BULLETIN 961
AUGUST 1960

INDENTATION AND RECOVERY TESTS OF COMMON RESILIENT FLOOR COVERINGS

THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
TEXAS AGRICULTURAL EXPERIMENT STATION
R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

SUMMARY

Indentation and recovery tests made on six common floor coverings indicate some differences in both total and residual indentation of these materials due to temperature, humidity and load differences.

Material thickness affects the total indentation characteristics of rubber, vinyl-asbestos and cork tile. The total indentation was smaller under the heavy and medium loads for the thinner materials. Little effect was noted under the light load.

Differences in residual indentation of materials due to material thickness was significant for cork and vinyl-asbestos tile. Tests indicated that residual indentation was greater for the thicker samples. The thinner gage of rubber tile tended to retain more residual indentation than the heavier gage.

Temperature increases tended to increase total indentation of all materials under all loads, but some materials showed a more rapid increase in indentation due to a temperature increase than others.

Only standard gage linoleum and three-sixteenth-inch cork showed a significant increase in total or residual indentation with a humidity increase from 48 to 92 percent.

Increases in load did not cause the same relative increases in total indentation for all materials. The interaction of loads and materials was significant for both total and residual indentation.

No material appeared to have the best characteristics with respect to both total and residual indentation under all conditions.

Under most conditions no significant differences were found among asphalt, vinyl, rubber and vinyl-asbestos tile. Linoleum and cork, on the other hand, were generally significantly separated from the other materials as well as from one another.

Contents

Indentation and Recovery Tests Of Common Resilient Floor Coverings

*B. R. Stewart, O. R. Kunze and Price Hobgood**

Floor coverings constitute approximately 3 to 6 percent of the total cost of the home. The cost of maintenance and replacement of floor coverings contribute heavily to the total cost of home maintenance.

Indentation of resilient floor coverings is a major problem of the floor covering industry. This is indicated by a survey made in 1958 by the Building Research Institute[1] to determine the repair and maintenance problems encountered with resilient flooring. Results of the survey indicated that indentation was the leading problem with asphalt tile and cork tile, and was the second most frequent problem with vinyl-asbestos tile, linoleum and rubber tile. Indentation was the third most frequent problem encountered with homogeneous vinyl tile.

Indentation and recovery tests on resilient floor coverings were made by the Department of Agricultural Engineering in order to develop comparable information on the materials in common use. This information should be of direct interest to the consumer in assisting him to select a floor covering from among those types available to meet his particular need.

Tests were conducted under controlled temperature and humidity conditions with three different loads, to determine the effect of temperature, humidity and load on the indentation and recovery characteristics of six common floor coverings.

Test Equipment and Procedure

Indentation and recovery determinations were made using equipment constructed in the Department of Agricultural Engineering, Figure 1. The indentation tester, shown in the right foreground consists of a set of weights (A) which can be lowered onto a plunger (B) containing an indenting tool (C). The test sample (D) was placed on the steel base plate under the indenting tool and plunger. Periodic thickness readings were made by using a dial micrometer (E) which had its foot in contact with an actuating arm (F). The dial micrometer foot was depressed at the beginning of a test and was extended by spring pressure as the actuating arm and indenting plunger moved downward while the sample was being indented. Recovery measurements were made with a depth gage micrometer[2] (G) mounted on a steel plate, in such manner that the gage rod could contact the base plate (H). Indenting loads were varied by changing the size and number of weights. The indenting tool was a flat-ended cylindrical steel rod, 0.125 inch in diameter. Indentation tests were made with pressures of 298.2, 2,015.8 and 3,995.2 pounds per square inch. Recovery measurements were made with the load removed.

Six common resilient floor coverings were tested. All of these materials were in tile form. A list and brief description of the materials follows:

Asphalt tile—Composed through full thickness of asphaltic or resinous binder with asbestos or other fibers, fillers and pigments formed under pressure.

Vinyl-asbestos tile—Composed through full thickness of vinyl resins, plasticizers, pigments, fillers and asbestos fibers formed under pressure while hot.

Homogeneous vinyl tile—Composed through full thickness of vinyl resin, plasticizers, pigments and fillers formed under pressure while hot.

Rubber tile—Composed through full thickness of vulcanized rubber compound binder.

Linoleum tile—Composed of oxidized linseed oil, fossil and other resins or other oxidized oleo-resinous binder mixed with ground cork, wood flour, mineral fillers and pigments and pressed on saturated felt backing.

Cork tile—Composed through full thickness of compressed granulated cork bonded with a heat processed resinous binder.

Two thicknesses each of rubber, vinyl-asbestos and cork tile were used. Eight 2 x 2-inch samples of each material and thickness were cut from standard 9 x 9-inch tiles. Each sample was conditioned and tested under a particular temperature-humidity con-

*Respectively, assistant professor, associate professor and head, Department of Agricultural Engineering.

[1]Building Research Institute, Installation and Maintenance of Resilient Smooth-Surface Flooring, National Academy of Sciences–National Research Council, Publication 597, p 126, 1958.

[2]608 RS Browne and Sharpe Micrometer Depth Gage, Browne and Sharpe Manufacturing Company, Providence, Rhode Island.

dition. Temperatures of 50° F., 72° F. and 94° F. were used in eight combinations with humidities of 48, 70 and 92 percent, Figure 2. Three replications of each test load were made on each sample. Nine test spots were marked on each sample to accommodate three replications of each test load.

Test loads were applied to the samples for 30 minutes, with indentation readings being made 15 seconds and 1, 2, 3, 5, 10, 15, 20 and 30 minutes after the load was applied. Recovery readings were made 15 seconds and 1, 2, 5, 10, 20 and 30 minutes after the test load was removed. Residual indentation as referred to in this work is that indentation remaining at the end of the 30-minute recovery period. A final recovery reading was taken 72 hours after removal of the test load. Before the beginning of each test, the sample to be tested was placed in the test chamber and conditioned for 24 hours at a particular temperature-humidity combination.

Throughout the testing, spots on each sample to be subjected to light, medium and heavy loads were selected at random. Three replications of one load were run on all the samples before another load was applied. Tests were run using the light load first, medium load second and heavy load last. Preliminary trials indicated this order was necessary because some materials buckled or curled when subjected to the heavy load.

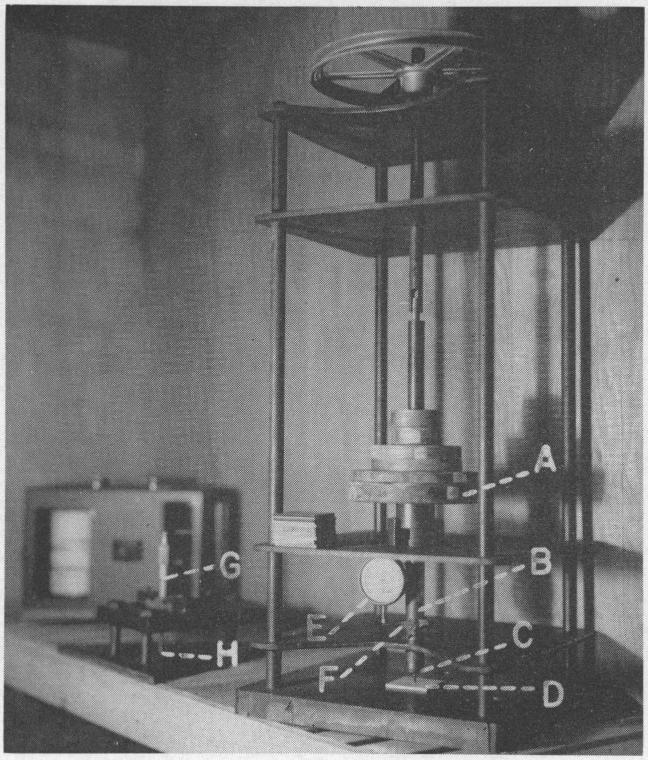


Figure 1. Indentation tester (right foreground) and recovery measuring apparatus (left) set up in the controlled temperature and humidity chamber. A Friez Hygrothermograph (left background) was used to record temperature and humidity. (See page 3 for identification of code letters.)

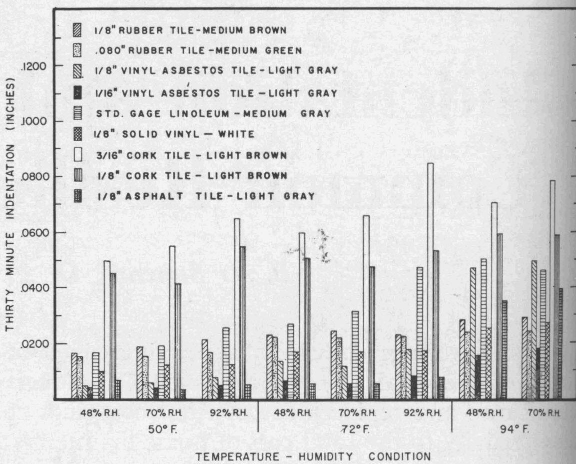


Figure 2. Average total 30-minute indentation of each floor covering tested, resulting from three replications of light, medium and heavy loads when applied under the temperature-humidity combinations shown.

Results and Conclusions

Average total 30-minute indentation of the floor covering materials tested is shown in Figure 2. The results indicate the tendency for all floor coverings tested to indent more deeply as temperature or humidity increases.

A statistical analysis of the resulting total and residual indentation was made. The analysis showed that a temperature increase from 50° F. to 94° F. caused a significant increase in total indentation of all materials tested. An increase from 50° F. to 72° F. caused a significant increase in total indentation of three-sixteenth-inch cork tile and standard gage linoleum tile.

Figure 3 shows the effects of temperature and humidity increase on residual indentation of the floor coverings tested. Considering all humidities, residual indentation of rubber and vinyl tile were not significantly affected by a change in temperature even though the general tendency was for the residual indentation to increase with temperature. A temperature increase from 50° F. to 94° F. caused a significant increase in residual indentation of all other materials tested. In addition, a significant increase in residual indentation of linoleum tile was caused by a 22° F. increase in temperature from either 50° F. to 72° F. or from 72° F. to 94° F. The thicker sample of cork tile retained significantly more indentation when subjected to the 72° F. temperature than when subjected to the 50° F. temperature. There was a significant increase in residual indentation of asphalt tile when the temperature increased from 72° F. to 94° F.

A significant increase of total and residual indentation of linoleum and three-sixteenth-inch cork tile was caused by the high humidity only. All other materials tested were not significantly affected by a humidity increase. High humidities caused linoleum samples to warp during the conditioning period. A humidity increase did not cause cork tile to warp.

The preceding conclusions were reached when all loads were considered. Under the light load, no significant difference in total or residual indentation of materials was caused by temperature or humidity increases. Figures 4 and 5 show the effect of load on the total and residual indentation of the common floor coverings considering all temperatures and humidities used. There were only small differences among the materials when tested under the light load. As the load increased, both total and residual indentation increased. These increases varied not only with the different materials but also with the two different thicknesses of the same material. The latter is particularly true of cork and vinyl-asbestos tile. Figures 2 and 4 show that for these two materials total indentation increases were smaller for the thinner samples of each material. This same characteristic regarding residual indentation may be seen in Figures 3 and 5. The total indentation increase was less for the thinner of the two samples of rubber tile, but the residual indentation increase was slightly more for the thinner sample.

Generally, those materials which indented most under any condition also retained the most indentation. This is an undesirable combination of characteristics which caused some difficulty in evaluating the relative ratings of the materials. The most desirable floor covering should indent readily but retain no indentation upon removal of a load. A floor covering which indents readily will present a more comfortable surface for walking. A minimum amount of residual indentation is desirable in maintaining appearance and in preventing wear.

The abilities of the floor coverings to indent readily were compared by measuring the amount of indentation which occurred 15 seconds after the application of a load of 298.2 pounds per square inch to each of the materials. The average indentation, considering all temperatures and humidities, is shown along the vertical axis of Figure 6.

The horizontal axis of Figure 6 shows the comparative abilities of the floor coverings to resist permanent indentation when subjected to a load of 2,015.8 pounds per square inch. This load was selected as being representative of loadings commonly encountered. Although cork and linoleum showed the ability to indent readily, they also retained a large amount of indentation when compared to the other materials. Vinyl tile, on the other hand, indented readily and showed an ability to recover very well from indentation. Asphalt tile showed the poorest ability to depress readily but retained a considerable amount of indentation.

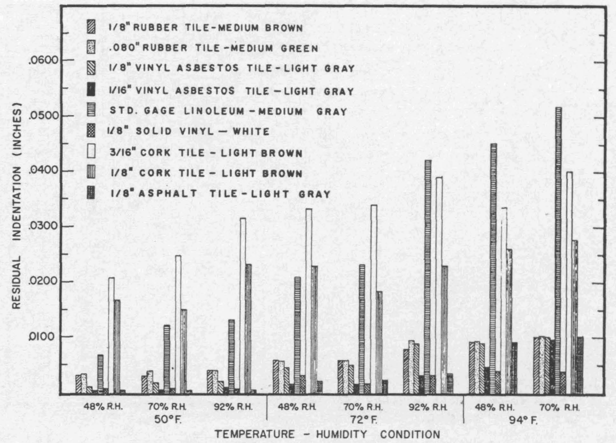


Figure 3. Average residual indentation of each floor covering resulting from three replications of light, medium and heavy loads applied under the temperature-humidity combinations shown.

Considering all temperatures, humidities and loads, the floor coverings tested ranged in the following order from least to most total indentation:

1/16-inch vinyl-asbestos tile
1/8-inch asphalt tile
1/8-inch vinyl tile (homogeneous)
1/8-inch vinyl-asbestos tile
0.080-inch rubber tile
1/8-inch rubber tile
Standard gage linoleum tile
1/8-inch cork tile
3/16-inch cork tile

The difference between any two materials as listed was not necessarily significant but there was a significant difference among several of them. The following differences between the materials listed were significant:

The thinner vinyl-asbestos tile showed less total indentation than asphalt tile.

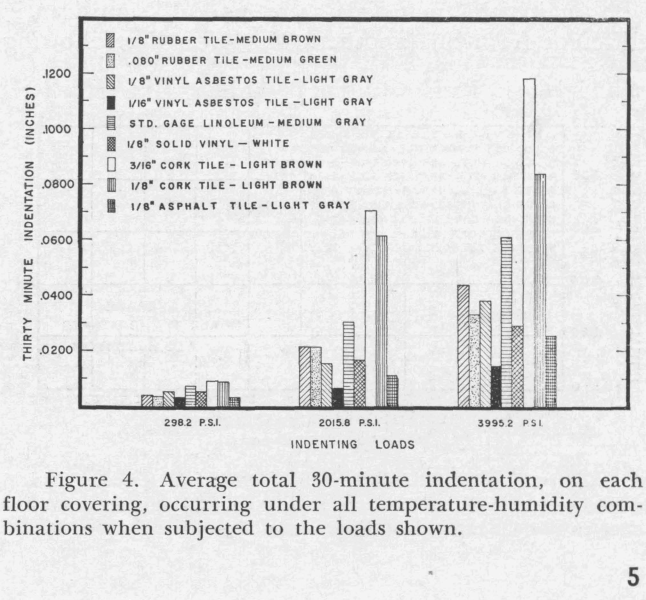


Figure 4. Average total 30-minute indentation, on each floor covering, occurring under all temperature-humidity combinations when subjected to the loads shown.

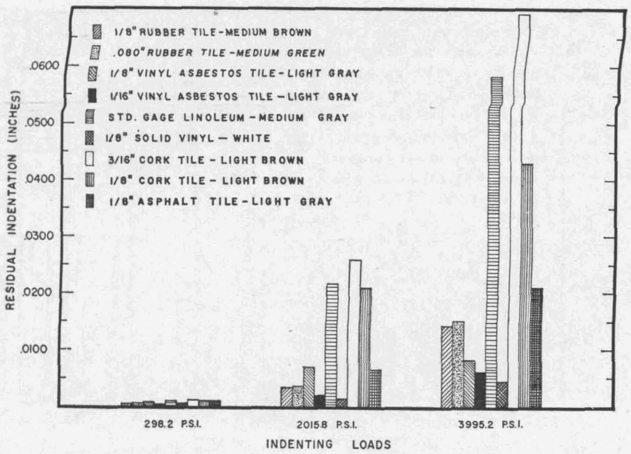


Figure 5. Average residual indentation on each floor covering that occurred under all temperature-humidity combinations when subjected to the loads shown.

Linoleum tile and the two thicknesses of cork tile indented more than any of the other materials and were also different from one another.

The 1/8-inch sample of rubber tile indented more than the 1/8-inch sample of asphalt tile.

A statistical analysis was made of residual indentation, considering all loads, temperatures and humidities. The materials ranked in the following order from least to most residual indentation:

1/8-inch vinyl tile
1/16-inch vinyl-asbestos tile
1/8-inch asphalt tile
1/8-inch vinyl-asbestos tile
1/8-inch rubber tile
0.080-inch rubber tile
1/8-inch cork tile
Standard gage linoleum tile
3/16-inch cork tile

Again, the materials were not all significantly different from one another. However, the following

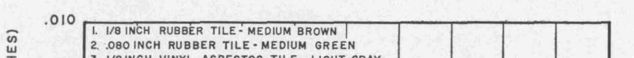


Figure 6. Overall comparison of materials tested. Vertical axis shows ease of indentation, and horizontal axis shows resistance to permanent indentation.

differences between the materials listed were significant:

The *thicker cork tile indented more than the* linoleum tile.

Linoleum indented more than the thinner sample of cork tile.

Both cork tiles and linoleum indented more than any of the other materials listed.

The thinner sample of rubber tile indented more than the thinner sample of vinyl-asbestos tile.

Vinyl tile indented less than the thicker sample of rubber tile.

Recovery readings made 72 hours after removal of the test load indicated that practically all the recovery occurred within the 30-minute recovery period. Visual inspection of the test samples over a 9-month period following the tests indicated that residual indentation of all samples remained as apparent as at the end of the 30-minute recovery period.

Application of Findings

Although all floor coverings tested exhibited good ability to resist permanent indentation under a load of 298.2 pounds per square inch, consideration must be given to the fact that this load was applied for only a 30-minute period. Longer loading periods may cause excessive additional indentation.

The selection of a proper type and size glider for furniture support is most important in preventing indentation to resilient floor coverings. The uniform contact between a floor covering and a glider surface area should be large enough to prevent excessive pressures. Where floor covering manufacturers' recommendations are followed, there should be no trouble with indentation.

Many glider sizes and types are available for use on household furniture. Figures 7, 8 and 9 show two types which are commonly used. The glider in Figure 7 is the three-prong type with an overall diameter of five-eighths inch. This photograph illustrates the curved surface of the glider. The area of contact of this glider with the floor covering is only approximately three-sixteenth inch in diameter. If this glider is installed on the legs of a 25-pound chair which is occupied by an individual weighing only 125 pounds, an initial pressure of 1,359 pounds per square inch would be applied to the floor covering under each leg. An equal size glider with a flat contact surface five-eighth inch in diameter applied to the same chair would subject the floor covering to a pressure of only 122 pounds per square inch.

A three-prong type glider seven-eighth inch in diameter was installed in the same manner as the five-eighth-inch glider. Figure 8 shows the small con-

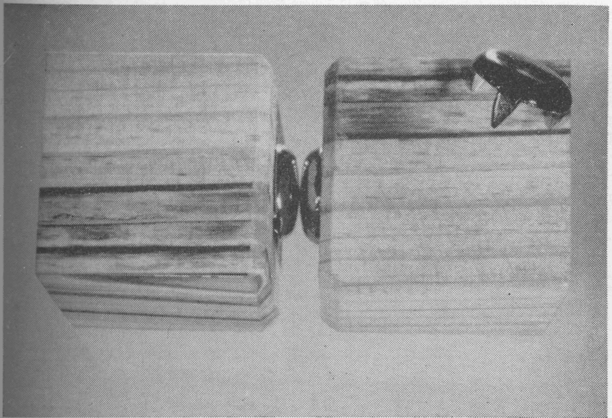


Figure 7. Five-eighth-inch diameter three-prong gliders, illustrating their small contact area when new.

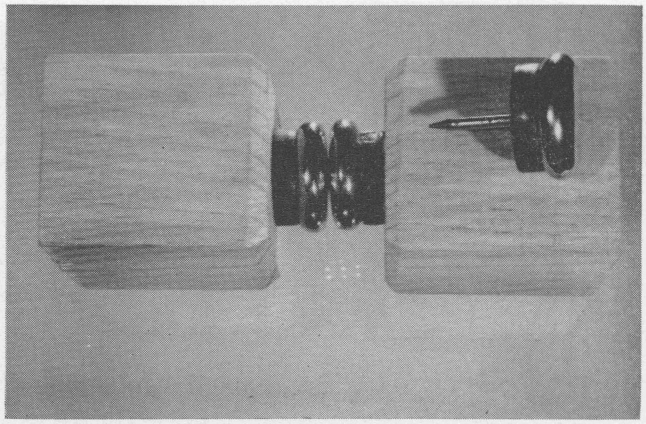


Figure 9. Single-prong gliders with rubber pad, illustrating their small contact area.

tact area of this glider due to the curvature of the contact surface.

The contact area of these gliders was determined by applying ink to the glider and making an imprint on a sheet of paper. The glider was placed on the paper in the same manner that it would contact a floor covering when installed on a chair. The contact area of the seven-eighth-inch glider was approximately the same as that of the five-eighths-inch glider. Likewise, a flat-surfaced glider seven-eighths inch in diameter installed on a chair with a total load of 150 pounds would subject a floor covering to an initial pressure of only 62.4 pounds per square inch. Figures 7 and 8 both show the relatively large amount of indentation that must occur before the contact area is appreciably increased.

A second type of glider, Figure 9, has a rubber cap which allows the glider face to adjust to the floor if the glider face and floor are not parallel. Again, the area of contact of the glider with the floor is relatively small due to the curvature of the glider surface. This glider offers a flatter surface than those shown in Figures 7 and 8. The initial contact area of this glider was only one-fourth inch in diameter.

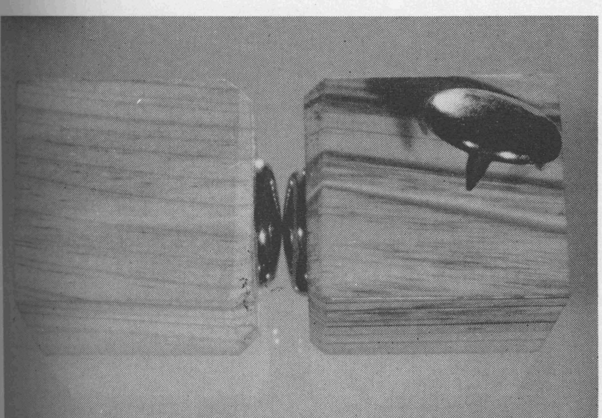


Figure 8. Seven-eighths-inch diameter three-prong gliders, illustrating small contact area of glider when new.

A 150-pound load applied to four gliders of this type would subject a floor covering to an initial pressure of 764 pounds per square inch.

Many items of furniture have legs which are large enough to reduce the pressure on a floor covering to considerably less than 100 pounds per square inch. However, unless the bottom of the leg is in complete contact with the floor covering, the pressures may be excessive. The corner or edge of a chair leg provides an extremely small contact area.

Where flat gliders are used, a comparatively heavy piece of furniture such as a couch, which may weigh as much as 400 pounds, does not require extremely large glider sizes in order to produce floor covering pressures under 100 pounds per square inch. For example, a 400-pound couch seating four individuals whose average weight is 175 pounds would require only four contact areas 1½ inches in diameter to reduce the pressure on a floor covering to less than 100 pounds per square inch.

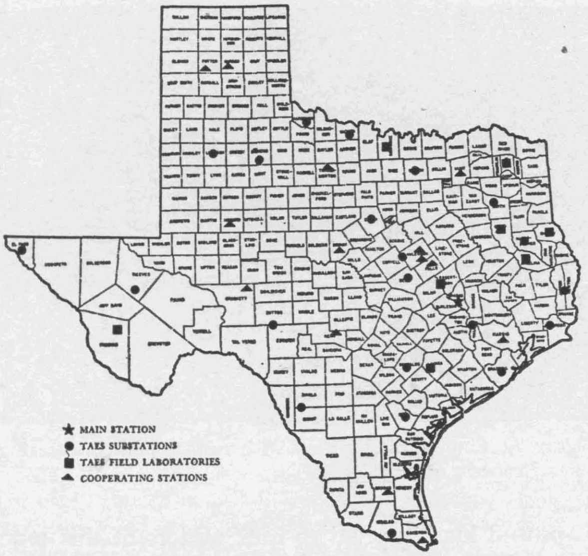
A floor covering which indents readily, yet resists permanent indentation even under large pressures, is very difficult to produce. With the resilient floor coverings now on the market, however, permanent indentation can be prevented by considering the loads that will be applied and providing proper glider sizes and types.

Acknowledgments

Recognition is given to the Department of Genetics, The A&M College of Texas, which supervised the statistical analysis of the indentation and recovery data.

This research was set up in 1954 as part of the Southern Regional Housing Project S-8.

Appreciation is extended to the floor covering manufacturers who furnished materials for the tests and made comments and suggestions on the report.



Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

★

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of the parts of the A&M College of Texas.

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

Conservation and improvement of soil	Beef cattle
Conservation and use of water	Dairy cattle
Grasses and legumes	Sheep and goats
Grain crops	Swine
Cotton and other fiber crops	Chickens and turkeys
Vegetable crops	Animal diseases and parasites
Citrus and other subtropical fruits	Fish and game
Fruits and nuts	Farm and ranch engineering
Oil seed crops	Farm and ranch business
Ornamental plants	Marketing agricultural products
Brush and weeds	Rural home economics
Insects	Rural agricultural economics
Plant diseases	

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tommorrow's Progress