DIMENSIONAL PROPERTIES OF SOUTHERN PINE PARTICLEBOARD UNDERLAYMENT

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ABSTRACT

The dimensional changes in particleboard underlayment installed over plywood subflooring on floor sections and exposed to different environmental conditions were investigated.

Gap formation between pairs of 8-ft particleboard panels attached by nailing occurred rapidly under drying conditions, causing print-through on narrow strips of vinyl floor coverings and rupture in the less elastic types. Attachment by glue nailing limited gap formation and prevented development of defects in floor coverings. Hot-melt coatings were effective in stabilizing particleboard panels of certain types when floor sections were exposed at 80 F and 10% relative humidity, but were of limited value when exposure was at 120 F and 20% relative humidity.

Changes in the distance from the joint between particleboard panels and points that were initially 1, 2, 3,—6 ft from the joint varied with the method of attachment of the panels to floor sections and were frequently in the opposite direction from that which occurs in unrestrained panels. The magnitude of the change and the direction of movement are explained in terms of the concurrent dimensional changes in the particleboard and the plywood subfloor to which it was attached.

INTRODUCTION

Particleboard was first produced commercially in the United States in 1946 (Lambert 1970). Total production has increased rapidly since the 1950's and was 3.3 billion square feet in 1970. The current rate of growth for the industry is in excess of 20% per year (Johnson 1956; Anon. 1970).

Among the uses of particleboard, one of the most important in terms of volume consumed is underlayment for floor coverings. The dimensional properties of board used for this purpose are important. Shrinkage of underlayment will mar the appearance of a floor by permitting print-through at the joints, and may ruin the floor covering by causing it to rupture at points of high stress. Problems associated with swelling, while of less frequent occurrence than those caused by shrinkage, also occur and are usually manifested by buckling of installed particleboard, thus necessitating major repairs to the floor.

Particleboard currently produced for use as underlayment is much improved in dimensional stability compared to the rather unpromising product that was first manufactured in this country. Nevertheless, problems still occur in finished floor systems that are caused by the movement of particleboard underlayment in response to changes in moisture content. The study reported here was undertaken by this laboratory to obtain information on the dimensional changes of particleboard in standard floor systems exposed to different environmental conditions, and to determine the effect of these changes on different grades and types of vinyl floor-covering materials. The study was sponsored by Georgia-Pacific Corporation.

PROCEDURE

Two conditioning cabinets of sufficient size to accommodate four 4′ × 16′ floor sections each were constructed (Fig. 1). Insulation and vapor barriers were installed on all sides of both cabinets to minimize temperature and humidity variations within the two units. One cabinet was equipped with electric heating units, blower, thermostat, and coil-type dehumidifier and was operated at 120 F and 20% relative humidity for the duration of the study. The other one was attached by means of ducts to an 1100 cfm Aminco-Aire Unit in parallel with a

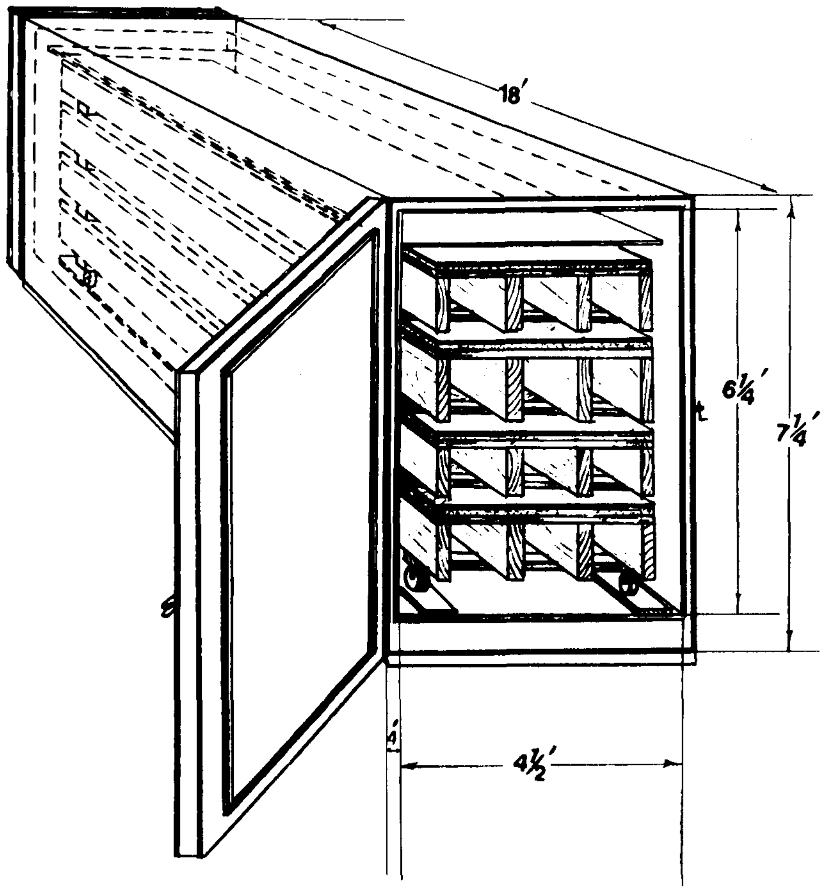

FIG. 1. Conditioning cabinet loaded with four floor sections.

Cargoaire, self-regenerating, desiccant-type dehumidifier. It was operated at either 80 F and 10% relative humidity or 90 F and 90% relative humidity, depending upon the type of test being conducted. The dehumidifier was disconnected when the unit was operated at the latter conditions. A 12′ × 12′ forced-draft, research dry kiln was used for one group of four floor sections.

Floor sections were constructed using 2″ × 10″ kiln-dried, southern pine joists on 16-inch centers and ⅝-inch, A-C grade Douglas-fir plywood subflooring. The subflooring was installed in three pieces—a 4-ft panel on each end of the floor assembly and an 8-ft panel in the center. Eight-penny nails spaced 6 inches apart were used in the installation, and the grain direction of the surface plies was oriented parallel to the long axis of the joists. Except as otherwise noted, the underlayment was ⅝-inch, 1B2 southern pine particleboard with a resin content of 11% and a specific gravity of 0.80. It was attached to the floor sections by either the standard-nailing pattern recommended by the National Particleboard Association, a modified-nailing pattern in which nail spacing was one-half that of the standard pattern, or by glue nailing using phenol-resorcinol, urea, polyvinyl acetate (PVA), or casein adhesives. Two 4′ × 8′ sheets were attached to each floor section. The moisture content of all panels at the beginning of a test ranged between 8 and 9%. This moisture content was used throughout the study because it corresponds

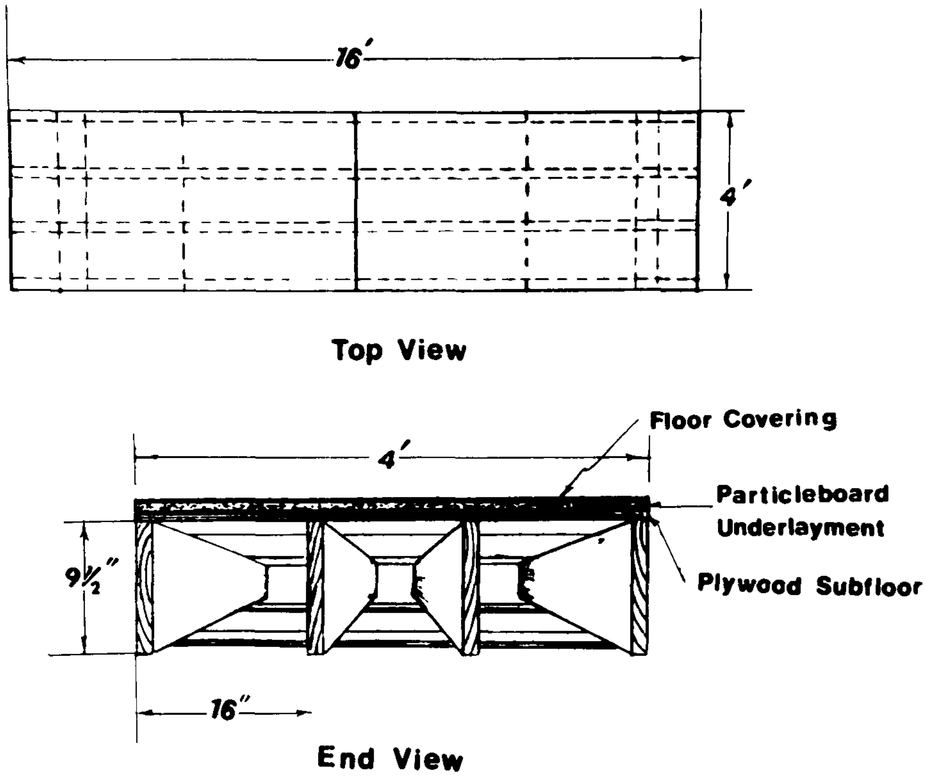

FIG. 2. Design of 4′ × 16′ floor sections.

approximately to the moisture content of southern pine particleboard at the time of installation. Construction details for the floor sections are shown in Fig. 2.

The response of 29 types and grades of floor-covering materials to the stresses imposed by dimensional changes in the underlayment was studied initially by gluing 6-inch-wide by 6-ft-long strips of vinyl sheet goods to the underlayment using a rigid epoxy adhesive and noting the development of print-through and ruptures at the joint between adjacent particleboard panels. In later studies, floor sections of the same design were covered completely with sheet goods, and the performance of the latter was studied as the underlayment shrank.

Sixteen experimental runs were made. Each run consisted of four floor sections in one or the other of the two cabinets. Measurements of dimensional changes for 14 of the 16 runs were made over a 2-inch span across the joint between adjacent particleboard panels on a floor section (Fig. 3). Brass eyelets were driven into predrilled holes on either side of the joint at points 6 inches from each side of the panel and at the center (Fig. 3). Changes in the dimensions across the joint were measured with a dial-gauge micrometer to the nearest 0.001 inch. This instrument was mounted on a frame with adjustable legs that were inserted into the eyelets at the time of measurement.

A similar procedure was used in making measurements on floor sections included in the other two runs, except that eyelets were placed at distances from the joint between particleboard panels of 1, 2, — 6 feet in each of the two panels on a floor section. Experimental run number 15 was conducted at 120 F and 20% relative humidity. Measurements on panels included in this run were made to determine the movement

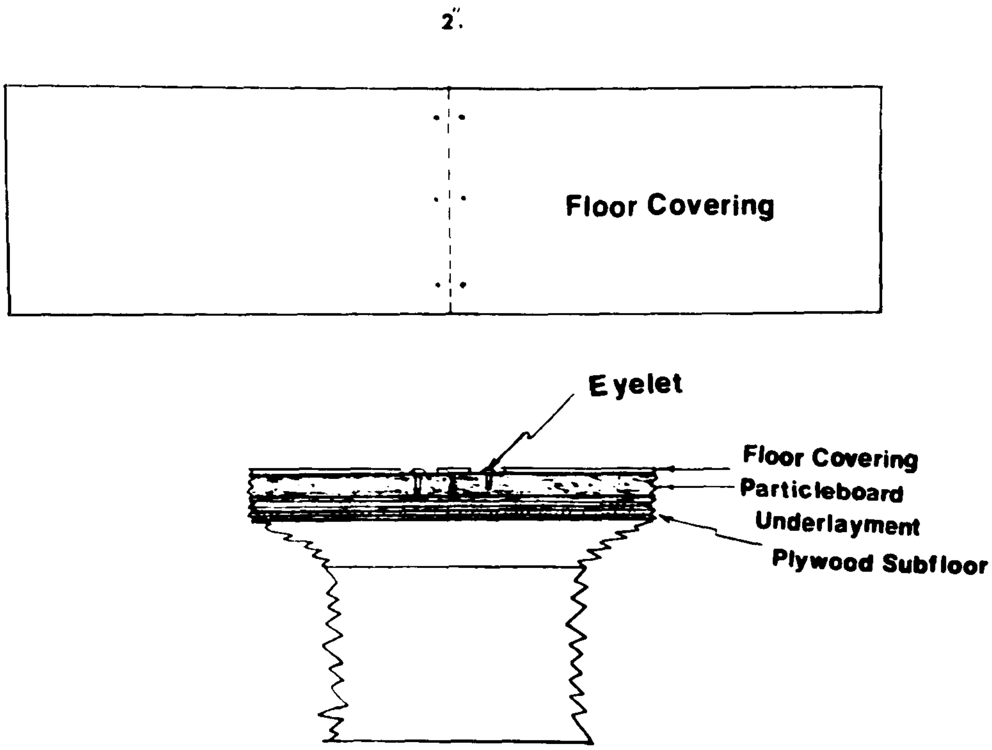

FIG. 3. Floor section showing placement of eyelets for measurements of dimensional changes.

of the eyelets with respect to the joint. For this purpose, the initial distance from the joint to each eyelet at the 1-ft point, 2-ft point, etc. was measured on first one panel and then on the other panel. At predetermined time intervals, these distances were remeasured, and the movement at each eyelet with respect to the joint was computed. The movement that had occurred at each of the six eyelets (three for each panel) representing the same distance from the joint were averaged. These results were plotted over exposure period to give a family of curves showing the relationship between exposure period and movement with respect to the joint for points 1-ft, 2-ft, etc. from the joint.

Run number 16 was conducted in a manner similar to that for number 15 except that a dry kiln was used instead of one of the humidity chambers and the exposure conditions were 125 F and 90% relative humidity. After the movement with respect to the joint for each distance from the joint had been calculated, the values for the corresponding positions (1-ft, 2-ft, etc.) in the two panels were added together to give the total movement over span widths of 2, 4, 6, and 8 ft that included the joint.

The length of the conditioning period for each run varied from 4 to 22 weeks. At weekly intervals the floor sections in all runs except number 16 were removed from the conditioning cabinets, the condition of the sheet goods was determined, and the dimensional changes in the underlayment were measured. For run number 16 measurements to determine dimensional changes were made at 48-hr intervals.

DISCUSSION OF RESULTS

Movement of standard-nailed particleboard

The average changes in dimension across the joint between panels of particleboard in floor sections are given in Table 1 for three exposure conditions.

TABLE 1. *Effect of method of attachment on dimensional changes in particleboard underlayment as measured at the joint between two 8-foot-long panels installed on floor sections*

Method of Attachment[a]	Average[b] Dimensional Change (0.001″) after 4 Weeks' Exposure at		
	120 F 20% RH	80 F 10% RH	90 F 90% RH
Standard Nailing	110 (27)	52 (18)	94 (3)
Modified Standard Nailing	104 (3)	–	–
Glue-Nailing:			
Phenol-resorcinol	12 (18)	17 (3)	14 (3)
PVA	20 (9)	–	29 (3)
Urea	15 (6)	10 (3)	–
Casein	4 (6)	–	15 (3)

[a] Does not include panels covered with sheet goods.
[b] Numbers in parentheses give the number of measurements represented by each value.

TABLE 2. *Rate of shrinkage of particleboard underlayment panels glue nailed using various adhesives when exposed at 120 F and 20 percent relative humidity*

Adhesive	Cumulative Change (0.001″) by Week			
	1	2	3	4
PVA	12	18	19	20
Phenol-resorcinol	6	10	11	13
Casein	5	7	8	10
Urea	7	10	13	13

Standard nailing was ineffective in preventing gap formation between particleboard panels. The gap between panels containing no floor covering, or with only strips of floor covering on their surfaces, increased rapidly in width at 120 F–20% relative humidity and usually reached equilibrium conditions in four to six weeks. Changes in length of panels occurred more slowly at 80 F–10% relative humidity. Average gap widths after four weeks for the two exposure conditions were 110 and 52 mils, respectively. Reducing the spacing of nails by one-half did not significantly affect the shrinkage of the underlayment at the joints.

Two runs were conducted at 90 F–90% relative humidity to obtain data on dimensional changes under swelling conditions. In one, a gap of approximately 125 mils was left between panels during installation. No gap was left between panels in the other run. Dimensional changes due to swelling in the former were comparable to those obtained under shrinkage conditions, but were in the opposite direction (Table 1). In the case of the latter run, the distance across the joint decreased until firm contact was made between the two panels—about 15 mils net movement—and then remained essentially constant for the remainder of the exposure period. No buckling occurred in the body of the panels and the distortion at the joint itself was minor, although the edge of one panel was elevated above the other 1/16 to 1/8 inch in some instances. Later studies, subsequently described, revealed that once firm contact is made between panels at a joint, the two panels continue to swell as a single unit. Under such conditions, movement occurs only at the free ends, and buckling does not become a serious problem unless the ends are restrained.

Movement of glue-nailed particleboard

Glue nailing using phenol-resorcinol formaldehyde, urea formaldehyde, PVA, and casein adhesives effectively restrained panels under both shrinking and swelling conditions. With the exception of panels glue nailed using PVA adhesives, the dimensional changes sustained by glue-nailed panels were less than 20 mils. Since rupture of floor coverings applied as narrow strips normally occurred at gap widths greater than 30 mils, all adhesives tested were effective, there being no instance of sheet goods failure in any of the tests.

The least effective adhesive tested was PVA. It permitted an average movement at the joint of 20 mils for panels undergoing shrinkage and 29 mils for panels undergoing swelling (Table 1). Comparable values for phenol-resorcinol, and casein adhesives were, in order, 12 and 14 mils and 4 and 15 mils. Urea formaldehyde resin was not tested under high humidity conditions, but it permitted an average shrinkage of only 13 mils in the tests conducted at low humidity.

Unlike the case for panels attached by

TABLE 3. *Comparison of dimensional stability of hot-melt coated Douglas-fir and uncoated southern pine particleboard panels without sheet goods*

Type of Underlayment and Method of Attachment	Cumulative Dimensional Change (0.001") by Week						
	1	2	3	4	5	6	7
(80 F–10% RH)							
Douglas-fir, coated; standard nailed	0	0	1	1	3	5	7
Pine, uncoated;[a] standard nailed	10	29	42	54	64	72	78
Pine, uncoated; glue nailed (urea glue)	3	7	9	10	13	13	–
(120 F–20% RH)							
Douglas-fir, coated; standard nailed	3	7	18	30	37	–	–
Pine, uncoated; standard nailed	76	87	93	104	110	–	–
Pine, uncoated; glue nailed (phenol-resorcinol glue)	16	16	16	19	19	–	–
Pine, uncoated; glue nailed (urea glue)	11	14	17	17	–	–	–

[a] Average values for two floor sections.

standard nailing, the dimensional changes in which continued throughout exposure periods of four to six weeks' duration, practically all of the movement in glue-nailed panels occurred during the first two weeks. This point is illustrated in Table 2, which gives data on average shrinkage of panels by week for the four adhesives. The response of glue-nailed underlayment in this regard suggests that, with one surface restrained by the adhesive, a limited amount of movement still occurs in the upper increments of a panel.

Movement of coated particleboard

Six runs with boards from two manufacturers that were treated with hot-melt coatings were conducted. Boards from one manufacturer (A) were made of Douglas-fir and had a specific gravity of 0.72 and a resin content of 6%. Those from the other manufacturer (B) were made of southern pine and had the characteristics previously described. Both sets of boards were coated by manufacturer A using commercial equipment. Coating thickness was approximately 2 mils. The results of these tests are summarized in Table 3, in which the performance of the coated Douglas-fir boards is compared with that of uncoated southern pine boards, and in Table 4, in which coated boards of both types are compared. The panels described in Table 3 contained no sheet goods, while those described in Table 4 received a full covering of sheet goods.

Coated Douglas-fir particleboard showed markedly less shrinkage at 80 F and 10% relative humidity than either coated or uncoated southern pine particleboard. Total gap width after seven weeks' exposure of panels without sheet goods was 7 mils. This value was only about one-half the shrinkage sustained by a glue-nailed assembly of southern pine included in the same test, which had a gap width of 13 mils (Table 3). The comparable value for standard-nailed pine particleboard was 78 mils. For coated Douglas-fir particleboard covered with sheet goods, total gap width was 9 mils after 22 weeks' exposure at 80 F, compared to an average value of 23 mils for coated southern pine board included in the same run (Table 4).

The performance of coated Douglas-fir board exposed without sheet goods at 120 F, in terms of dimensional stability, was considerably less favorable than that obtained at 80 F, but was still much better than that for uncoated southern pine board (Table 3). The hot-melt coating appeared to restrict moisture loss, and hence shrinkage, for the first two weeks' exposure. However, shrinkage increased rapidly after the second week and totaled 37 mils at the end of five weeks. This value was still significantly lower than the 110 mils recorded for uncoated southern

TABLE 4. *Comparison of dimensional stability of hot-melt coated southern pine and Douglas-fir particleboard covered with vinyl sheet goods and attached to subfloor by standard nailing*

Type of Underlayment and Method of Attachment	Cumulative Change (0.001″) by Week						
	10	12	14	16	18	20	22
	(80 F–10% RH)						
Pine, coated 2 sides	4	8	10	16	25	26	25
Pine, coated 1 side	4	6	9	13	15	21	21
Pine, uncoated	12	13	16	18	30	29	29
Douglas-fir, coated 2 sides	1	2	4	6	9	9	9
	(120 F–20% RH)						
	2	4	6	8	10	12	14
Pine, coated 2 sides	–1	26	46	72	78	87	95
Pine, coated 1 side	6	31	49	70	77	84	93
Pine, uncoated	–5	12	25	38	42	49	54
Douglas-fir, coated 2 sides	2	14	24	41	43	50	54

pine board for the same period, but was approximately two times as great as that for the two uncoated glue-nailed assemblies included in the same run. A shrinkage value of 54 mils was obtained for coated Douglas-fir boards with sheet goods exposed for 14 weeks at 120 F. The same shrinkage occurred in uncoated southern pine boards (Table 4).

Hot-melt coatings were for all practical purposes ineffective on southern pine particleboard under both exposure conditions. The gap between boards coated on both sides and covered with sheet goods was 25 mils after 22 weeks' exposure at 80 F (Table 4). For control boards, which also contained sheet goods but were uncoated, the value was 29 mils. Matched assemblies exposed for 14 weeks at 120 F had shrinkage values of 95 and 93 mils for panels coated on two sides and one side, respectively. The comparable value for control assemblies, which were uncoated but covered with sheet goods, was 54 mils (Table 4). The low value for the control panels was caused by a below-average initial moisture content of 7.0%. The reason the performance of coated pine boards was less favorable than that for similarly treated Douglas-fir boards is not known, but was probably related to the surface characteristics of the two board types and manufacturing variables.

Dimensional changes over spans of different width

Typical results of measurements of dimensional changes over spans of 1 to 6 ft for particleboard underlayment attached to floor sections by standard nailing and glue nailing and exposed to low humidity conditions are given in Figs. 4 and 5, respectively. Comparable data for nailed and glue-nailed panels exposed to high humidity conditions are given in Figs. 6 and 7.

For panels attached by standard nailing, the span length from the center of the joint between panels on a floor section to points 1 ft and 2 ft from the joint increased at a decreasing rate with exposure time, reaching a maximum after approximately five weeks (Fig. 4). This trend was reversed after this period and the length of the 1- and 2-ft spans decreased during the remaining two weeks. Changes in spans greater than 2 ft were negative; that is, the distance from the center of the joint to points 3, 4, 5, and 6 ft from the joint decreased upon exposure of the floor assemblies to low humidity conditions. The rate of decrease increased with span length, and for any given span, decreased as the particleboard panels ap-

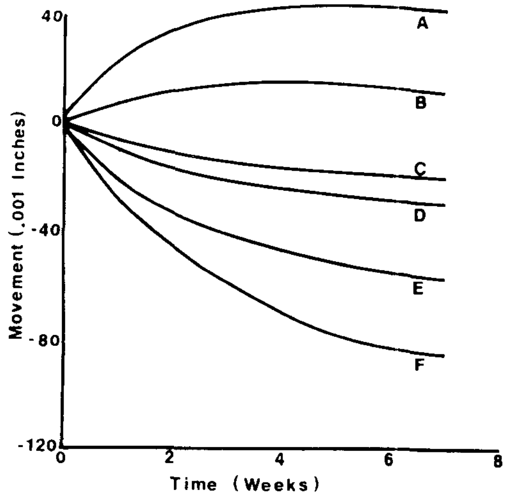

FIG. 4. Dimensional changes over spans of 1(A), 2(B), 3(C), 4(D), 5(E), and 6(F) feet in particleboard attached by nailing to floor sections exposed at 120 F–20% RH.

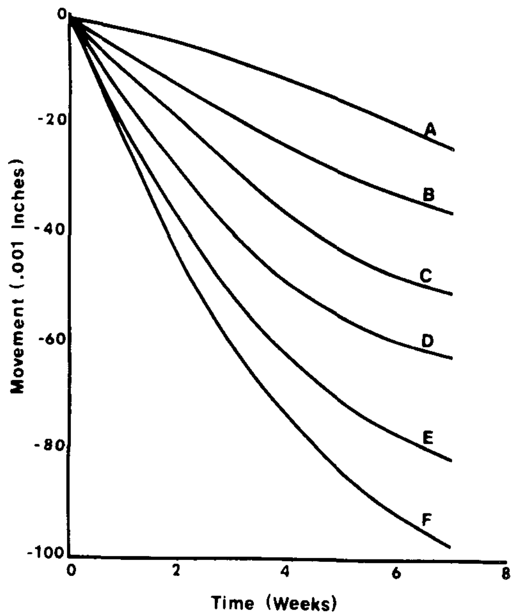

FIG. 5. Dimensional changes over spans of 1(A), 2(B), 3(C), 4(D), 5(E), and 6(F) feet in particleboard attached by nail gluing to floor sections exposed at 120 F–20% RH.

proached equilibrium. Changes in span length for panels glue nailed to floor sections followed a pattern similar to that for panels attached by standard nailing, except that they were all negative (Fig. 5).

The procedure followed in measuring changes in the length of spans for underlayment exposed to swelling conditions was identical to that described above, except that the joint between panels was at the center of each span. Results of this phase of the study are summarized in Figs. 6 and 7, which show the relationship between changes in span length and exposure period for panels attached to floor sections by standard nailing and glue nailing, respectively. Total elongation over an 8-ft span for panels that were standard nailed was 200 mils. Movement over the same span length for glue-nailed assemblies was 118 mils. The elongation for shorter spans decreased with decreasing span length.

These results show that the dimensional changes parallel to the long axis of panels of particleboard are influenced to a significant degree by both the nature of the attachment by which the panels are held to the subfloor and by the dimensional properties of the subfloor itself. For unrestrained panels exposed to drying conditions, shrinkage occurs in all points in a panel, with maximum movement occurring at points farthest removed from the center. The center itself remains stationary. For a two-panel assembly such as that shown in Fig. 3, the change in distance from the center of the joint to the center of a panel is always zero. It follows that the changes in distance from the center of the joint to intermediate points are always positive. Similarly, the change in distance to points farther removed from the joint than 4 ft (in the case of an 8-ft panel) would always be negative, since the shrinkage of such points is toward the joint.

When the underlayment is restrained, as in the present case, shrinkage of the various points in the panel toward the panel center occurs as described above, but the center of the panel itself moves toward the joint under the influence of the plywood subfloor to which it is attached. Under these conditions, the change in distance from the center of the joint to a given point on the panel may be

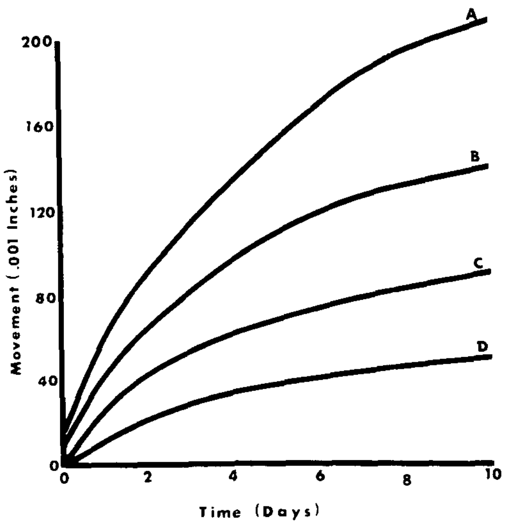

FIG. 6. Dimensional changes over spans of 2(D), 4(C), 6(B), and 8(A) feet in particleboard attached by nailing to floor sections exposed at 125 F–90% RH.

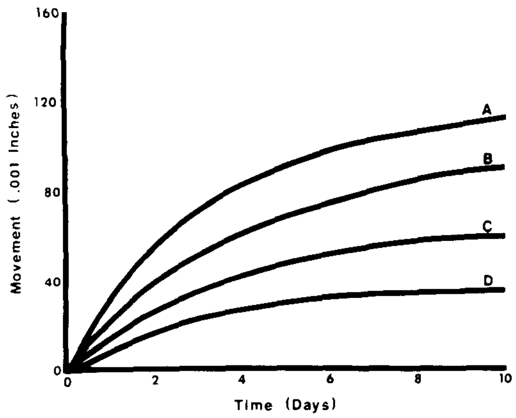

FIG. 7. Dimensional changes over spans of 2(D), 4(C), 6(B), and 8(A) feet in particleboard attached by nail gluing to floor sections exposed at 125 F–90% RH.

positive or negative, depending upon the movement of the point relative to the joint (Fig. 4). The change in distance from the center of the joint to the center of the panel would of course be negative. The magnitude of this change provides information on the shrinkage of the subfloor and the efficiency of the method used to attach the underlayment to the subfloor. With regard to the latter point, the greatest change should occur in glue-nailed assemblies, and the direction of change should ordinarily be negative (Fig. 5). In this type of assembly, the underlayment and attached subfloor in effect move as a single 16-ft panel with the joint between underlayment panels as its center.

Dimensional changes in panels undergoing swelling should follow the same pattern as described for shrinkage, but would be in the opposite direction. In the case of adjacent underlayment panels on a floor assembly such as the one depicted in Fig. 3, movement in each piece of underlayment and subfloor would be outward from their respective centers; i.e. the distance from the edge to the center of each piece increases. During the early stages, movement of the particleboard is restrained by the plywood subfloor, which moves at a slower rate and, in a normal floor assembly, in the opposite direction from that of the particleboard. Movement in the plane parallel to the long axis of each piece is in two directions during this phase. However, after the "slack" at the joints is taken up in both the underlayment and subflooring, the total movement in both materials is outward from the center of the assembly. From that point on, the assembly moves as one piece, unrestrained except for the nails holding it to the joists. Movement in the subfloor, while occurring at a slower rate than that for the particleboard, is in the same direction. It is significant that any movement in the subfloor accentuates the movement in the underlayment. The effect is analogous to a person walking while riding an escalator. The total movement at the ends of a floor section is approximately proportional to the length of the section.

Buckling at the joint between adjacent panels of underlayment was not severe in this study because the ends of the assemblies were free to move. Had they been restrained, as were the interior ends, the expansion measured here as horizontal movement would have been manifested by severe buckling of the panels. Because of the large spans involved, the potential for buckling of flooring in a house under certain conditions is great if the underlayment is restrained and thus unable to move laterally.

Performance of sheet goods as strips

Development of print-through and failure of the samples were related to the elasticity of the floor coverings. In theory, all of the samples should have failed, since stress at the joint was applied over a zero span. In actual practice, there was enough "give" in the system that failure occurred only after the development of a minimum gap width of 30 mils. For this reason, failure of the test materials, as well as severe print-through, was confined to floor sections to which the underlayment was attached by nailing.

The incidence of failure was not large. Of 62 tests conducted on 29 different patterns of floor coverings, there were only 19 failures. Sixteen of the 19 failures occurred in two patterns of vinyl floor coverings from the same manufacturer. These patterns are relatively rigid, compared to products of other manufacturers. Normally, print-through was either absent or barely noticeable prior to failure of these products. First failure was characterized by one or more ruptures ⅛ to ¼ inches long over the joint between particleboard panels. The ruptures increased in size and number as shrinkage of the underlayment continued and eventually involved most of the cross-sectional area of the samples.

Performance of sheet goods as complete coverings

These tests were conducted following the same procedure as that described above except that all floor sections were completely covered with the test materials. Only those products that accounted for most of the failures in the previous tests were included in this phase of the study. Results of measurements of panel movement are given in Table 4.

An asphalt-base adhesive commonly used in installing vinyl floor coverings was used as the mastic in the first series of tests. Gap width at the joint between panels after eight weeks' exposure of two sets of floor sections was sufficient in four of the eight sections involved to produce failure, based on results of tests using strips of sheet goods. However, no failure occurred. This was attributed to the persistent tackiness of the mastic, which may have prevented the floor covering from being stressed to the point of failure. That some movement of the floor covering on the underlayment did occur is indicated by the fact that ¼-inch holes drilled through the floor covering and into the underlayment were not aligned in the two materials after a period of several weeks.

Another set of eight floor sections was prepared identical to the first, except that Armstrong's No. S-235 adhesive was used as the mastic. The results of these runs were similar to the first. No failure in the sheet goods occurred in floor sections exposed at either 80 F or 120 F after prolonged exposure, although shrinkage values twice as large as those previously observed to cause failure were recorded for floor sections exposed at the higher temperature. As was the case with the other adhesive, there was evidence of slippage of the floor covering on the underlayment in these assemblies.

In the final test, which involved a single floor section, the same procedure described above was used, except that a two-component epoxy resin was used as the mastic to give a rigid joint between floor covering and underlayment. The section was conditioned at 120 F and 20% relative humidity for 11 weeks. At the end of this period, the average shrinkage at the joint was 40 mils. No failure occurred in the sheet goods.

Two differences serve to distinguish the results obtained in the above three tests from results provided by tests in which narrow strips of sheet goods were used: first, the total shrinkage at the joint between particleboard panels in a floor section was less when the panels were completely covered with sheet goods than when narrow strips were applied; and second, the rate of shrinkage in panels covered with sheet goods was smaller than the rate in panels on which strips were used. These facts are believed to account in part for the lack of failure of sheet goods on panels with a full covering of the test material. The smaller total shrinkage after approximately equilibrium conditions were obtained in the panels indicates that partial relief of drying stresses in the panels occurred by internal relaxation, rather than by external shrinkage. Such internal adjustment to stresses that accompany moisture loss is much more likely to occur when the drying rate is slow than when it is rapid, as was the case for panels that received narrow strips of sheet goods.

The lack of failure of the test material on panels the total shrinkage of which exceeded the level at which failure occurred in narrow strips is more difficult to explain. It is possible that because of the relatively slow rate of gap development, the floor covering itself was able to accommodate a wider gap without failing than was the case when rapid shrinkage occurred.

The lack of failure in floor sections with full coverings of sheet goods is significant. Only those panels exposed at 120 F and low humidity for a prolonged period of time shrank sufficiently to cause failure, on the basis of results obtained by using narrow strips. Panels exposed at the more-nearly-normal service conditions of 80 F and 10% relative humidity shrank only 21 mils on average after an exposure period of 22 weeks (Table 4), or about one-half the amount observed to cause failure in narrow strips. These data suggest that failure of sheet goods in the field is probably caused in part by abusive treatment of the underlayment during building construction. Wetting of panels by rain or snow, or prolonged exposure to high humidity conditions, prior to the installation of sheet goods could result in excessive shrinkage of the underlayment when the building is heated.

SUMMARY

The dimensional stability of particleboard underlayment exposed to different environmental conditions was studied. Floor sections 4-ft wide and 16-ft long were constructed of 2″ × 10″ joists on 16-inch centers and ⅝-inch plywood subflooring. Particleboard ⅝-inch thick was attached to the floor sections by nailing, or by a combination of nailing and gluing, and vinyl floor covering was glued to the particleboard. The assemblies were exposed to selected conditions of temperature and humidity for periods of 4 to 22 weeks, and the dimensional changes in the particleboard underlayment and condition of the floor coverings were observed at weekly intervals.

Attachment of underlayment to floor sections by nailing did not prevent gap information at the joint between panels and failure of floor coverings. Floor coverings usually failed following the development of a 30-to-50 mil gap. Two types of floor coverings manufactured by the same company accounted for 84% of all failures during the study. Glue nailing limited gap formation to less than 20 mils and prevented failure of sheet goods.

Dimensional changes sustained by panels at 90 F and 90% relative humidity were about the same as those that occurred at low humidities, but were in the opposite direction. Shrinkage of panels exposed at 80 F and 10% relative humidity was less than for those exposed at 120 F 20% relative humidity, even after prolonged exposure. The difference was attributed to partial internal equalization of drying stresses due to the slower rate of movement that occurred at the lower temperature.

Hot-melt coatings were effective in reducing dimensional changes in Douglas-fir particleboard at 80 F and 10% relative humidity. Shrinkage under these conditions was equal to or less than that obtained with glue-nailed panels without hot-melt coatings. The coatings were also effective at 120 F and 20% relative humidity for the first two to three weeks, but shrinkage occurred rapidly in coated panels thereafter. Hot-melt coatings did not perform satisfactorily on southern pine particleboard.

Failure of sheet goods applied as narrow strips occurred only on panels attached by standard nailing. Movement of boards containing strips of the test materials was equal

to that of panels containing no floor covering. No failure occurred in sheet goods applied as a complete covering to floor sections. This was attributed in part to the tendency of the particleboard to equalize drying stresses internally because of the much slower drying rate, and in part to the ability of the sheet goods to accommodate comparatively large gaps without failing when stresses were applied slowly.

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