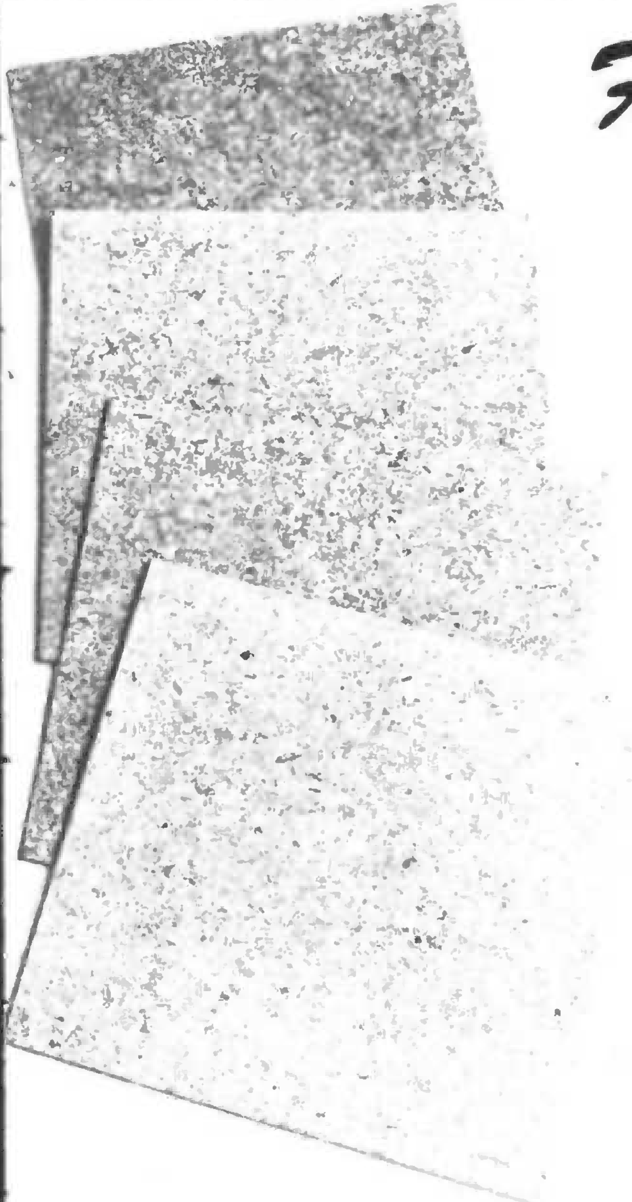
Floor Tile

FROM

PLANER

SHAVINGS



By C.H. Burrows

STATE OF OREGON Forest Products Research Center

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ACKNOWLEDGMENTS

The author is grateful for assistance from several individuals, especially R. A. Currier, H. M. Demaray, and W. W. Dostelik. An expression of thanks is also given to Red Blanket Lumber Company, for providing planer shavings, and to the several companies that furnished adhesives and other materials as well as technical advice.

FLOOR TILE held by the author was made from screened hammer-milled planer shavings, wax, and resin, as shown in foreground.

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SUMMARY

Floor tile with adequate wear resistance was made from wood planer shavings. Ponderosa pine shavings were used in the study, as this material represents a surplus in the lumber industry. It is logical to assume other species would perform equally well with minor modifications in manufacture.

Results of laboratory tests showed that physical properties of experimental tile were equivalent to, or better than, properties of two commonly used flooring materials, linoleum and cork tile.

Estimated manufacturing and retail costs for tile of ponderosa pine planer shavings compared favorably with cost of most commercial flooring materials.

The experimental floor tile can be made by standard techniques for manufacturing particle board, with minor modifications or additions to equipment. It appeared likely that a system could be engineered to manufacture tile by a "scaled-down" production system for particle board. Such a system might be integrated into a sawmill or planer mill to enable increased utilization of residue.

Floor Tile from Planer Shavings

by

C. H. Burrows

INTRODUCTION

The market for hard-surface floor covering has enormous potential. In 1952, over four billion square feet of hard-surface flooring was consumed. In 1954, the area covered increased to 4,375 million square feet. It can be assumed that even more flooring materials are being consumed now, and the need should increase. Development of a floor tile made from wood residue would provide the wood-using industry with a product that could compete with other materials in this lucrative market. This product would provide an outlet for residue materials and also give the industry a new specialty.

To produce a tile to compete satisfactorily with commercial flooring materials, it was concluded that tile made from wood residue would need physical properties comparable to, or better than, commercial tiles. Also, manufacturing costs preferably should be lower than, or at least equivalent to, costs of presently available flooring materials. Obtaining a tile with both adequate wearing properties and satisfactory cost was considered mainly a function of materials and manufacturing technique. Exploratory work was undertaken to arrive at an optimum combination of these two factors.

Both Douglas fir and ponderosa pine planer shavings were investigated during initial work and found to be satisfactory raw materials. Present use of Douglas fir planer shavings in commercial particle board is further evidence of suitability of this species for floor tile. Ponderosa pine was chosen as a representative species to permit further investigation of other variables within alloted project time.

Numerous adhesives, sizing agents, and other additives were investigated. Pressing conditions were varied to arrive at best combinations. From this extensive exploratory screening, there evolved a wood shaving tile that was thought to be optimum. This report is concerned with evaluation of this final tile product and not with exploratory research that led to its development.

In the balance of the report, tile of ponderosa pine planer shavings will be referred to as wood tile.

Table 1. Conditions and Variables For Making Wood Tile.

Raw material	Ponderosa pine planer shavings (hammer-milled)
Screen mesh	-4, +10
Specific gravity	1.04
Thickness	0.1875 ± 0.015 inch
Size	2% Paracol 600N
Binder	10% Phenol-formaldehyde
Batch moisture content	Average: 11.1% Range: 10% to 12.2%
Caul release agent	Zinc stearate
Press conditions:	
a) temperature	315 F
b) pressure	350 psi
c) press time	8 min and 10 min

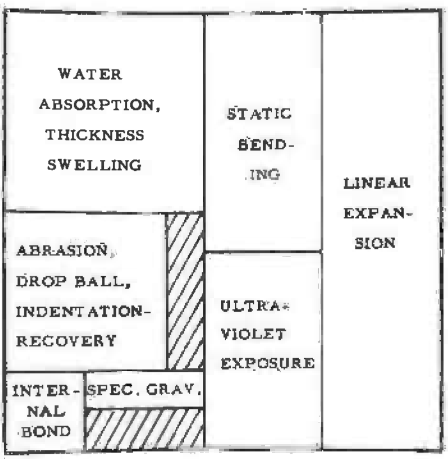


Figure 1. Scheme for cutting test specimens from 11 1/2-inch-square tile.

EXPERIMENTAL PROCEDURE

All experimental work described was done under laboratory conditions. Details of conditions and variables for making wood tile are shown in Table 1.

Board production

Shavings at 6-8 per cent moisture content were hammer-milled, then screened to obtain a -4, + 10 mesh size. This fraction produced a pleasing particle pattern in the finished tile.

After drying to a moisture content of 3-4 per cent, shavings were weighed and placed in a rotary drum mixer. Two per cent size, then 10 per cent resin, based on oven-dry weight of shavings, were sprayed into the mixer. Paracol 600N (a wax emulsion made by Hercules Powder Company) and PF 594 (a phenol-formaldehyde impregnating resin made by Monsanto Chemical Company) were size and binder.

Several other phenol-formaldehyde impregnating resins tried in exploratory work had properties similar to PF 594. Three such resins are BRL 1100 (Bakelite Company), AMRES 6110 (American-Marietta Company), and FORASITE SW 1910 (Reichhold Chemical Company).

After mixing for five minutes, the resin-impregnated shavings, now at a moisture content of 10-11 per cent, were removed from the mixer. Shavings then were ready for mat forming, in which the desired amount of shavings were sprinkled (enough to make the tile 3/16 inch thick, and 1.04 specific gravity) on a 12-inch-square metal caul in a forming box. When the mat had been formed, another caul was laid on the mat and the entire unit placed in a press. After 8-10 minutes in the press at a pressure of 350 pounds a square inch and temperature of 315F, the assembly was removed and the pressed tile withdrawn. Following trimming, the tile was ready for finishing.

Finishing was done on one side in the following manner:

1. Sand with 1 1/2 D heavy garnet, then 3/0 paper
2. Apply 1 coat of filler-sealer
3. Sand with 5/0 paper
4. Apply 1 coat of lacquer
5. Burnish with steel wool, and wax

Other finishing techniques could be followed. The above system was chosen for simplicity, adaptability to production schemes, and low cost.

Tests made

Wood tile was compared with commercial cork and linoleum tile by several tests and measurements. Tile of each material were cut into test specimens as shown in Figure 1.

Tests and measurements made were:

- Water absorption
- Thickness swelling
- Linear expansion
- Static bending
- Internal bond (tension perpendicular to surface)
- Abrasion
- Drop-ball
- Indentation-recovery
- Ultraviolet light exposure

Details on methods and procedures are presented in the Appendix.

RESULTS OF TESTS AND MEASUREMENTS

Properties of wood tile were compared to properties of commercial linoleum and cork except in bending and internal bond. All test values in graphs or otherwise mentioned are averages of ten specimens, except for ultraviolet and abrasion test values in which five specimens were averaged.

Water absorption

Dimensional stability is essential in flooring materials. Frequent wetting of flooring is normal in maintaining floor cleanliness and beauty. Ability of a floor covering to resist water absorption is an index of dimensional stability. Thickness swelling and linear expansion are other indices.

How linoleum, cork and wood tile compared in water absorption is illustrated in Figure 2. Wood specimens exhibited low water absorp-

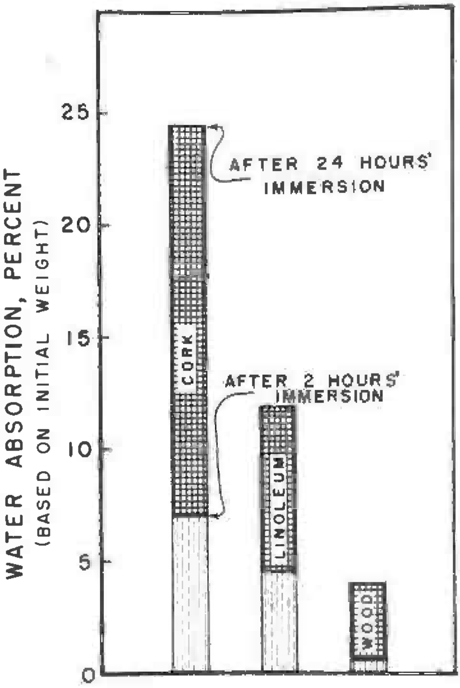


Figure 2. Absorption of water by wood, linoleum and cork tile while immersed.

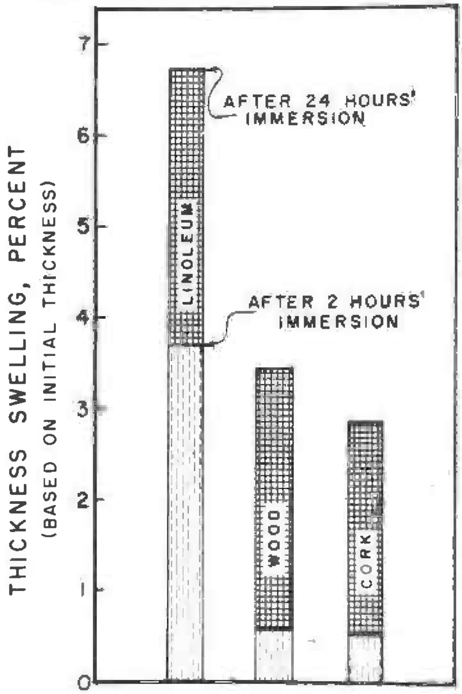


Figure 3. Swelling in thickness of wood, linoleum, and cork tile after soaking in water.

tion--0.5 per cent after immersion for 2 hours and 4 per cent after 24 hours. Linoleum absorbed 4.4 per cent water after 2 hours and 11.8 per cent after 24 hours. Cork specimens had highest water-absorption values, with 7.1 per cent and 24.4 per cent for 2- and 24-hour periods, respectively. Finished surfaces of wood and linoleum specimens showed little or no change after 24-hour immersion. Cork specimens, however, had bumpy surfaces and a white film (undoubtedly caused by the wax finish) after 24 hours of immersion.

Thickness swelling

Commercial cork specimens exhibited lowest thickness swelling. Following 2 hours of immersion, cork specimens swelled 0.52 per cent, and after 24 hours of immersion this value increased to 2.88 per cent (Figure 3). Wood specimens showed 0.57 per cent thickness swelling after 2 hours and 3.46 per cent after 24 hours. Linoleum had greatest thickness swelling; 3.71 per cent after 2 hours and 6.73 per cent after 24 hours.

Linear expansion

It is apparent from Figure 4 that linoleum and wood specimens demonstrated similar linear expansion when exposed to water vapor. Wood specimens expanded linearly 0.029 per cent when changed from 8 to 12 per cent EMC conditions; linoleum showed 0.072 per cent linear expansion from the same change. From 12 to 20 per cent EMC conditions, wood specimens expanded linearly 0.239 per cent, and linoleum expanded 0.236 per cent. Cork specimens showed greatest linear expansion; 0.264 per cent when moved from 8 to 12 per cent EMC conditions, and 1.242 per cent from 12 to 20 per cent EMC conditions.

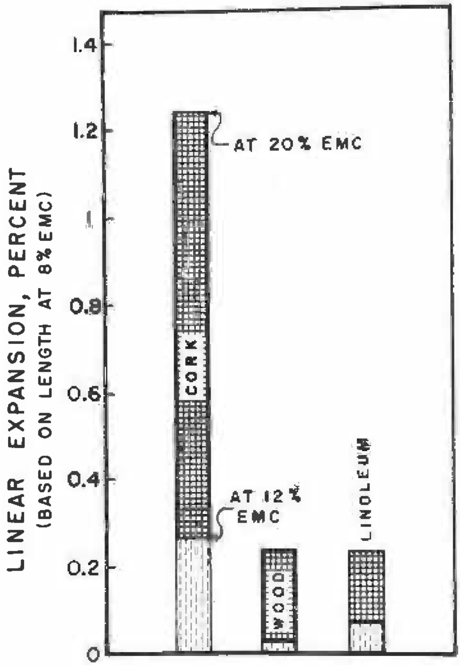
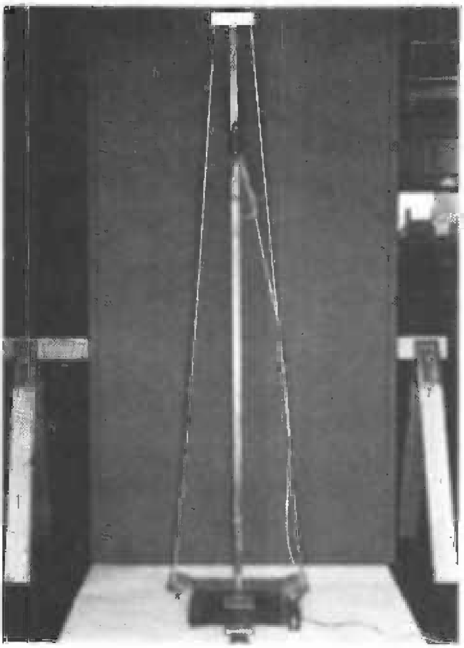


Figure 4. Linear expansion of wood, linoleum, and cork tile when moved from 8% to 20% EMC conditions.



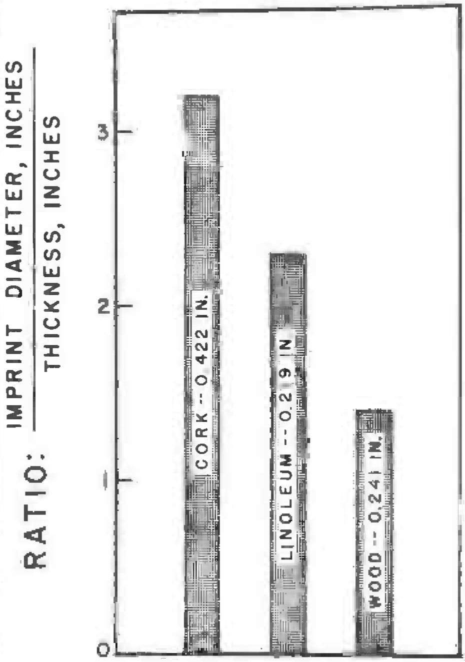


Figure 5. Apparatus for testing impact hardness of wood, cork, and linoleum tile.

Figure 6. Ratios of impact hardness for wood, cork, and linoleum tile.

Bending and internal bond

Tests of bending and internal bond strength were performed only on the wood specimens. The bending test is a measure of flexural strength, and the internal-bond test measures tension perpendicular to the surface. Since these properties are not critical for a flooring tile laid flat on a rigid subfloor, test data are merely supplementary.

In static bending, wood specimens had an average modulus of rupture (MOR) of 5514 pounds a square inch. Average value of internal bond was 388 pounds a square inch.

Impact hardness

The falling-ball impact test (Figure 5) was performed to measure relative impact resistance of the three flooring materials. A measure was obtained of resistance to damage that occurs when flooring is struck by a moving (dropped) object. An index of resistance was provided by a ratio of diameter of ball impression to specimen thickness at point of

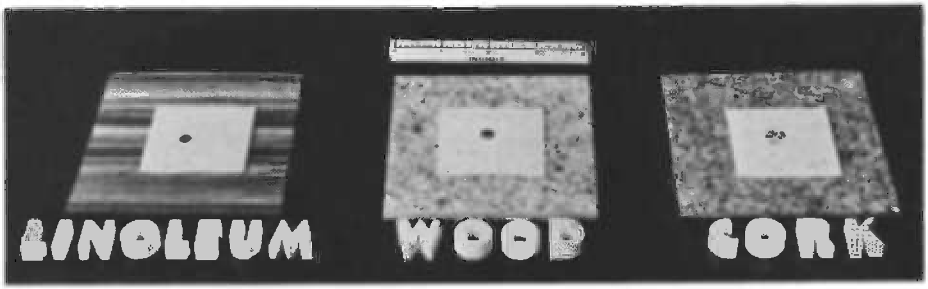


Figure 7. Diameter of mark left by carbon paper indicated extent of indentation in drop-ball test.

blow (Figure 7). Average ball-imprint diameters are shown in Figure 6 in columns for each of the tested materials. Ratio value for wood tile was lowest at 1.39. Linoleum had a ratio of 2.29, and cork was highest with 3.20. Wood specimens, therefore, showed most resistance to impact, and cork the least.

Indentation recovery

Ease of indentation under load imparts a cushioning effect to floor coverings when walking over them. On the other hand, failure to recover from indentation caused by temporary loads will cause an irregular and unsightly floor surface that is hard to clean. The indentation-recovery test (Figure 8) provides a means of evaluating a floor's resistance to, or recovery from, indentation by foot traffic and other short-term loads. Referring to the bar graph in Figure 9, it is shown that the wood specimens indented less than the other two materials. Initial indentation of the wood specimens was 0.34 per cent, and residual indentation was 0.29 per cent. Linoleum indented 0.72 per cent initially and remained at 0.72 per cent after one hour. Cork indented initially 0.75 per cent and recovered after one hour to 0.60 per cent. This test indicated wood specimens indented least, and cork indented slightly more than linoleum. Cork specimens exhibited most recovery from indentation, but linoleum showed no recovery.

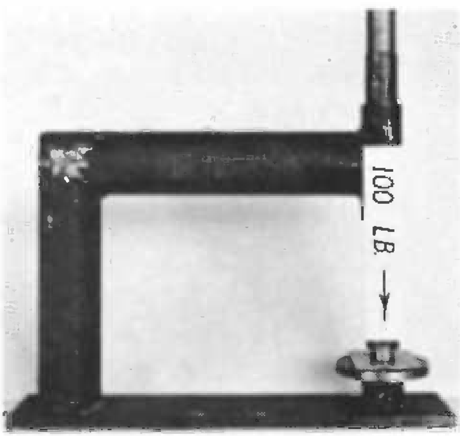


Figure 8. Apparatus for testing indentation recovery.

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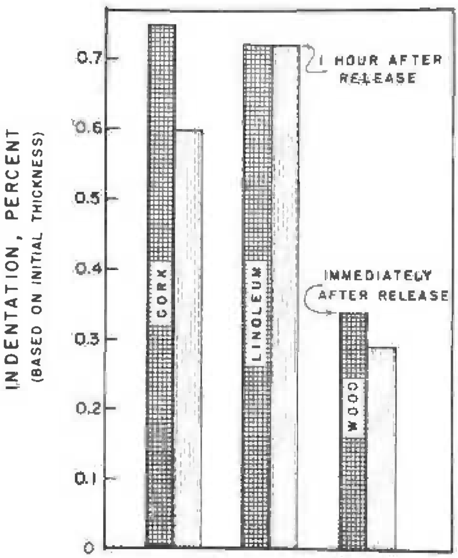


Figure 9. Recovery after indentation by 100-pound load over a circular area 1.125 inches in diameter.

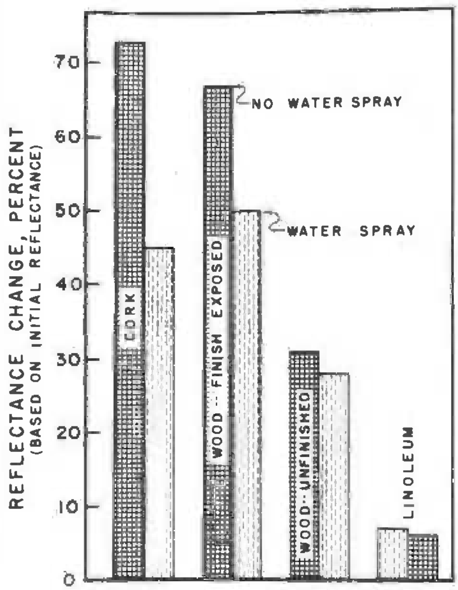


Figure 10. Reflectance change in 48 hours of exposure to ultraviolet light.

Ultraviolet exposure

Sunlight and periodic wetting deteriorate floor covering finishes. Specimens were exposed to ultraviolet light and water spray to simulate these conditions. Relative performance of the flooring materials is shown in Figure 10. Reflectance change is indicative of color change.

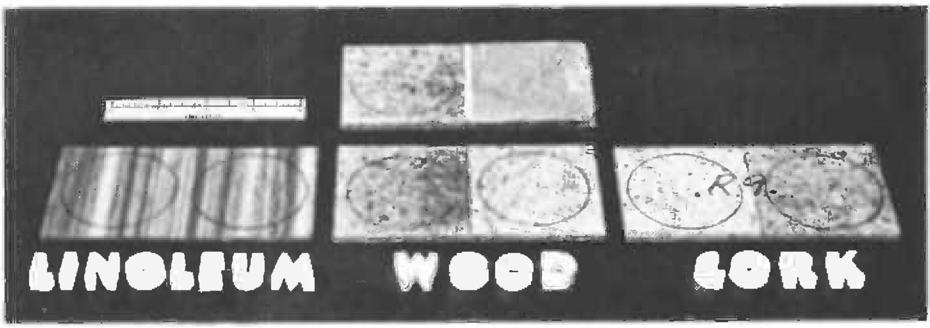


Figure 11. Left half of each specimen shown was exposed to ultraviolet light for 24 hours. Note darkening of wood tile and bleaching of cork. Top piece has aluminum cover.

Figure 12. Taber Abraser model 140 PT.

Linoleum specimens exhibited little change from initial color (Figure 11). With no water spray, linoleum bleached 6 per cent of initial color; with water spray, linoleum darkened from initial color 7 per cent.

Wood specimens, with finished surface exposed, darkened 67 per cent with no spray and 50 per cent with spray. When unfinished wood surface was exposed, specimens darkened 31 per cent with no spray and 28 per cent with spray. It was evident that the finish on wood specimens was causing most of the color change.

Cork specimens bleached from exposure. With no spray, change was 73 per cent, and with spray there was a 45 per cent change.

Figure 13. Wearing ability assessed by the Taber Abraser. Wood and cork have finished faces up in front row, unfinished faces up in back row.

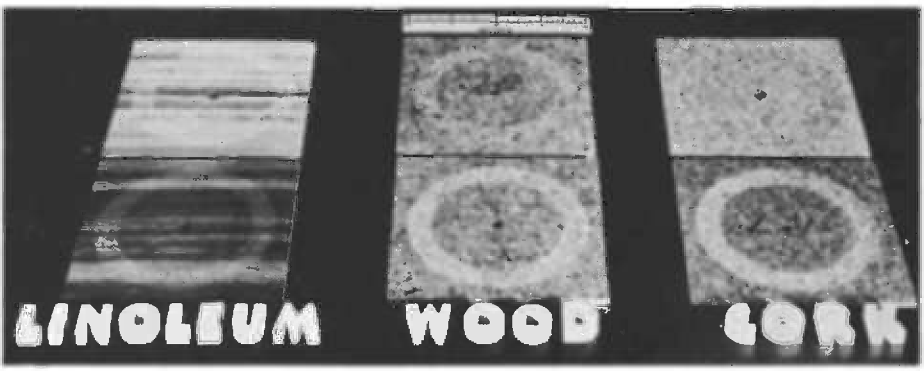
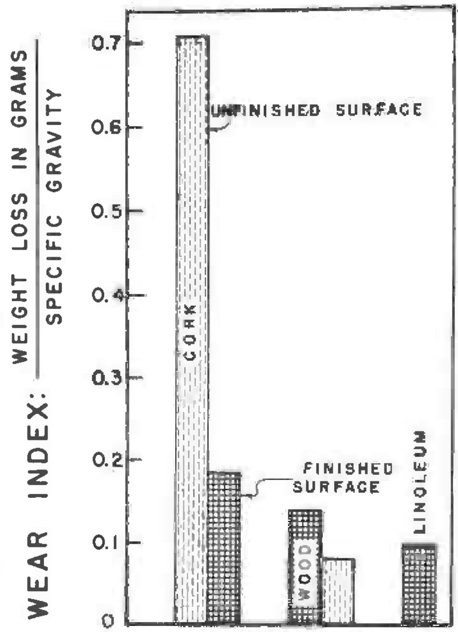


Figure 14. Wear resistance of wood, cork, and linoleum tile as measured by 1000 cycles on a Taber Abraser. ⟶



Abrasion resistance

Ability of a flooring material to wear well under traffic is directly related to its abrasion resistance. The abrasion test (Figure 12) provided a basis to compare wear resistance of linoleum, cork, and wood (Figure 13). Although actual use conditions could not be duplicated in this test, a relative index was possible by dividing weight loss (in grams) by specific gravity of material tested.

Unfinished wood had most resistance to abrasion, with an index of 0.079 (Figure 14). Finished wood had an index of 0.140, indicating the finish was less resistant to abrasive action than was the wood itself. The index of linoleum was 0.097. Cork specimens showed lowest resistance to abrasion with an index of 0.185 on finished surface and 0.708 on unfinished surface. Wax finish on the cork tiles increased abrasion resistance considerably.

Specific gravity

Specific gravity computed by immersion (3)* was, for linoleum, 1.19; for cork, 0.51; and for wood, 1.04.

In-service test

To determine how wood tiles wear under actual use conditions, two rectangular test sections containing vinyl, asphalt, linoleum, cork, and wood tiles were made. One test section was laid on concrete at a laboratory work bench; another on a portable plywood panel was laid at an entrance to the Research Center (Figure 15).

Both sections were inspected after six months of wear. Tiles on

* Numbers in parentheses indicate similarly numbered references in the Bibliography.

the portable section showed more wear from traffic at an entrance than did the tiles laid at a work bench.

Condition of tiles at the entrance was as follows:

Tile material	Condition
Asphalt	Moderately scratched, dented, and worn; slightly faded.
Commercial cork	Pitted, worn badly; darkened from ground-in dirt.
Linoleum	Moderately scratched, dented, and worn; color fair.
Vinyl	Slightly to moderately dented, scratched, and worn; color good
Wood	Moderately scratched, dented, and worn; color good.

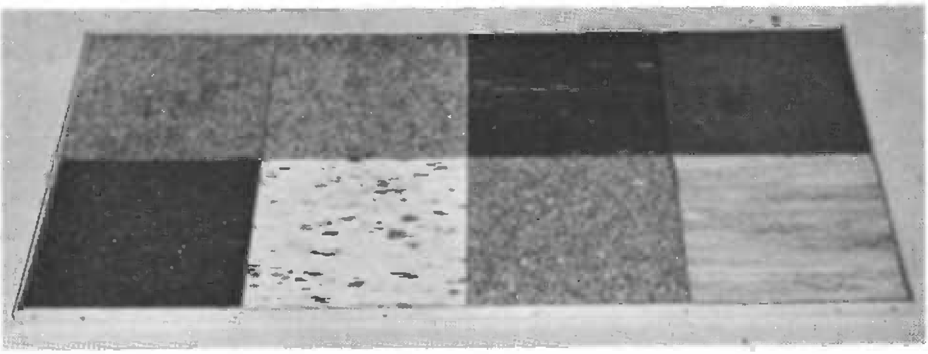


Figure 15. After six months at an entrance to the Forest Research Center, appearance of floor tile was as above. Back row, left to right; cork, wood, asphalt, experimental cork. Front row, left to right; experimental cork, linoleum, wood, vinyl.

COST ESTIMATE

Estimated manufacturing costs for wood tile are given in Table 2. Material costs were reasonably accurate, but other costs--general operating, labor, overhead and depreciation--were rough estimates. Any of the cost figures may change, as they are dependent on such factors as plant location, raw material availability, degree of plant automation, and local utility rates. With the exception of material costs, all cost figures were derived from manufacturing costs relating to particle board plants (1,5,7). Costs listed in Table 2 do not include possible expense for surface finishing the tile.

All tiles were made 3/16 inch thick to stay within capabilities of present particle board presses. However, a thinner tile (1/8-inch) would have certain advantages. For example, manufacturing and transportation costs would be lowered and flexibility of the tile improved.

Table 2. Estimated Manufacturing Costs for 3/16-inch Wood Shavings Tiles in a Plant Operating Three Shifts Daily.

Cost item		Cost/M sq ft
Material costs		$ 45.20
Shavings	$10.00/ton, dry	
Resin	10% @ $0.395/lb solids	
Size	2% @ $0.128/lb solids	
General operating expense		4.00
Electricity		
Maintenance		
Miscellaneous		
Labor		15.00
Overhead and depreciation		15.00
100% of labor		
	Total	$ 79.20

To illustrate comparisons of retail price between commercial flooring materials and wood tile, Table 3 was prepared. Current retail prices for commercial materials were obtained from several sources (2,4,6). Estimated manufacturing cost for wood tile was increased 200-250 per cent to arrive at estimated retail prices.

Table 3. Retail Price Comparisons.

Floor covering	Thickness	Price
	Inches	Cents per sq ft
Vinyl asbestos tile	1/16	22 to 42
Rubber tile	(1/16	29
	(2/25	29 to 30
	(1/8	30 to 62
Asphalt tile	1/8	9 to 23
Cork tile	(1/8	40 to 79
	(3/16	45 to 64
Vinyl tile	2/25	26 to 71
Linoleum tile	standard gauge	14
Linoleum, inlaid	---	11 to 33
Wood tile	3/16	30 to 35

CONCLUSIONS

From information accumulated in the study, certain conclusions can be drawn:

- Floor tile from planer shavings can be made with adequate floor-wearing properties.

- Cost of manufacturing floor tile of planer shavings appeared reasonable, based on estimates thought to be well-founded.

- Technique of manufacturing floor tile from planer shavings differs little from current practices in particle board plants. A system could be incorporated easily into an established particle board mill, or a "scaled down" production scheme could be devised.

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APPENDIX

Details of tests and measurements are described here.

Linoleum and cork tiles were not waxed or otherwise changed from factory finish before testing.

Conditioning

All specimens, with the exception of those to measure linear expansion, were placed in a conditioning room for two weeks to stabilize at 12 per cent EMC (equilibrium moisture content) conditions (65 per cent relative humidity and 70 F). Specimens to measure linear expansion were conditioned for two weeks at 8 per cent EMC conditions (44 per cent relative humidity and 90 F). Two commercial flooring materials, linoleum and cork tile, were cut into test specimens and conditioned similarly to the wood tiles.

Water absorption and thickness swelling

Tests for water absorption and swelling were run concurrently on the same specimens. ASTM procedures D1037-55T for water-absorption tests were followed, with few exceptions. Weights and thicknesses were measured initially, after 2, and after 24 hours of immersion in water. Each 5-inch square specimen was weighed to the nearest 0.1 gram and measured to the nearest 0.001 inch in thickness. Thickness measurements were taken at five locations on each specimen, one in the center and the other four equidistantly around the perimeter, 1/2 inch from the edge. Thickness swelling for each specimen was expressed as an average of all five measurements. Water absorption and thickness swelling, expressed as per cent, were based on initial weights and initial thicknesses, respectively, of specimens.

Linear expansion

After two weeks conditioning at 8 per cent EMC conditions, specimen lengths were measured to the nearest 0.001 inch. The 3- by 11-inch specimens next were placed in a conditioning room at 65 per cent relative humidity and 70 F (12 per cent EMC conditions) for one week. Following this period, lengths were measured again and specimens placed in a room maintained at 90 per cent relative humidity and 90 F (20 per cent EMC conditions). One week later, specimen lengths were measured for the final time. Changes in length occurring at 12 and 20 per cent EMC conditions were expressed as pe· ... length measured at 8 per cent EMC conditions.

Static bending

Bending tests were performed according to ASTM Standard D1037-55T. Specimens were 3 by 6 inches, span was 4 inches, and headspeed 0.08 inch a minute. Finish side of specimen was up during test. Only wood tiles were tested in bending; linoleum and cork were too flexible to test.

Internal bond

Only wood specimens were tested for internal bond strength. The 2-inch-square specimens were tested at a headspeed of 0.15 inch a minute. Finish had to be removed from specimens to insure adequate bonding to metal test blocks. Procedures outlined in ASTM Standard D1037 were followed.

Impact hardness

In the test for impact hardness, a 1-inch steel ball was dropped five feet into the center of a 4-inch-square specimen (Figure 5). A piece of carbon paper with inked side up was placed on the specimen and under a piece of white paper. When the ball was dropped, an imprint on the white paper indicated amount of deformation (Figure 7). Imprints were measured to the nearest 1/32 inch. Specimen thickness before test was obtained by averaging 10 measurements taken within 1-inch radius of the specimen's center. These measurements varied little and allowed for error when the ball did not hit exact center. The test is outlined in Impact Hardness Tests on Wood, by N. H. Kloot, Reprint No. 178, Commonwealth Scientific and Industrial Research Organization, Australia.

Indentation recovery

Indentation recovery was tested on 4-inch-square specimens. After measuring specimen thickness at center to the nearest 0.001 inch, a 100-pound load was applied to the specimen face through a flat-ended, cylindrical plunger 1.125 inches in diameter (Figure 8). Load was maintained for 10 minutes, then removed and indentation measured to the nearest 0.001 inch. One hour later the specimen was remeasured to determine recovered thickness. Details on this test can be found in Federal Specification LLL-T-431, Tile; Cork, paragraph F-2d. Initial indentation and residual indentation are expressed as per cent, based on original thickness.

Ultraviolet [illegible]

Test specimens were exposed to ultraviolet light in an Atlas weatherometer for 48 hours. Temperature in the chamber was 110 F. Half the specimens were tested with no water spray during the 48 hours. The remaining specimens were tested with water spray introduced the first 18 minutes of each 24-hour cycle, giving a total of 36 minutes spray for the 48-hour period.

Water was sprayed directly on the specimens and was intended to provide some information on how specimen surfaces were affected by wetting. To obtain a measure of color change, reflectance readings of specimen surfaces were taken before and after test. A photovolt photometer was used to obtain reflectance readings with a black standard of 0 per cent and white standard of 81 per cent. Half of each 2 3/4- by 5 1/4-inch specimen was covered with an aluminum foil jacket over a piece of asbestos (Figure 11). This jacket preserved the original color. Half the wood specimens were exposed on the finish side, and half on the unfinished side. Linoleum and cork were exposed on finish side only. Change in color occurring during test was expressed as per cent, based on initial reflectance.

Abrasion resistance

Relative abrasion resistance of wood, linoleum, and cork specimens was determined with a Tabor Abraser, model 140-PT, with CS-17 wheels and 1000-gram weight (Figure 12). A vacuum pickup removed loose dust from the surface of the specimen during test. Each 4-inch-square specimen was weighed to 0.0001 gram prior to test, then weighed after 250, 500, 750, and 1000 cycles. A wear index was computed based on weight loss after 1000 cycles and specific gravity of the specimen. This technique is described in detail in the Taber Instruction Manual, Section VI, page 39. Both finished and unfinished surfaces of wood and cork specimens were abraded. Linoleum was tested only on the finish side. Abrading wheels were cleaned and resurfaced at intervals during the test to reduce experimental error.

Forest Products Research Center

. . . Its Purpose

Fully utilize the resource by:

- developing more by-products from mill and logging residues to use the material burned or left in the woods.
- expanding markets for forest products through advanced treatments, improved drying, and new designs.
- directing the prospective user's attention to available wood and bark supplies, and to species as yet not fully utilized.
- creating new jobs and additional dollar returns by suggesting an increased variety of saleable products. New products and growing values can offset rising costs.

Further the interests of forestry and forest products industries within the State.

. . . Its Program

- Accelerated air drying of lumber with fans, to lower shipping costs.
- Kiln schedules for thick Douglas fir lumber, to speed drying.
- Bevel siding from common lumber, to increase sales.
- End gluing of dimension lumber, to utilize shorts.
- Effect of spacing and end distance on strength of bolted joints.
- Production and bleaching of high-yield pulps from Douglas fir mill residues.
- Strength of wood and wood structures.
- Douglas fir wood and bark lignin and bark extractives for full recovery.
- Ammoniated wood and bark as improved soil amendments.
- Service tests of treated and untreated wood products.
- Floor tile from wood and bark residues.