems was satisfactory, but all could have been improved. Using new adhesives to join the materials would undoubtedly have improved all these installations; nevertheless, the need for two layers of base materials (subfloor and underlayment) proved to be the most expensive construction feature, both in labor and materials, and caused most of the installation difficulties.

Two layers of base materials were used because continuity across the joints between adjacent sheets was difficult to maintain with only a single layer of base material. One solution would be to install a single sheet of material large enough to cover the entire floor area. Although this solution would probably be impractical if it required rigid units of excessive size, a single sheet could be built up in place by pouring an organic slab of some material such as polyurethane foam, or by the tongue-and-groove assembly of factory-built materials. The use of tapes, structural adhesives, or both might make the installation of a single layer of base material possible.

A MOISTURE PROTECTION SYSTEM FOR FLOORS MADE FROM WOOD AND WOOD PRODUCTS

Procedure

The study examined one method of isolating the wood and wood-product floors from moisture, thereby making them unsuitable for the growth of decay-causing organisms and insects. Moisture migration was slowed in two ways: (1) By diverting water from the structure and (2) by placing two or more moisture barriers below the flooring materials.

Moisture was diverted from the floors by sloping the grade away from the structures on all sides, and by installing a diversion ditch around the structures to collect surface water and to carry it away from the floors. Both the diversion ditch and the sloping grade created an area of low soil-moisture pressure that caused soil moisture to migrate away from the floors.

The barriers to moisture migration were two polyethylene films that were placed under the wood slabs and separated by a layer of soil. Two barriers were used because of the danger of mechanical damage to the film during or after installation. Unless both films had been damaged at the same location. moisture that passed the first film would have to travel between barriers for some distance before passing through the second film.

The layer of soil between the polyethylene films served several purposes: (1) It protected the first moisture barrier while the base for the floor was being leveled and prepared, (2) it served as a medium that could be leveled to form a base for the floor, and (3) it provided another medium through which soil moisture had to travel as it moved toward the test floors. If the bottom vapor barrier should leak, the soil would serve as a sink for moisture during periods of high soil moisture, and by using coarse sand as fill material, movement of moisture through this area by capillary forces could be nearly eliminated.

The bottom vapor barrier was placed over the subgrade, then a 2- to 4-inch layer of earthfill was spread over the vapor barrier. Next, the soil was screeded level, creating a level surface for installing the test floors. For termite protection, a chemical solution of an effective insecticide can be applied to the fill material,[1] but no such precautions were taken in this installation.

The earthfill was leveled by using conventional concrete-screeding techniques. Though this fill was not packed or tamped, an optional step would have been to roll or compact the earthfill and then screed for final leveling. Electric heating cables capable of delivering from 5 to 10 watts per square foot were installed on top of the screeded soil as a heat source for evaporating excess moisture between films. This low-wattage

[1]See "Subterranean Termites: Their Prevention and Control in Buildings," U.S. Department of Agriculture Home and Garden Bulletin No. 64, available for 20 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

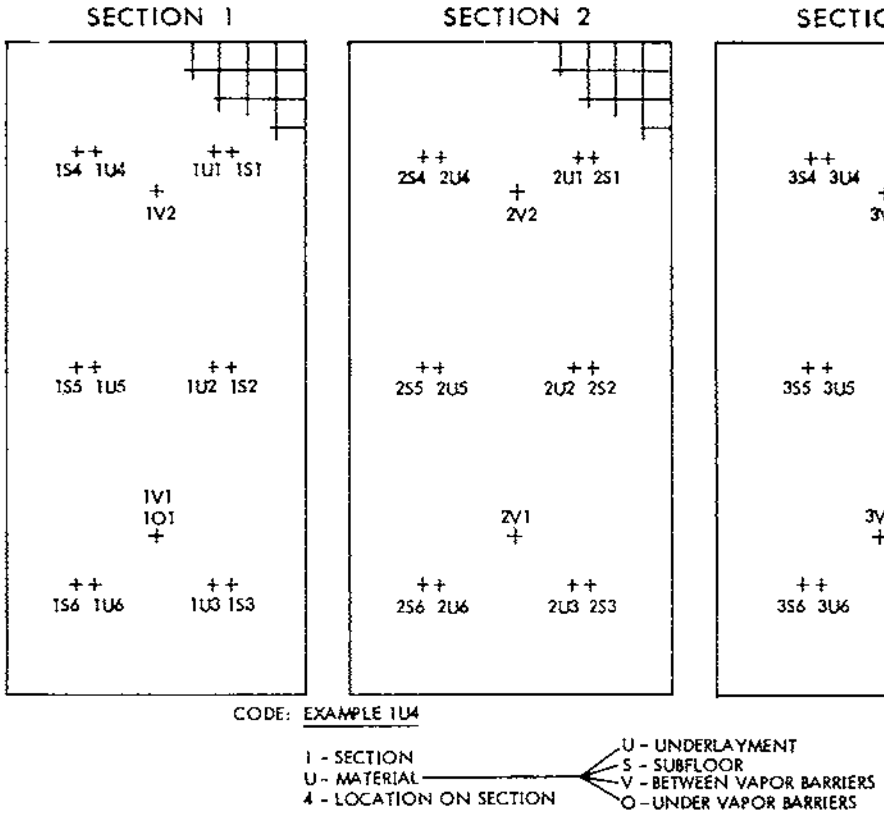

FIGURE 3.—Grid layout for taking moisture measurements in flooring materials.

cable was sunk about one-quarter of an inch into the earthfill.

The second plastic film was placed over the leveled earth and the heating cable.

The total floor area was divided into three 10- by 20-foot sections. A 4- by 20-foot nontest section at each end of the structure provided similar conditions for all three test floors.

To determine moisture concentrations in flooring materials, a resistance moisture meter was used. Probes were placed in the subfloor (6 locations on each test floor as shown in fig. 3) and in the underlayment (6 locations on each test floor as shown in fig. 3). Two probes with wire leads attached to them were spaced 1 inch on center in a small block of wood and buried in the soil at 2 locations between the vapor barriers and 1 location under both vapor barriers on each test floor (fig. 3). These were used as the sensing elements under and between the plastic films. Probes were driven into the subfloor and into the underlayment for moisture measurement in these materials.

Observations

After the subgrade had been prepared and before the floor structure was installed, condensation appeared on the bottom side of the top vapor barrier. The electric heating cable was plugged in to determine its effect on the polyethylene vapor barrier and on moisture evaporation. Heat from the cable caused expansion and localized warpage in the vapor barrier. The warpage pattern was about three-eighths of an inch wide.

The heat evaporated the moisture from the vapor barrier in a belt about 2 inches wide, but much condensation remained on the film between cables for several days. After about a week, the condensation disappeared as rapidly as it had appeared. It is possible that this moisture removal was the result of the direct effects of the heating cable, but it is also possible that an unrecorded change in the atmospheric conditions, possibly low atmospheric moisture, removed the moisture. A third possibility is that the heating cable gradually evaporated moisture from the bulk of the fill, and that once soil moisture was below the dew point, the condensation on the film began to evaporate. Furthermore, higher temperatures caused by heat buildup in the earthfill would increase the moisture-carrying capacity of the soil air, and thus allow the moisture to evaporate.

Moisture readings were begun on September 6,

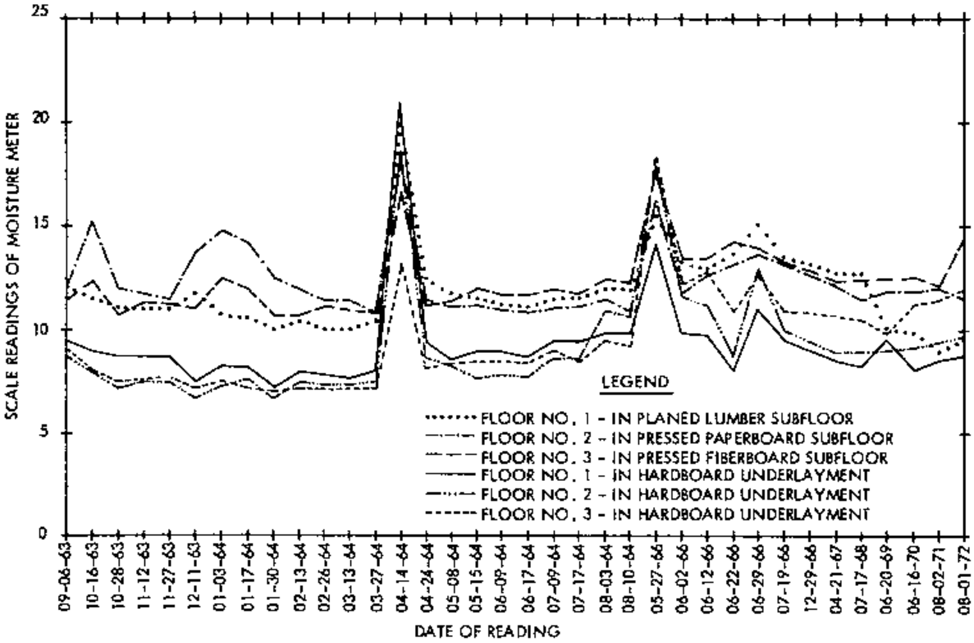

FIGURE 4.—Moisture readings in test-floor materials.

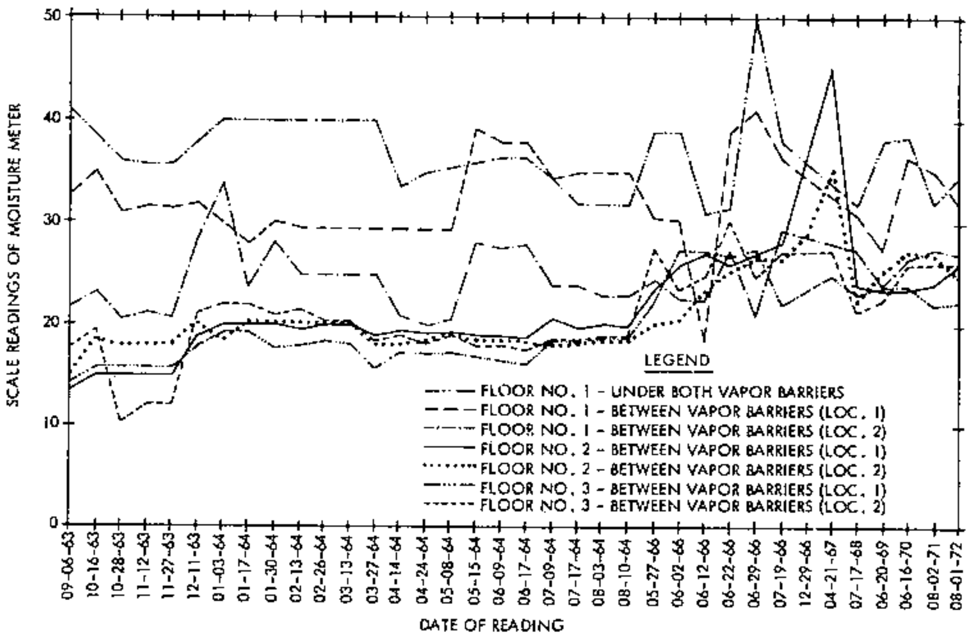

FIGURE 5.—Moisture readings in soil and between vapor barriers.

1963, and taken at 2-week intervals until August 10, 1964, after which time periodic moisture checks were made as indicated in figures 4 and 5 until August 1, 1972.

Figure 4 illustrates the relative moisture contents of different materials in the test floors during the period from September 6, 1963, to August 1, 1972. Each point on the graph represents the average of six readings taken on a particular test floor. An exact calibration of the moisture meter has not been established, but soil-moisture contents of 8 to 12 percent are comparable to meter readings of 10 to 15.

Moisture concentration was generally uniform, with only slight variations. Since the flooring materials were very dry upon installation, these readings indicate that the structural materials remained dry throughout the test period.

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FIGURE 6.—One- by ten-foot section of floor removed to permit inspection of materials and taking of soil samples. Engineer's left hand rests on earthfill formerly between plastic films.

Readings of soil moisture between the polyethylene films (fig. 5) revealed no significant patterns. They fluctuated up and down but did not vary much from the initial readings. Some initially low readings increased slightly, and all moisture contents were approximately the same at the end of the test period. The curve for floor No. 1 ("under both vapor barriers") demonstrates that the moisture content of the soil under the second polyethylene film remained fairly constant throughout the test period. Meter readings of 35 to 40 are comparable to soil moistures of 6 to 8 percent.

On April 21, 1967, a 1- by 10-foot section of each test floor was removed for inspection (fig. 6). Soil samples were taken under each test floor from between both polyethylene films and from beneath the lower polyethylene film to determine soil moisture. Each sample was sealed in plastic and sent to a laboratory to be weighed and dried. Table 1 shows the calculated percentage of moisture on both a wet and a dry basis. On a wet basis, moisture contents varied between 1.98 and 8.07 percent. On a dry basis, they varied between 2.02 and 8.78 percent.

Laboratory determination of the moisture content of the soil specimens permitted determination of the relationship between the actual soil moisture and instrument readings obtained through probes in wood blocks. Probes for measuring soil moisture under both layers of the polyethylene film were available only under floor No. 1.

Table 1 also shows the meter readings as they corresponded to the actual soil moistures. These data do not indicate a close correlation between soil moisture and the meter readings. An accurate calibration curve could not be established because of the limited data available. However, readings of 35 to 40 on the instrument are associated with soil moistures of 6 to 8 percent.

Discussion

The two polyethylene vapor barriers under the test floors and the 1-foot-deep diversion ditch around the structure housing the test floors provided an effective system for keeping the moisture level of the wooden floor slabs at a low level. Some soil probes consistently produced high readings, but soil samples taken after 4 years of tests revealed that the soil beneath the

TABLE 1. *Meter readings and calculated moisture contents of soil samples from various locations*

Test floor number	Location of moisture reading relative to polyethylene films	Meter reading (average)	Percent moisture content on Wet basis	Percent moisture content on Dry basis
1	Between	38	6.63	7.12
1	Under	35	7.11	7.66
2	Between	29	8.07	8.78
2	Under		1.98	2.02
3	Between	32	5.27	5.57
3	Under		6.09	6.50

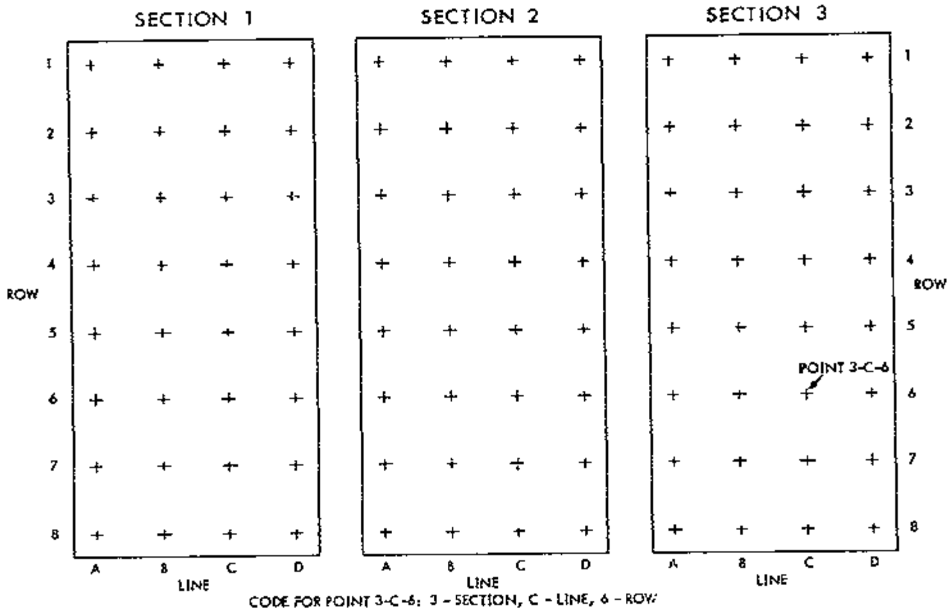

FIGURE 7. — Grid layout for measuring floor elevations.

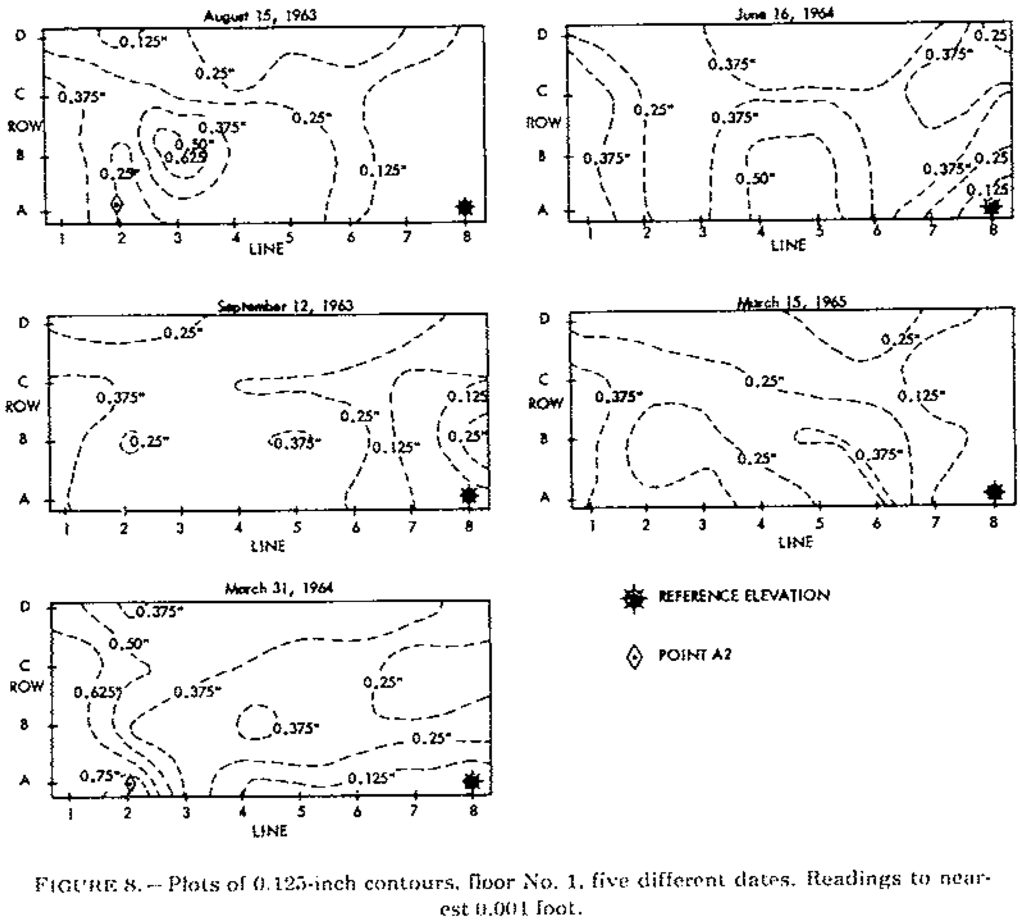

FIGURE 8. — Plots of 0.125-inch contours, floor No. 1, five different dates. Readings to nearest 0.001 foot.

structures was relatively dry, which indicated that the probe was not calibrated in percentage units and that there had never been a moisture buildup under the films.

One problem with the test was that the perimeter ditch was so effective in diverting moisture from the structure that the polyethylene films were never subjected to severe moisture conditions. The tests showed that the two vapor barriers successfully served as barriers to moisture in low soil-moisture conditions and that they could be used effectively with a diversion ditch in relatively dry climates. Future tests should be conducted under more severe moisture conditions so that the vapor barriers can be evaluated for use in high-moisture climates.

ELEVATION STABILITY OF THREE WOOD FLOORING SYSTEMS

Procedure

To determine the original contour of the floor, 32 points were selected for measurement on each test floor (fig. 7). These points formed a lattice of squares 27 inches on a side.

Elevation readings were made at the time of installation to determine levelness, and additional readings were taken at intervals during the following 3 years to detect any changes in the contour of the floors. Five readings were taken at each reference point, one on each of the following dates: August 15, 1963; September 12, 1963; March 31, 1964; June 16, 1964; and March 15, 1965. Levelness of the floors was demonstrated by plotting contour curves at 0.125-inch intervals on the floor plans.

Observations

Floor No. 1.—The plot of the floor contours taken on August 15, 1963 (fig. 8), showed a relatively smooth pattern; the difference between the high and the low points was 0.055 foot (0.66 inch).

By September 12, 1963, settling had produced greater uniformity in elevation. The maximum variation in floor elevation was now 0.035 foot (0.42 inch).

On March 31, 1964, the floor remained smooth

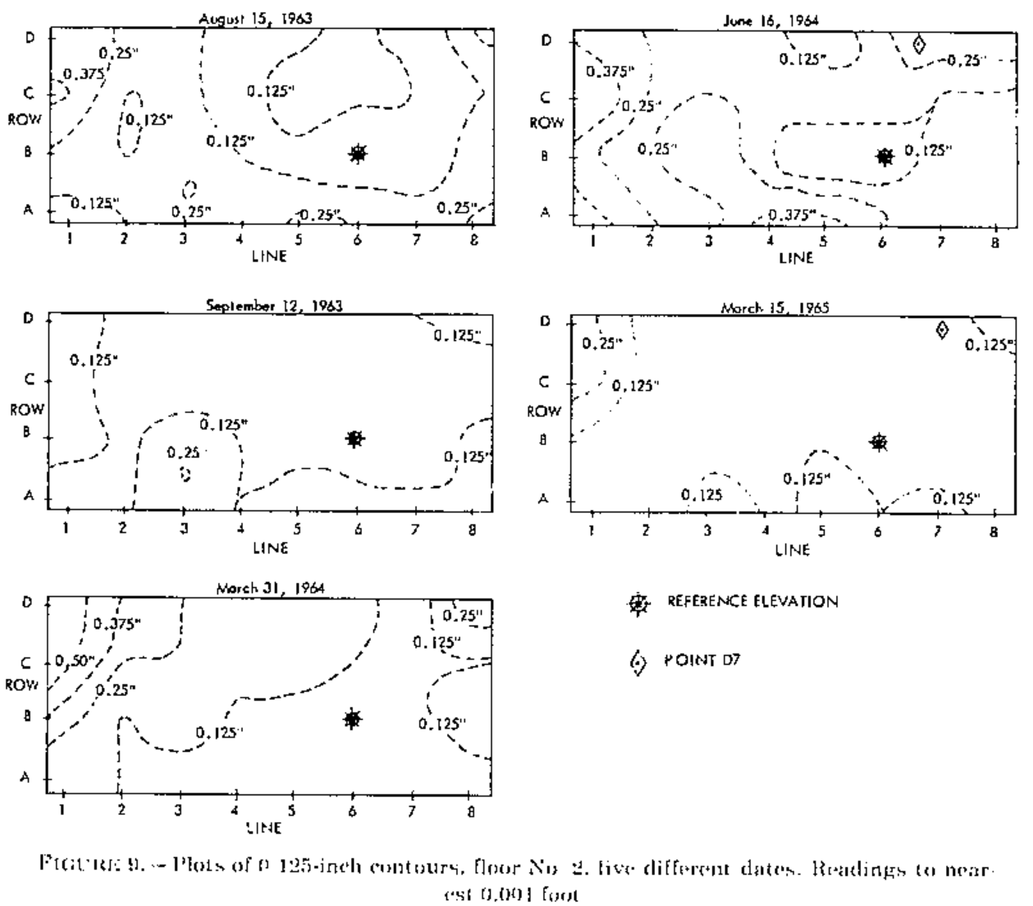

FIGURE 9.—Plots of 0.125-inch contours, floor No. 2, five different dates. Readings to nearest 0.001 foot

TABLE 2.—*Observed floor elevations, calculated variation of each point over test series, and calculated difference in floor elevation at each test for floor No. 1*

Location code[1]	Measured elevations (foot) on—					Variation in elevation	
	Aug. 15, 1963	Sept. 12, 1963	Mar. 31, 1964	June 16, 1964	Mar. 15, 1965	Foot	Inch
1A1	0.035	0.030	0.055	0.060	0.032	0.030	0.36
2	.020	.025	.070	.040	.024	.040	.48
3	.022	.025	.025	.040	.026	.018	.22
4	.025	.030	.010	.050	.012	.040	.48
5	.025	...	...	.055	...	.020	.24
6	.015	.020	.010	.040	.034	.030	.36
7	.008	.010	.005	.020	.010	.015	.18
8	0	0	0	0	0	0	0
1B1	.040	.035	.060	.055	.033	.027	.32
2	.015	.020	.030	.040	.012	.028	.34
3	.055	.025	.025	.040	.018	.037	.44
4	.030	.030	.033	.055	.030	.025	.30
5	.028	.032	.030	.055	.032	.027	.32
6	.020	.025	.025	.035	.026	.015	.18
7	...	...	...	.040	.014	.026	.31
8	.005	.025	.025	.020	-.008	.033	.40
1C1	.035	.035	.060	.060	.032	.028	.34
2	.028	.030	.045	.040	.028	.017	.20
3	.020	.025	.035	.040	.024	.020	.24
4	.020	.020	.030	.040	.020	.020	.24
5	.016	.020	.025	.040	.016	.024	.29
6	.015	.015	.025	.040	.016	.025	.30
7	0	.005	.010	.020	-.002	.022	.26
8	.005	.010	.015	.032	-.004	.036	.43
1D1	.017	.017	.045	.039	.014	.025	.30
2	.008	.015	.030	.039	.012	.031	.37
3	.018	.020	.040	.040	.014	.026	.31
4	.025	.028	.040	.055	.016	.039	.47
5	.024	.028	.040	.055	.024	.031	.37
6	.027	.031	.040	.055	.030	.028	.34
7	.020	.025	.035	.040	.016	.024	.29
8	.008	.015	.025	.020	.008	.017	.20
Highest	.055	.035	.070	.060	.034	...	...
Lowest	0	0	0	0	-.008	...	...
Difference	.055	.035	.070	.060	.042	...	...

[1]See figure 7.

and comfortable. A high point at A2 accounted for most floor elevation variation, which was 0.070 foot (0.84 inch).

Readings on June 16, 1964, revealed a slight increase in elevation at several points near the center. However, elevation remained satisfactorily uniform again and the greatest recorded variation was 0.060 foot (0.72 inch).

On March 15, 1965, maximum variation in floor elevation was 0.042 foot (0.50 inch).

Comparison of the five contour plots of floor No. 1 confirms that there was very little vertical movement throughout the test period. Table 2 shows the elevation of each point on the five different dates in the 3-year period. The maximum variation occurred at point A2, which varied from 0.070 foot (0.84 inch) to 0.020 foot (0.24 inch), or a total of 0.050 foot (0.60 inch).

Floor No. 2.—On August 15, 1963 (fig. 9), the contours of floor No. 2 were relatively smooth, but there were variations slightly less than those found in floor No. 1. Maximum variation in elevation was 0.032 foot (0.38 inch).

Readings on September 15, 1963, indicated that the floor was slightly more level than it had been at the time of the first reading, with a maximum variation of 0.025 foot (0.30 inch).

There was a slightly greater variation in eleva-

TABLE 3. —*Observed floor elevations, calculated variation of each point over test series, and calculated difference in floor elevation at each test for floor No. 2*

Location code[1]	Measured elevations (foot) on—					Variation in elevation	
	Aug. 15, 1963	Sept. 12, 1963	Mar. 31, 1964	June 16, 1964	Mar. 15, 1965	Foot	Inch
2A1	0.005	0	0.005	0.033	0	0.033	0.40
2	.012	.010	.010	.020	.002	.018	.22
3	.020	.020	...	.020	.016	.004	.05
4	.015	.010	.005	.031	.006	.026	.31
5	.020	.020	.010	.031	.014	.021	.25
6	.020	.015	.005	.020	.010	.015	.18
7	.015	.012	0	.020	-.012	.032	.38
8	.020	.015	.005	.020	0	.020	.24
2B1	.015	.015	.025	.020	.006	.020	.24
2	.010	.007	.010	.020	.002	.018	.22
3	.020	.020	.020	.030	.004	.026	.31
4	.010	.010	.005	.011	.002	.009	.11
5	.005	0	0	0	-.010	.015	.18
6	0	0	0	0	0	0	0
7	0	0	-.005	.020	-.003	.025	.30
8	.015	.015	.015	.020	.007	.013	.15
2C1	.032	.020	.045	.040	.022	.025	.30
2	.010	0	.020	.020	.004	.020	.24
3	.012	0	.020	.021	.004	.021	.25
4	.005	0	.015	.015	.002	.010	.19
5	.020	.010	.020	.020	.004	.018	.22
6	.012	.005	.010	.020	.004	.016	.19
7	.010	-.002	.010	.010	-.002	.012	.14
8	.010	0	.010	.010	.002	.010	.12
2D1	.030	.020	.050	.030	.022	.030	.36
2	.015	-.005	.030	.020	.004	.035	.42
3	.015	-.005	.020	.020	.004	.025	.30
4	0	-.005	.015	.015	.008	.023	.28
5	.008	0	.015	0	0	.015	.18
6	.015	0	.015	.020	.002	.020	.24
7	0	.010	0	.038	-.013	.051	.61
8	.020	.015	.030	.038	.015	.023	.28
Highest	.032	.020	.050	.040	.022	...	...
Lowest	0	-.005	-.005	0	-.013	...	...
Difference . .	.032	.025	.055	.040	.035	...	...

[1]See figure 7.

tion in the March 31, 1964, readings of 0.055 foot (0.66 inch), but on June 16, 1964, the variation dropped to 0.040 foot (0.48 inch).

Readings on March 15, 1965, also revealed little change in the floor contour, with elevation variations of 0.035 foot (0.42 inch).

The slight increase in elevation variation during March 1964 could have resulted from the reduced traffic on the floor during the winter months. The asphalt tile cement could have loosened under these conditions and thus permitted slight warpage in the flooring materials.

Table 3 shows the elevation for each point on five dates in the 3-year period. The maximum variation occurred at point D7, which varied from 0.038 foot (0.46 inch) to −0.013 foot (−0.16 inch), or a total of 0.051 foot (0.62 inch).

Floor No. 3.—Initial readings on floor No. 3, taken just after installation, showed very little variation in elevation. The contour lines were spread far apart, indicating a very gentle slope.

On August 15, 1963 (fig. 10), the maximum variation in elevation was 0.060 foot (0.72 inch). Readings made on September 12, 1963, were similar. Maximum variation was 0.055 foot (0.66 inch).

TABLE 4.—*Observed floor elevations, calculated variation of each point over test series, and calculated difference in floor elevation at each test for floor No. 3*

Location code[1]	Measured elevations (foot) on—					Variation in elevation	
	Aug. 15, 1963	Sept. 12, 1963	Mar. 31, 1964	June 16, 1964	Mar. 15, 1965	Foot	Inch
3A1	0.060	0.055	0.040	0.080	0.067	0.040	0.48
2	.038	.035	.020	.046	.049	.029	.35
3	.035	.035	.015	.040	.047	.032	.38
4	.040	.040	.015	.050	.053	.038	.46
5	.050	.050	.020	.060	.065	.045	.54
6	.050	.050	.015	.051	.065	.050	.60
7	.055	.055	.020	.051	.047	.035	.42
8	.050	.055	.010	.055	.037	.045	.54
3B1	.030	.028	.020	.025	.043	.023	.28
2	.022	.022	.010	.025	.029	.019	.23
3	.022	.025	.010	.020	.027	.017	.20
4	.022	.025	.005	.025	.027	.022	.26
5	.024	.028	.005	.025	.037	.032	.38
6	.035	.030	.010	.039	.042	.032	.38
7	.032	.032	.010	.035	.039	.029	.35
8	.042	.045	.015	.059	.052	.044	.53
3C1	.036	.037	.040	.035	.042	.007	.08
2	.020	.020	.015	.020	.027	.012	.14
3	.040	.020	.015	.015	.027	.025	.30
4	.030	.025	.015	.031	.030	.016	.19
5	.035	.040	.025	.031	.043	.018	.22
6	.040	.040	.025	.040	.052	.017	.20
7	.040	.040	.025	.040	.055	.020	.24
8	.043	.045	.025	.040	.053	.018	.22
3D1	.020	.015	.025	.010	.023	.015	.18
2	.015	.010	.015	.010	.007	.008	.10
3	0	0	0	0	0	0	0
4	.010	.005	0	.020	.003	.020	.24
5	.030	.025	.025	.025	.030	.005	.06
6	.038	.025	.030	.040	.047	.022	.26
7	.045	.045	.030	.042	.047	.017	.20
8	.050	.050	.035	.050	.054	.019	.23
Highest	.060	.055	.040	.080	.067	. . .	. . .
Lowest	0	0	0	0	0	. . .	. . .
Difference . .	.060	.055	.040	.080	.067	. . .	. . .

[1]See figure 7.

On March 31, 1964, the contour pattern had not changed appreciably, but the variation in elevation was down to 0.040 foot (0.48 inch).

Data taken on June 16, 1964, showed a high point at A1. At this time, there were slightly greater variations at the other points than in previous readings, but point D3 remained the low point, and was lower than point A1 by 0.080 foot (0.96 inch).

Readings taken on March 15, 1965, were again very similar to previous readings, and the maximum variation was 0.067 foot (0.80 inch).

Floor No. 3 was very level, and there was scarcely any change in the relative elevation of points during the test period. Table 4 indicates the elevation of each point on five different dates in the 3-year period. The maximum variation occurred at point A6, which varied from 0.065 foot (0.78 inch) to 0.015 foot (0.18 inch), or a total of 0.050 foot (0.60 inch).

Discussion

All three floors remained smooth and comfortable to walk on. The measured differences in elevation were not noticeable to a person walking

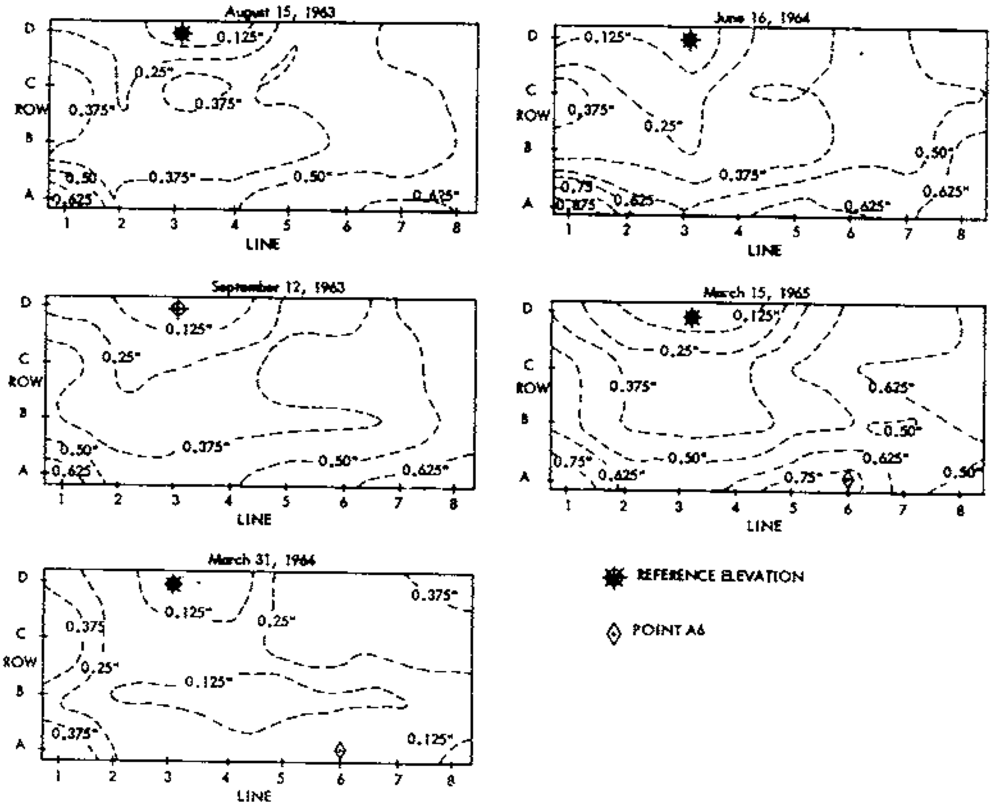

FIGURE 10.—Plots of 0.125-inch contours, floor No. 3, five different dates. Readings to nearest 0.001 foot.

and were comparable to those that might be expected with regular concrete slabs.

At times, the three floors were exposed to considerable traffic, but it did not seem to affect the floors significantly. Although heavy items were stored on these floors, there was hardly any movement or settling. Most settling which did occur was uniform over the entire floor area.

CONCLUSIONS

1. The perimeter ditch around the structure was effective in carrying ground moisture away and prevented a buildup of soil moisture under the structure.

2. Since there was never a significant buildup of moisture under the polyethylene films, the true effectiveness of the films could not be evaluated.

3. Throughout most of the test period, there was a slightly greater moisture content immediately under the polyethylene films than between them, which indicated that the plastic film was maintaining a moisture gradient between the soil and the flooring materials.

4. Meter readings in all flooring materials were lower than the meter readings made either between the films or under them; however, since the instrument was calibrated in wood but not in the other materials tested, this comparison was not quantitatively very meaningful.

5. Floors were easy to install, and there were no significant problems in leveling when the soil between the polyethylene films had been screeded according to conventional practices used in leveling concrete. Some variation in floor level could have been the result of rocks or wood blocks having been mixed into the soil between the plastic films, which would have prevented uniform settling. Compacting the soil would have reduced uneven settling, and it would have revealed large rocks or other solid materials, which then could have been removed. A series of tests should be conducted to determine the effect of compacting the soil on settling.

6. Floors were resilient and comfortable to walk on. Other scientists and associates, as well as casual visitors, judged them superior to conventional concrete floors.

7. Materials costs for these floors were about the same as those for a concrete floor. Variation of prices in different geographical regions

would affect the relative cost. All prices should be checked at each building location.

8. Asphalt mastic was not satisfactory for joining hardboard to other subfloors. Additional tests should be conducted to determine the applicability of construction adhesives to join these flooring materials.

9. The accidental wetting of floors on several unrecorded occasions was not apparent in the recorded moisture of the flooring materials. Future studies should investigate the effect of frequent flooding with cleaning water.

10. Patching floors constructed of wood materials was simple, and the resulting finish was neat. There was some problem with the strength of the mastic; a stronger construction adhesive should be tried.

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