THE RELATIONSHIP OF GLOSS AND SKID RESISTANCE OF SPECIFIC FLOOR SURFACES

by

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The objectives of this study were to correlate gloss and force of friction of diversely finished unpolished wood floor surfaces; to correlate gloss and force of friction for unpolished hard and resilient floor surfaces; and to determine the effect of different floor polishes on the relationship of gloss and force of friction of hard and resilient floor surfaces.

The wood floor finishes appraised were penetrating seal, satin and gloss varnish, shellac, lacquer, an epoxy and a polyurethane. The hard floor materials investigated were aggregate, ceramic unglazed and glazed, ceramic in vinyl or rubber, cement, quarry tile, and terrazzo. Six surface conditions were tested for each material, the unpolished surface, and the surfaces after polishing with four different water emulsion polishes. The resilient floor materials investigated were linoleum, asphalt, vinyl asbestos, rubber, vinyl cork, greaseproof asphalt, solid vinyl opaque, solid vinyl translucent and plain cork. Ten surface conditions were tested for each material, the unpolished surfaces, and the surfaces after polishing with nine different water emulsion polishes.

Gloss and force of friction values were obtained respectively with the sixty degree Gardner Portable Glossmeter, and the Bowen Friction Tester, for each material specimen tested with each varying surface condition.

The gloss and friction data were subjected to correlation analysis. The hypotheses tested was that there is a negative correlation between gloss and skid resistance for (1) diversely finished unpolished wood floor surfaces, (2) unpolished hard and resilient floor surfaces, and (3) hard and resilient floor surfaces polished with different polishes.

Results of this investigation indicated a wide variation in the pattern of relationship between gloss and skid resistance. These differences may be attributed to the kinds of finishes tested for the wood floors, and the nature of the floor materials tested, rather than an increase in gloss indicating an increase in skid resistance. The conclusion was drawn that the skid resistance of the floor surfaces tested cannot be predicted from the glossiness of the surfaces.

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CHAPTER I

INTRODUCTION

Skid resistance of floor surfaces has been a topic of single and collective investigation, controversy, and conjecture over a period of several years. From the standpoint of safety this factor is of vital importance not only to pedestrians but to insurance companies, to manufacturers of flooring materials and polishes, and to all individuals concerned with the selection and maintenance of floors in public and private buildings. With a marked increase in resilient and hard floor materials, wood floor finishes and the number of polishes available in today's market, effective consumer choice of materials relative to safety and suitability becomes increasingly difficult.

Appearance, a visual characteristic of floor surfaces, is perhaps one of the primary considerations of the consumer in the selection of a specific floor material. Related to appearance is the constituent of gloss. In recent years the concerted efforts of polish manufacturers have been successful in marketing products which not only protect resilient, hard, and wood floor surfaces, but which in many instances enhance appearance by increasing surface glossiness. This presents a question of the relationship of gloss to skid resistance involving appearance of the floor surface.

Mrs. Bush, Consumer Education Director, Johnson's Wax, made the following reference to visual evaluation of gloss:

> . . . Never assume that a highly polished floor is not a safe floor. It happens to be a fact that the brighter the polish on a floor, the safer it is. The more you buff a polishing wax, the harder and drier the finish becomes. And the brighter the shine on a self-polishing wax, the more perfect the application, and, therefore, the harder and drier it is. A hard dry finish on a floor is a safe surface.[1]

Using the psychological approach to this subject, another appraisal was made by Dr. J. Vernon Steinle in a speech delivered in May, 1961 at a meeting of the Chemical Specialties Manufacturers Association:

> . . . I have proved by experiment that the manner in which people walk and slip is affected by what they see. To most people gloss means slipperiness. I have conducted an experiment where I had 100 people walk over two surfaces one glossy, the other not. They did this twice, once blindfolded and once not. When they saw the floors there was almost unanimous agreement that the glossy floor was the more slippery. When they were blindfolded, this was not the case. About half the walkers thought the duller floor was the more slippery.[2]

Documentary evidence of tests conducted correlating gloss measurements and skid resistance is generally confined to the psychological aspect and quite limited. Data were not available to substantiate the conclusions in the two observations presented above.

I. THE PROBLEM

Statement of the Problem

The objectives of the study are threefold:

> To correlate gloss and force of friction of diversely finished unpolished wood floor surfaces.

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[1]Lucille Bush, "The Safe Home... in 1959." Speech given at 29th Annual Safety Convention of the Greater New York Safety Council, New York City, (April, 1959), p. 2, (Mimeographed).

[2]J. Vernon Steinle, "Waxed Floors Are Safe," Soap and Chemical Specialties, XXXVII (September, 1961), p. 82.

To correlate gloss and force of friction of unpolished resilient and hard floor surfaces.

To determine the effect of different floor polishes on the relationship of gloss and force of friction of resilient and hard floor surfaces.

Importance of the Study

Several instances were noted in literature sustaining a belief that glossiness of a floor surface is indicative of a slippery floor. However, references found with substantiating data establishing the relationship of gloss and skid resistance were quite limited indicating there has been little exploration in this field.

II. DEFINITIONS OF TERMS USED

Force of Friction

The resisting force which opposes any effort to roll or slide one body over or through another.[3] The force of friction referred to in this study is force of kinetic friction.

Specular Gloss

The ratio of reflected light to that light incident on the surface of a specimen for a specified solid angle. The gloss referred to in this study is sixty degree specular gloss.

Surface Conditions

The new and worn hard and resilient floor surfaces in an unpolished and polished condition.

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[3]Madalyn Avery, Household Physics (New York: The Macmillan Co., 1946), p. 23.

Wood Floor Finishes[4]

Epoxy. Epoxies are a class of resins derived from the interaction of epichlorohydrin and bis-phenol. These resins are thermosetting when cured in the presence of catalysts and yield hard, tough, adherent films with good abrasion, water and alkali resistance. Combined with vegetable oil fatty acids, they yield esters which are useful in the manufacture of highly resistant industrial finishes.

Lacquer. The term Lacquer is restricted to coatings of which the characteristic ingredient is a solution of nitrocellulose or "pyroxylin" in a combination of ester, ketone and alcohol solvents. Nitrocellulose is the nitric acid ester of cellulose produced by subjecting the short fibers of cotton to the action of mixed nitric acid and sulphuric acid. Drying of a lacquer film is accomplished through the evaporation of the solvent.

Penetrating Seal. A floor seal chemically identified as a linseed oil-modified polyol, maleate, phthalate polyester reduced in aliphatic mineral spirits solvent. It is used as a penetrant for wood substrates to increase abrasion resistance of the wood.

Polyurethane. When an isocyanate reacts with a hydroxy compound, an addition reaction takes place giving a urethane. If polyfunctional compounds are used, useful polymers, polyurethanes are formed and some of these find application in the surface coating field. Polyurethane finishes contain polyisocyanates and polyhydroxy compounds and, in some cases, amines which serve as catalysts and cross linking agents.

Shellac. Shellac is an exudation from the Coccus Lacca on the smaller branches of certain members of the fig family in India and neighboring countries. In this form, it is designated as "stick lac" and after boiling to extract the red "lac dye," it is known as "seed lac." This is melted, strained and made into thin films which, broken into small flakes, become "shellac." Shellac varnishes are made by dissolving the shellac in an alcohol solvent.

Varnish. Varnish is a solution which when spread upon a surface in a thin film dries by the evaporation of its volatile constituents, by the oxidation or chemical reaction of other constituents, or partly by evaporation and partly by oxidation and chemical reaction to a continuous protective coating which may be either highly lustrous or practically devoid of luster. "Alkyds," which are members of the varnish family, are reaction products of polyhydric alcohols and

[4]F. J. Martinek of The Sherwin-Williams Company, in letters dated March 12, and March 31, 1965. Permission to quote secured.

polybasic acids to form polyesters. These polyesters combined with drying oils, such as linseed oil, produce a fluid material which when spread in a thin film will oxidize to the desired protective membrane. A typical alkyd is "Linseed Glycerol Phthalate."

CHAPTER II

REVIEW OF THE LITERATURE

Investigations correlating gloss and force of friction are quite limited. This review includes procedures used in the measurement of gloss, the available studies concerned with the instrument measurement and visual estimation of gloss of specific floor surfaces, and brief abstracts of comprehensive studies testing skid resistance of specific floor surfaces.

I. PROCEDURES FOR MEASUREMENT OF GLOSS

Gloss and color, according to Hammond and Nimeroff are two of the main attributes for evaluating the appearance of objects.[5] In considering the aspect of gloss the statement has been made that gloss means different things to different people.[6] Daniel Smith comments on gloss:

> . . . An individual does not consider the reflectance from a surface as a function of an angle when he looks at it, but rather he gets an impression that he is most frequently at a loss to explain but which he does not hesitate to evaluate.[7]

Hunter, who has explored the field of gloss testing rather extensively, concluded from studies conducted in the 1930's that gloss was made up of at least six types of visual criteria. The establishment

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[5] Harry K. Hammond, III, Isadore Nimeroff, "Measurement of Sixty-Degree Specular Gloss," Journal of Research of the National Bureau of Standards, XLIV (June, 1950), p. 585.

[6] G. I. Norman, "Gloss Readings Depend on These Variables," Industrial Finishing, XXXIX (March, 1963), p. 103.

[7] Daniel Smith, "Gloss and Its Evaluation In Floor Waxes," Soap and Sanitary Chemicals, XXVI (March, 1950), p. 133.

of these criteria has made possible successful procedures in gloss rankings and testing a variety of materials.[8] Hunter defines the types of gloss as follows:

> Specular gloss - shininess, brilliance of highlights (medium-gloss surfaces of paint, plastics, etc.).
>
> Sheen - shininess at grazing angles (low-gloss surfaces of paint, paper, etc.).
>
> Contrast gloss - contrast between specularly reflecting areas and other areas (low-gloss surfaces of paint, textile cloth, etc.).
>
> Absence-of-bloom gloss - absence of haze, or milky appearance adjacent to reflected highlights (high and semigloss surfaces in which reflected highlights may be seen.).
>
> Distinctness of image gloss - the distinctness and sharpness of mirror images (high-gloss surfaces in which mirror images may be seen.).
>
> Surface-uniformity gloss - surface uniformity, freedom from visible nonuniformities (medium-to-high gloss surfaces of all types.).[9]

Satisfactory standard tests for instrument measurement have been established for three of these types, specular gloss, sheen, and contrast gloss. Hunter made the following conclusions relative to gloss measurements:

> . . . Gloss cannot be measured as precisely as color and reflectance. It is a phenomenon of the skin of a material and thus tends to be quite variable from point to point and changes with the condition of surface preparation. Thus, gloss measurements of high precision are impossible and even if they could be made they would probably be meaningless.[10]

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[8]Richard S. Hunter, "New Directions in Material Testing...Color Gloss, Texture," Materials in Design Engineering LXIII (June, 1961), p. 138.

[9]Richard S. Hunter, "Gloss Evaluation of Materials," ASTM Bulletin No. 186, (December, 1952), p. 51.

[10]Hunter, New Directions in Material Testing...Color, Gloss, Texture, op. cit., p. 140.

Relative to gloss, Hammond and Nimeroff stated the appearance of an object depends on the following factors, namely: the illuminent, the reflection characteristics of the material, the surface texture, the viewing geometry, and the observer. To obtain accuracy in instrument measurement of sixty-degree specular gloss they emphasized the necessity of following specifications as established by The American Society for Testing Materials.[11] Estimation has been made that seventy-five per cent of all gloss measurements made today use The American Society for Testing Materials D 523 test for sixty-degree specular gloss.[12]

II. INSTRUMENT MEASUREMENT AND VISUAL ESTIMATION OF GLOSS

In 1960, The Chemical Specialties Manufacturers Association, reported an investigation of gloss conducted by Snell Laboratories of New York City. In this account Hackett and Kimball relate the value of waxing resilient floor surfaces subjected to heavy duty traffic for enhancement and maintenance of floor beauty, and for protection of floor covering. Asphalt tile, solid vinyl asbestos, homogeneous vinyl tile, rubber tile, vinyl and linoleum sheet were included in the study. Representative test panels of uniform size were installed in areas three feet square and duplicated in corridors on eight floors of the building. The test panels of the different materials in each area were treated with three types of water emulsion waxes. Identical panels of

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[11] Hammond and Nimeroff, op cit., p. 139.

[12] Hunter, "New Directions in Material Testing...Color, Gloss, Texture," op. cit., p. 139.

these same materials were left in an untreated state. All panels within each test area, and between each test area were subjected to like treatment relative to traffic exposure, periodic cleaning and wax application. Using the Gardner Glossmeter, gloss measurements were recorded for all panels before exposure to traffic. After exposure to traffic, measurements taken at two week cycles were averaged and recorded at intervals of six, ten and sixteen weeks.[13]

Among other conclusions from this study, Hackett and Kimball noted that regular waxing produced marked increase in gloss measurements of the floor coverings, provided protection against scratching and dulling, and greatly facilitated soil removal from the floor surface.[14]

Comparative analysis of the tabular data recorded in this study indicated a wide range in gloss measurements among the materials investigated. In both untreated and treated conditions one of the vinyls was highest in gloss with linoleum having the lowest gloss values.[15]

A study by Penn, one of a series[16] conducted at The Woman's College of the University of North Carolina, Greensboro was concerned with gloss investigation of unpolished and polished resilient floor surfaces.[17] Test panels included rubber, vinyl asbestos, asphalt, solid

[13]Walter J. Hackett, Cyril S. Kimball, _The Value of Waxing Resilient Smooth Surface Floor Coverings_. Research sponsored by the Wax and Floor Finishes Division, Chemical Specialties Manufacturers Association, Inc., (May, 1960), pp. 3-14.

[14]_Ibid._

[15]_Ibid._

[16]Savannah S. Day, "Testing Smooth Floor Surfaces from the Standpoint of Safety," North Carolina Agricultural Experiment Station Project No. 3115, Contributing to Southern Regional Project S-54.

[17]Janice Carol Penn, "Appraisal of Gloss and Slipperiness of Resilient Floor Covering Materials," (Unpublished Master's thesis, The Woman's College of the University of North Carolina, Greensboro, 1963).

vinyl translucent, greaseproof asphalt, plain cork, battleship linoleum, vinyl cork, and solid vinyl opaque. Using the Gardner Glossmeter, gloss measurements were obtained on duplicate panels of these materials designated as Set A and Set B. Readings were taken in an untreated condition and after application of three kinds of water emulsion polish.[18]

Gloss values obtained from instrument measurement of untreated panels in Set A ranged from 4.90 for battleship linoleum to 71.65 for rubber; values for panels tested in Set B ranged from 5.90 for plain cork to 63.70 for solid vinyl translucent. General conclusions indicated a wide range in gloss for materials measured. Battleship linoleum and cork were lowest in gloss with rubber and solid vinyl translucent highest.[19] Hackett and Kimball obtained similar results in their study.[20]

Analysis of variance computed from gloss data for the polished panels resulted in the following conclusions:

> There was a highly significant difference in gloss at the one per cent level among polishes and even a greater difference in gloss among materials. These differences were greater in Set B than in Set A, suggesting the possibility that there is heterogeneity among the same types of materials made by different manufacturers.[21]

Penn's study was not only concerned with instrument measurement of gloss but also involved correlation of visual estimation with the values obtained from instrument measurement. Students selected from the School of Home Economics were asked to rank the untreated and polished test panels of resilient floor materials according to gloss.[22]

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[18] Ibid., pp. 22-27.

[19] Ibid., p. 30

[20] Hackett and Kimball, loc. cit.

[21] Penn, op. cit., p. 34.

[22] Ibid., pp. 22-27.

Correlation coefficients for instrument values and visual estimation of gloss were .906 for Set A and .952 for Set B. After treatment with three types of polish, correlation coefficients obtained were as follows:[23]

	Set A	Set B
Polish A	.978	.979
Polish B	.975	.984
Polish C	.977	.951

Correlation coefficients computed for the values obtained from instrument measurements and gloss rankings made by the individuals were consistently high for both the untreated and polished floor covering materials.

In 1962, The American Society for Testing Materials Committee C-21 on Ceramic Whitewares and Related Products conducted an interlaboratory test for determining the specular gloss of glazed ceramic tile. In order to establish broad ranges for classification of bright, semimat, and mat tiles, the Committee listed the following questions which they were interested in having answered:

1. Is it possible to measure gloss numerically with satisfactory precision on available instruments?

2. How well do numerical values correlate with visual estimates of gloss?

3. Which one of the established ASTM test methods for specular gloss is best suited to set up limits for bright, semimat and mat surfaces of glazed ceramic tile?[24]

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[23] Ibid., p. 43.

[24] Arno M. Illing, "Comparison of Instrument Measurement and Visual Estimation of Specular Gloss of Glazed Ceramic Tile," Material Research and Standards, II (February, 1962), p. 117.

In the group of sixty specimens used in the experiment, twenty-seven were designated as bright finish, five semimat, and twenty-eight mat. The back of each tile was coded specifying the manufacturer, the grouping, and the producers evaluation of finish. The entire group of specimens were sent progressively to four different organizations. Three organizations were equipped with sixty-degree Gardner Glossmeters, and the fourth used the Hunter Photometric Unit which measured sixty, forty-five, and twenty degree specular gloss. Using the same instrument, and following standard procedures, several operators within each organization took readings on all the tiles and forwarded the recorded results to the Committee. In order to correlate visual estimation with instrument measurements tiles were selected from the specimen groups and designated as group standards. Twenty laboratory personnel untrained in visual estimation of gloss were chosen from one of the organizations and asked to visually evaluate the remaining tiles by placing them in the appropriate group.[25] Analysis of the data from the four participating organizations provided the following information in answer to the three questions:

1. Exercising proper care, glossmeter readings can be reproduced within ± 8 units which is satisfactory for classifying glazed ceramic tiles into groups having broad ranges of specular gloss.

2. The correlation between visual estimation and instrument measurement was close enough to establish broad numerical value ranges for the three glazes of tile.

3. The sixty-degree method was found to be the most satisfactory for establishing numerical classification of gloss for these three glazes of tile.[26]

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[25] Ibid., pp. 118-119.

[26] Ibid., pp. 119-121.

Results obtained from the two preceeding investigations, correlating instrument measurements with gloss rankings, indicate that individuals can judge and accordingly rank gloss.

III. STUDIES OF SKID RESISTANCE OF SPECIFIC FLOOR SURFACES

Spanning the forty year period, since the beginning of skid resistance testing of various floor materials, a number of procedures have been developed.

As early as 1926 the National Bureau of Standards was concerned with establishing a code for the safety of walkway surfaces. The outgrowth of this was the development of testing procedures and a friction testing machine. The machine consisted of a right angle frame carrying a slotted seventy-five pound weight mounted between two vertical bars. The shoe material was drawn forward over the test surface. The horizontal force increased until the shoe slipped letting the weight drop. A graduated scale registered the coefficient of friction. Testing was conducted on a number of classified materials including smooth faced natural stone, wood, artificial stone products, metal products, and clear metal surfaces. Tests were performed on the material specimens in various combinations of conditions of use, using rubber and leather shoe sole materials.[27]

Results indicated a need for further experimentation before judgment could be made of the skid resistant properties of materials or a code established for walkway safety.[28]

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[27]R. B. Hunter, "A Method of Measuring Frictional Coefficients of Walkway Materials," Journal of Research of the National Bureau of Standards (August, 1930), pp. 330-33.

[28]Ibid., p. 346

Shortly afterwards, the National Bureau of Standards, still interested in a code for safety of walkway surfaces, cooperated with the National Safety Council in a research project. Their concern was a practical and satisfactory testing apparatus for measuring the skid resistance of walkway surfaces. Prior to experimentation in designing an instrument, the human gait of individuals was studied from pictures obtained by concealed slow motion cameras. From this study the Sigler Pendulum-Impact Type Slipperiness Tester was developed to be used in testing floors in actual service. Still used today, this instrument consists of a pendulum with a mechanical shoe at the end to which the test material is attached. The pendulum sweeps the heel material over the test surface. This machine was used for extensive investigation of skid resistance of a wide variety of floor materials using rubber and leather shoe heels. Testing was accomplished with all materials in various conditions of service.[29]

Evaluation of the data resulted in the following general conclusions:

> The results of these tests, considered in relation to slipperiness as actually experienced, indicate that a slippery condition does or does not exist according to whether the coefficient is less or greater than 0.4.[30]

The Michigan State University study extending from 1957-61, used a different approach in investigating skid resistance. Personal interviews were conducted with one hundred victims of stairway accidents. Information obtained revealed that the majority of the accidents resulted from slipping. Interest was directed toward quantative measure-

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[29] Thomas H. Boone, Martin N. Geibe, Percy A. Seigler, "Measurement of the Slipperiness of Walkway Surfaces," Journal of Research of the National Bureau of Standards, XL (May, 1948), pp. 339-46.

[30] Ibid., p. 346.

ment of skid resistance of various stairway tread covering materials when tested with various shoe sole materials. Preliminary testing was accomplished using a portable machine which proved unsatisfactory. The second machine, used in laboratory experimentation, was a movable table to which the tread material was fastened and this was pulled under the shoe sole. In various combinations of new and worn conditions, testing was completed on linoleums, rugs, bare wood and wood finishes, abrasive materials, rubber mats and marble, using shoe soles of ripple, neoprene, Neolite, crepe, Goodrich, and leather.[31]

Relative to frictional characteristics of stair tread materials and shoe sole materials, Esmay summarized the results obtained from the extensive testing as follows:

> The coefficient of friction value for the abrasive strip was 0.75, the highest overall average of six materials studied. This material showed no difference in its slipping characteristics after being used.
>
> Linoleum had the smallest frictional value of 0.56. This was nineteen points less than the coefficient of friction for the abrasive strip.
>
> The ripple sole performed with a considerably higher friction value than any of the other materials. Neoprene, Neolite, crepe, and Goodrich showed frictional characteristics in the same range but with 0.04 difference in a descending order as named. Leather soles performed most poorly of those tested with a coefficient of friction much less than half that of the ripple sole.[32]

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[31]Agricultural Engineering Department, Michigan State University, "The Cause and Nature of Stairway Falls," Michigan Contributing Project Report for 1959, p. 1 (Mimeographed).

[32]Merle L. Esmay, "Home Stairway Safety Research Results," East Lansing: Agricultural Engineering Department of Michigan State University, 1961, pp. 8-10.

Prior reference has been made to a series of skid resistance studies completed at The Woman's College of the University of North Carolina, Greensboro.[33] All of these tests were conducted under controlled laboratory conditions. Testing was accomplished using the Bowen Friction Tester. This machine was designed and developed by Dr. Henry Bowen specifically for this test series.[34] Data obtained were analyzed following statistical procedures outlined by members of the staff of the Institute of Statistics.[35]

The first in the group, a pilot study completed in 1962, was an investigation of coefficients of friction existing between shoe heel materials and resilient floor covering materials in a new, worn, and waxed condition. Specimens of asphalt, greaseproof asphalt, vinyl asbestos, solid vinyl opaque, solid vinyl translucent, rubber, linoleum, plain cork and vinyl cork were tested with a variety of shoe heel materials including leather, nylon, Adiprene, hard rubber, rubber crepe, Neolite, and neoprene-cord.[36]

From statistical analysis of the data obtained in this investigation the following general conclusions were made:

> The coefficients of friction for all types of floor materials in the new, worn, and waxed conditions were lowest with the leather heel and highest with neoprene-cord. The differences among

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[33]Savannah S. Day, loc. cit.

[34]Dr. Henry Bowen, Department of Agricultural Engineering, North Carolina State University at Raleigh.

[35]Dr. David Mason, Head, Department of Experimental Statistics, Dr. R. J. Hader, Professor, Institute of Statistics, North Carolina State University at Raleigh.

[36]Jean Webb Trogdon, "Skid Resistance of Waxed and Unwaxed Smooth Floor Surfaces," (Unpublished Master's thesis, The Woman's College of The University of North Carolina, Greensboro, 1962).

coefficients of friction for heel materials were considerably greater than the differences among floor surface materials. However, for both heel and floor materials the difference in coefficients of friction were highly significant.[37]

The second test of the series was completed in 1963. The same resilient floor materials were used as those in the pilot study. The object was to obtain information relative to the effect of size of the shoe heel, and the weight load applied to the heel in testing on the coefficient of friction values. Five different sizes of rubber and leather heels were used including a spike heel, a stacked heel, a Cuban heel, a child's, or woman's flat heel, and a man's heel. For testing, weight loads of 5, 11, 18.5, 26 and 33.5 pounds were applied to the heels.[38]

From statistical analysis of data obtained in this study the following general conclusions were made:

> The size of the heel was not a significant factor in determining the force of friction existing between floor surface and heel material.
>
> Significant differences were found in the mean coefficients of friction among the five different weight loads applied to the heels. Coefficients of friction of the floor surface materials and heel materials increased when the heavier weight loads were applied to the heels.[39]

Hard floor surfaces were involved in the third investigation of skid resistance, completed in 1964. The purpose, somewhat similar to the first in the test series, was to determine coefficients of friction existing between hard floor surfaces and various heel materials.

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[37] _Ibid._, pp. 85-86.

[38] Fern Tuten, "Testing of Skid Resistance of Smooth Floor Surfaces Using Various Sizes of Rubber and Leather Shoe Heels," (Unpublished Master's thesis, The Woman's College of the University of North Carolina, Greensboro, 1963), pp. 24-29.

[39] _Ibid._, pp. 52-53.

Additional information was desired relative to the effect of certain emulsion polishes and/or moisture on the coefficient of friction values. Specimens of aggregate, ceramic unglazed and glazed, ceramic in vinyl or rubber, concrete, quarry tile and terrazzo were tested in combination with shoe heel materials of leather, Neolite, nylon, rubber, and rubber crepe.[40]

From statistical analysis of the data obtained in this study, the following general conclusions were made:

> The seven floor materials varied in skid resistance. Compared with the other materials tested in a dry unpolished or polished condition, terrazzo was the least skid resistant and aggregate the most skid resistant. In an unpolished or polished condition with applied moisture, glazed ceramic was found to be the least skid resistant and quarry tile the most skid resistant. Generally, polishes and moisture lowered the skid resistance of hard floor surfaces. Among the heel materials, there was a marked difference in skid resistance. Leather was the least skid resistant and rubber crepe was the most skid resistant under all conditions tested.[41]

SUMMARY

Documentary evidence found of investigations correlating gloss and force of friction of floor surfaces was confined to the psychological approach involving visual estimation of gloss as determined by individuals. Limited investigations have been conducted relative to gloss measurements of specific floor surfaces. Since 1926, some studies have been completed investigating the skid resistance of walkway surfaces and floor surface materials. To date, experimentation in this field has failed to establish a code for the safety of walkway surfaces.

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[40] Marianne Hodges, "Skid Resistance of Treated and Untreated Hard Floor Surfaces Using Various Shoe Heel Materials," (Unpublished Master's thesis), The University of North Carolina, Greensboro, 1964), pp. 74-75.

[41] Ibid., p. 78

CHAPTER III

EXPERIMENTAL PROCEDURE

The relationship of gloss and the force of friction of resilient, hard and wood floor materials comprised this study. The phase of the study investigating wood floor materials was completed in 1965. Included in the chapter is a report of flooring selection and preparation of test panels, selection and application of floor finishes, procedures used for obtaining all gloss measurements, and the designation of data analyses.

I. GLOSS AND FORCE OF FRICTION DATA FOR RESILIENT AND HARD FLOOR SURFACES

Gloss and force of friction data for the resilient and hard floor surfaces were obtained from earlier investigations contributing to the series of studies of floor covering materials and finishes conducted at The University of North Carolina.[42] The resilient floor materials tested obtaining gloss and friction data which was used for correlation analysis in this study, were identical to the ones reported by Trogdon and Tuten.[43] Hodges' investigation, reports the hard floor surfaces tested for obtaining data for correlation analysis, and in addition outlines procedures for obtaining force of friction data. Similar procedures were followed in obtaining force of friction data for the resilient floor coverings and for the diversely finished wood floor surfaces.

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[42] Day, loc. cit.

[43] Trogdon and Tuten, loc. cit.

[44] Hodges, op. cit., pp. 14-23.

II. FLOORING SELECTION AND PREPARATION OF TEST PANELS

The Department of Agriculture, Forest Service and the National Oak Flooring Manufacturers' Association specifications were followed in selecting the wood floor material and preparing the test panels for finishing.[45] Because of economy in initial cost and adaptability to a variety of architectural styles strip flooring is the most common type for all wood species. Hardwoods, classified in terms of the layman as trees with broad leaves, supply the greatest proportion of wood flooring material because of wear resistance and the natural grain which lends to finished floor beauty. Ninety-two per cent of the hardwoods are either red or white oak. Of the twenty oak species found in the United States nine are classified as white oak and the remaining eleven as red oak. There is little difference between the two in utility or quality. Both groups are light in color; white oak having a brownish tinge compared to the pink cast of the red oak. Color due to variations produced by climatic conditions and soil types is not a factor considered in grading either type. Specifications established by the National Oak Flooring Manufacturers' Association for tongue and grooved strip flooring include: Clear, face practically clear with an average of 3/8" bright sap; Select, face containing slight imperfections of pin worm holes, burls, knots averaging not more than one to every three feet; No. 1 Common, face containing streaks, pin worm holes, knots and other minor imperfections; No. 2 Common, face containing natural forest variations and manufacturers imperfections;

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[45] The Hardwood Flooring Handbook, A Manual Prepared by the National Oak Flooring Manufacturers' Association (Memphis, Tennessee: 1962), pp. 1-11. United States Department of Agriculture, Wood Floors for Dwellings, Agriculture Handbook No. 204 (Washington: Government Printing Office, 1961), pp. 1-7.

Shorts 1-1/4", combination bundles of all grades in short lengths. Both types of flooring are available in plainsawed and quartersawed in standard patterns of lengths and thickness combinations. For homes, the widely used standard pattern is plainsawed, 25/32" thick, 2-1/4" face width.[46]

Red and white oak, tongue and grooved strip flooring, clear grade, conforming to the widely used standard pattern were selected for the study. The flooring was obtained from a local flooring company for construction of twenty-eight test panels. Fourteen 9" x 9" panels were duplicated in both red and white oak. Construction of these panels, involved fitting together the tongue and grooved edges of four 2-1/4" strips, grain lengthwise, and cutting in trapezoidal shapes to fit the circular surface of the Bowen Friction Tester. The panels were mounted with plastic glue on 1/4" plywood panels of corresponding size. Alternating the panels, grain lengthwise and grain crosswise, the specimens of red oak were attached to one half section of a plywood ring by means of plastic glue. Following the same procedure, the fourteen white oak specimens completed the second section of the plywood ring which was then secured to the movable table top of the Bowen Friction Tester.

Before application of the finishes, panel sanding was completed with a small power driven rotary disc sander. The surface was first traversed with #2 sandpaper; #0 sandpaper was used for final traverses leaving the test panel surfaces smooth. All dust from sanding was removed with a vacuum cleaner.[47]

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[46] Ibid.

[47] Finishing Hardwood Floors, A Manual Prepared Jointly by Maple Manufacturers' Association, (Chicago, Illinois: 1961), The National Oak Flooring Manufacturers' Association (Memphis, Tennessee: 1961), National Paint Varnish and Lacquer Association, Inc., (Washington: 1961), pp. 1-2.

III. SELECTION AND APPLICATION OF WOOD FINISHES

Among other considerations, floor finishes are chosen to accentuate and preserve the natural beauty of the wood.[48] Penetrating floor seal, varnish, shellac, and lacquer are four floor finishes recommended by the National Oak Flooring Manufacturers' Association.[49] At a recent meeting in Chicago of the Paint and Wallpaper Association of America, merits of the polyurethanes and epoxies for finishing wood floors were discussed. Hardness and resistance to abrasion were the prime characteristics mentioned. Such qualities were listed as contributing to maximum value in floor coatings.[50]

The finishes mentioned above were selected for this study. Procured from local paint and varnish dealers, they were found to be typical of those used by floor finishing companies in the area. A penetrating floor seal, particularly recommended by the National Oak Manufacturers' Association, a satin and a gloss varnish, shellac, lacquer, an epoxy, and a polyurethane represented products of four manufacturers. A table of random numbers was used in assigning finishes to the test panels. Coating application in each case was in accordance with instructions prescribed by the specific manufacturer.

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[48] Ibid.

[49] National Oak Flooring Manufacturers' Association, op. cit., p.9.

[50] Jack Neslage, "Discussion on New Paints Drew Crowd," American Paint and Wallpaper Association, (January, 1965), p. 34. "New Coatings," Decorating Retailer. (Panelist Report), (February, 1965), p. 6.

IV. PROCEDURES USED IN OBTAINING GLOSS MEASUREMENTS

The sixty-degree geometric angle is employed by most researchers in measuring the specular gloss of untreated and treated floor surfaces.[51] The sixty-degree Gardner Portable Glossmeter was used for obtaining specular gloss measurements of the resilient, hard and wood floor specimens. Gloss measurements were first obtained on the untreated resilient and hard floor panels. Five glossmeter readings were taken for each panel, one center and one in each of the four corners. Using the same method, gloss measurements were obtained for the diversely finished wood test panels. The same process was repeated for the panels after treatment with the different kinds of polish. In the study of the nine resilient floor materials nine brands of water emulsion polishes were used, three clear, three ordinary, and three skid resistant. Four brands of the same three kinds were used in the study of the seven hard floor materials. The American Society for Testing Materials Designation No. 3-1436 was used as a guide for application of each polish to the test panels.[52] Between polish applications, the test panels were subjected to cleaning with an ammoniacal detergent solution and gloss measures were obtained to assure removal of the previously used polish.

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[51]"Tentative Method of Test for Specular Gloss," ASTM Designation D-523-53T (Reprinted from Copyrighted 1953 Supplement to Book of ASTM Standards, Part 8), pp. 847-50.

[52]"Tentative Methods for Application of Emulsion Floor Polishes to Substrates for Testing Purposes," ASTM Designation: D-1436-56T. (Reprinted from Copyrighted 1956 Supplement to Book of ASTM Standards, Part 4), pp. 111-114.

V. DESIGNATION OF DATA ANALYSIS

Gloss averages were computed from the five gloss readings, obtained for each test panel of the unpolished and polished resilient and hard floor materials. Like averages were computed for the diversely finished wood panels. Average friction values were computed from the friction values obtained from testing the floor materials with the different heel materials, for each test panel of the wood, hard, and resilient floor surfaces.

For the resilient and hard floor tests a twenty-five pound weight load per square inch was the normal pressure existing between the heel and floor material. For testing the wood floors, the twenty-five pound weight load damaged the finishes of the test panels. The weight load was reduced to twelve and one-half pounds, one-half the load used for the resilient and hard floor tests. In order to make all friction measurements comparable for each type of floor material and finish, the force of friction values for the wood floor finishes were doubled for analyses of the data.

The average gloss values obtained from gloss measurements, and the average force of friction values obtained from skid resistance testing were subjected to linear correlation for determining the relationship of gloss to skid resistance. Correlation coefficients between X (gloss) and Y (force of friction) were calculated for each wood floor finish, and for each hard and resilient floor material tested under varying surface conditions. Likewise, correlation coefficients between X and Y were calculated for each floor surface condition for the various floor materials tested.

Within cell correlations were calculated for X and Y from an average of all gloss values and an average of all force of friction values for the wood floor finishes. Corresponding within cell correlations were calculated for the hard and resilient floor materials tested with the varying surface conditions. The computations were completed using the covariance form of analyses with both floor materials and surface conditions held constant.

The hypotheses tested in the study were:

> There is a negative correlation between gloss and force of friction of diversely finished unpolished wood floor surfaces.
>
> There is a negative correlation between gloss and force of friction of unpolished hard and resilient floor surfaces.
>
> There is a negative correlation between gloss and force of friction of hard and resilient floor surfaces polished with different polishes.

The results obtained from correlation analyses will be presented in the following chapter.

CHAPTER IV

EXPERIMENTAL RESULTS

Gloss and force of friction data were correlated in this study. Correlation coefficients were calculated to determine the relationship of gloss and skid resistance for the diversely finished wood floor materials, and the unpolished and polished hard and resilient floor materials.

I. CORRELATION OF GLOSS AND SKID RESISTANCE OF WOOD FLOOR FINISHES

Correlation coefficients were calculated for wood floor finishes and for new surface condition of the wood floor material, indicating the relationship of gloss and skid resistance. This was accomplished by using an average of the gloss values obtained from glossmeter readings and an average of the friction values obtained from friction testing.

Wood Floor Finishes

The wide range in variation of the relationship between gloss and skid resistance for the seven wood floor finishes is noted in Figure 1. A negative relationship was indicated for the polyurethane finish with a correlation coefficient of -0.933, significant at the five per cent level, (Table I). The correlation coefficient for epoxy was -0.594, for gloss varnish -0.496, and for lacquer -0.169; each indicated an insignificant negative relationship between gloss and skid resistance. The correlation coefficient for penetrating seal was 0.893 and indicated a positive relationship between gloss and skid resistance, significant at the five per cent level. Satin varnish and shellac, with respective correlation

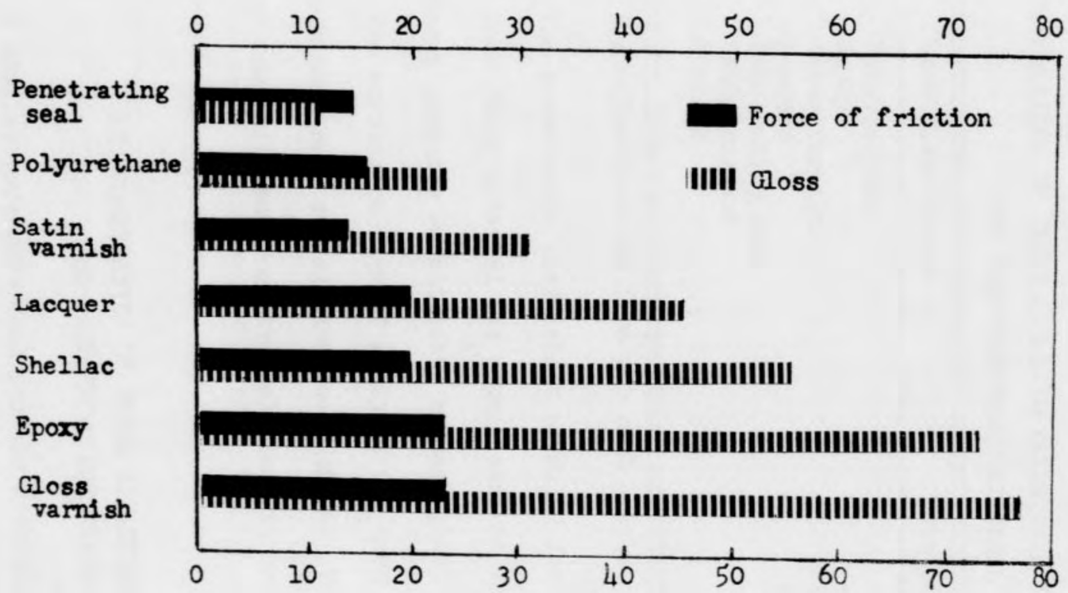


FIGURE 1

CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH SURFACE FINISH OF THE WOOD FLOOR MATERIAL coefficients of 0.748, and 0.299, both indicated insignificant positive relationships. The hypothesis that there is a negative relationship between gloss and skid resistance for diversely finished wood floor surfaces was rejected.

TABLE I

CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH FLOOR FINISH FOR THE WOOD FLOOR MATERIAL TESTED

Wood floor finish	Correlation coefficient
Polyurethane	-0.933*
Epoxy	-0.594
Gloss varnish	-0.496
Lacquer	-0.169
Penetrating seal	0.893*
Satin varnish	0.748
Shellac	0.299

*Significant at the five per cent level.

The correlation coefficient of 0.787 for the new surface condition of the wood floor material was significant at the one per cent level, and indicated a positive relationship between gloss and skid resistance.

The covariance form of analysis was used for calculating the average within cell correlation coefficient. The value of 0.067 indicated an insignificant positive relationship between gloss and skid resistance.

II. CORRELATION OF GLOSS AND SKID RESISTANCE OF HARD FLOOR MATERIALS

A similar procedure used for the wood floor materials was followed for determining the relationship of gloss and skid resistance for the hard floor materials. Correlation coefficients were calculated from an average of the gloss values and an average of the force of friction values for each of the floor materials tested with the six surface conditions, and for each of the surface conditions tested for the seven hard floor materials.

<u>Floor Materials</u> (Surface conditions allowed to vary)

The variation between gloss and skid resistance for the floor materials under all surface conditions tested can be noted in Figure 2. The correlation coefficient was -0.630 for unglazed ceramic, -0.593 for quarry tile, and -0.506 for cement, each significant at the one per cent level (Table II). A negative relationship was indicated between gloss and skid resistance for these three materials. An insignificant negative relationship was indicated for ceramic in vinyl or rubber, and aggregate with respective correlation coefficients of -0.313, and -0.037. The correlation coefficient for terrazzo was 0.041, and for ceramic unglazed 0.067; both indicated an insignificant positive relationship between gloss and skid resistance. The hypothesis that there is a negative relationship between gloss and skid resistance of floor surfaces in an unpolished condition and when polished with different polishes was not rejected.

<u>Floor Surface Conditions</u> (Floor materials allowed to vary)

The correlation coefficient was 0.860 for skid resistant polish #2, 0.780 for skid resistant polish #1, 0.614 for clear polish, and 0.498 for the worn unpolished surface (Table III). The three polished conditions, each significant at the one per cent level, and the unpolished worn surface

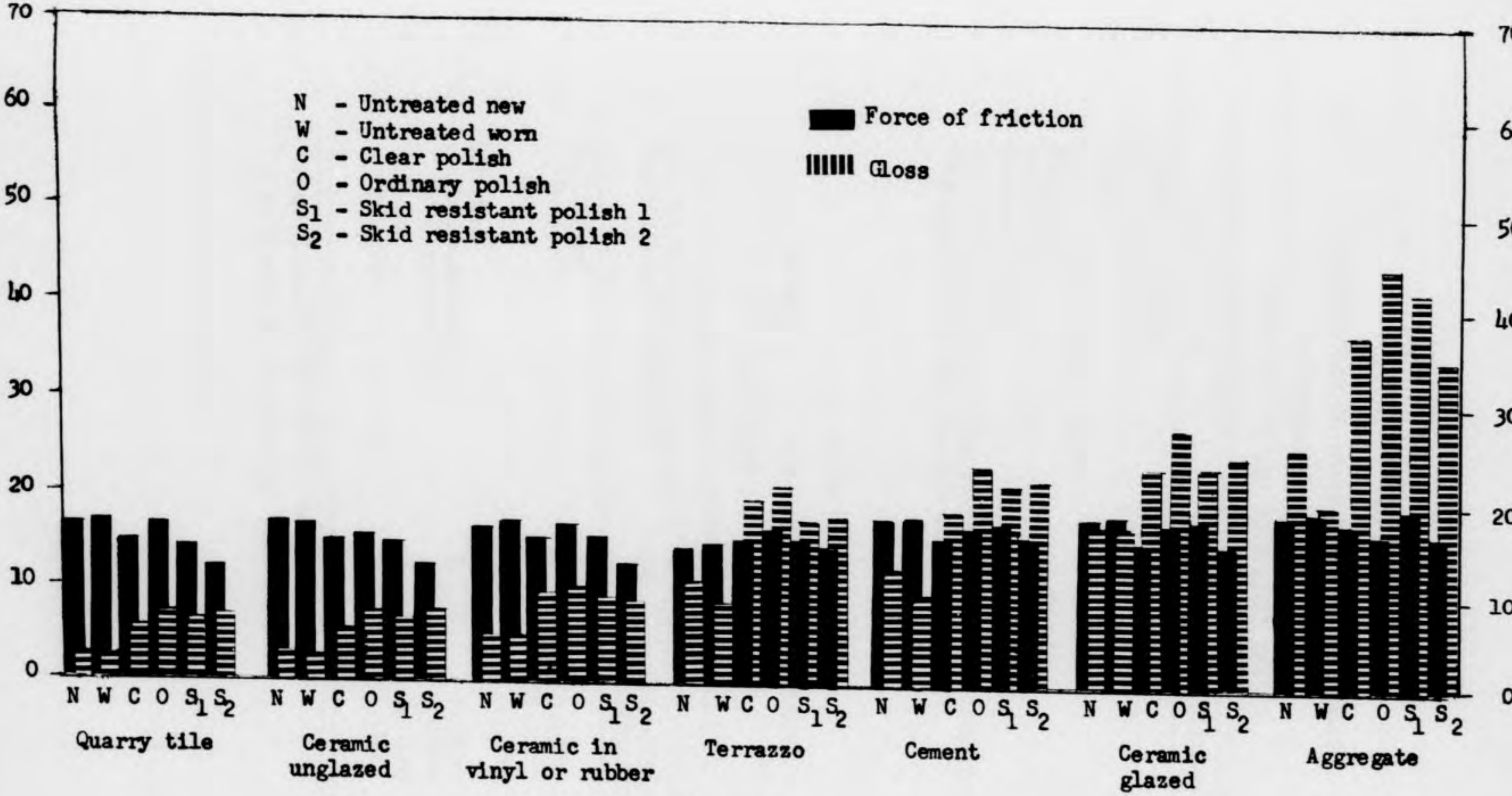


FIGURE 2

CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH HARD FLOOR MATERIAL UNDER ALL SURFACE CONDITIONS TESTED

TABLE II

CORRELATION OF GLOSS AND SKID RESISTANCE
FOR EACH HARD FLOOR MATERIAL
UNDER ALL SURFACE CONDITIONS TESTED

Floor material	Correlation coefficient
Ceramic unglazed	-0.630**
Quarry tile	-0.593**
Cement	-0.506**
Ceramic in vinyl or rubber	-0.313
Aggregate	-0.037
Terrazzo	0.041
Ceramic glazed	0.067

**Significant at the one per cent level.

TABLE III

CORRELATION OF GLOSS AND SKID RESISTANCE
FOR EACH FLOOR SURFACE CONDITION
FOR THE HARD FLOOR MATERIALS TESTED

Floor surface conditions	Brand	Correlation coefficient
Unpolished		
Worn	--	0.498*
New	--	0.252
Polished		
Skid resistant 1	E	0.780**
Skid resistant 2	D	0.860**
Clear	I	0.614**
Ordinary	K	0.196

**Significant at the one per cent level.
*Significant at the five per cent level.

condition, significant at the five per cent level indicated in each case, a positive relationship between gloss and skid resistance. For a given surface condition with an increase in gloss there was also an increase in skid resistance. This can be noted by examination of Figure 3. The hypothesis that there is a negative relationship between gloss and skid resistance for floor surfaces in an unpolished condition and when polished with different polishes was rejected.

The average within cell correlation coefficient of 0.103 indicated an insignificant positive within cell relationship between gloss and skid resistance.

III. CORRELATION OF GLOSS AND SKID RESISTANCE OF RESILIENT FLOOR MATERIALS

The relationship of gloss and skid resistance for the resilient floor surfaces tested was determined following the same method as used for the hard floor materials. From an average of the gloss values and average of the force of friction values, correlation coefficients were calculated for each of the floor materials tested with the ten surface conditions, and for each of the surface conditions tested for the nine floor materials.

<u>Floor Materials</u> (Surface conditions allowed to vary)

The correlation coefficient for linoleum was -0.376, which was significant at the one per cent level (Table IV). This indicated a negative relationship between gloss and skid resistance for this material. Also noted, was the tendency for skid resistance of linoleum to decrease

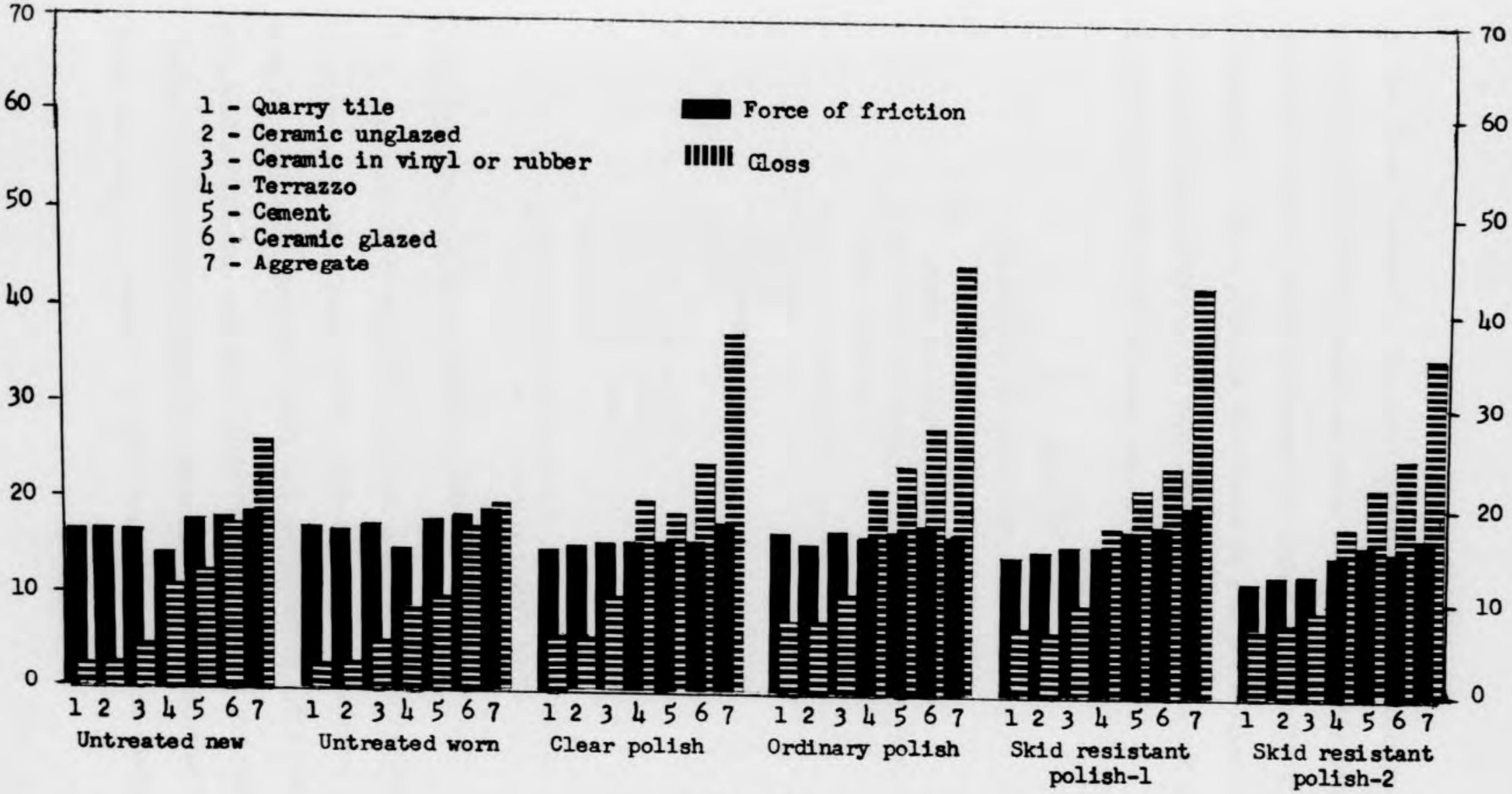


FIGURE 3

CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH FLOOR SURFACE CONDITION FOR THE HARD FLOOR MATERIALS TESTED as the gloss increased. Insignificant negative and positive relationships between gloss and skid resistance were indicated for the other floor materials tested. These instances are easily discernable by examination of Figure 4. The hypothesis that there is a negative correlation between gloss and skid resistance of unpolished floor surfaces and floor surfaces treated with different polishes was rejected.

TABLE IV

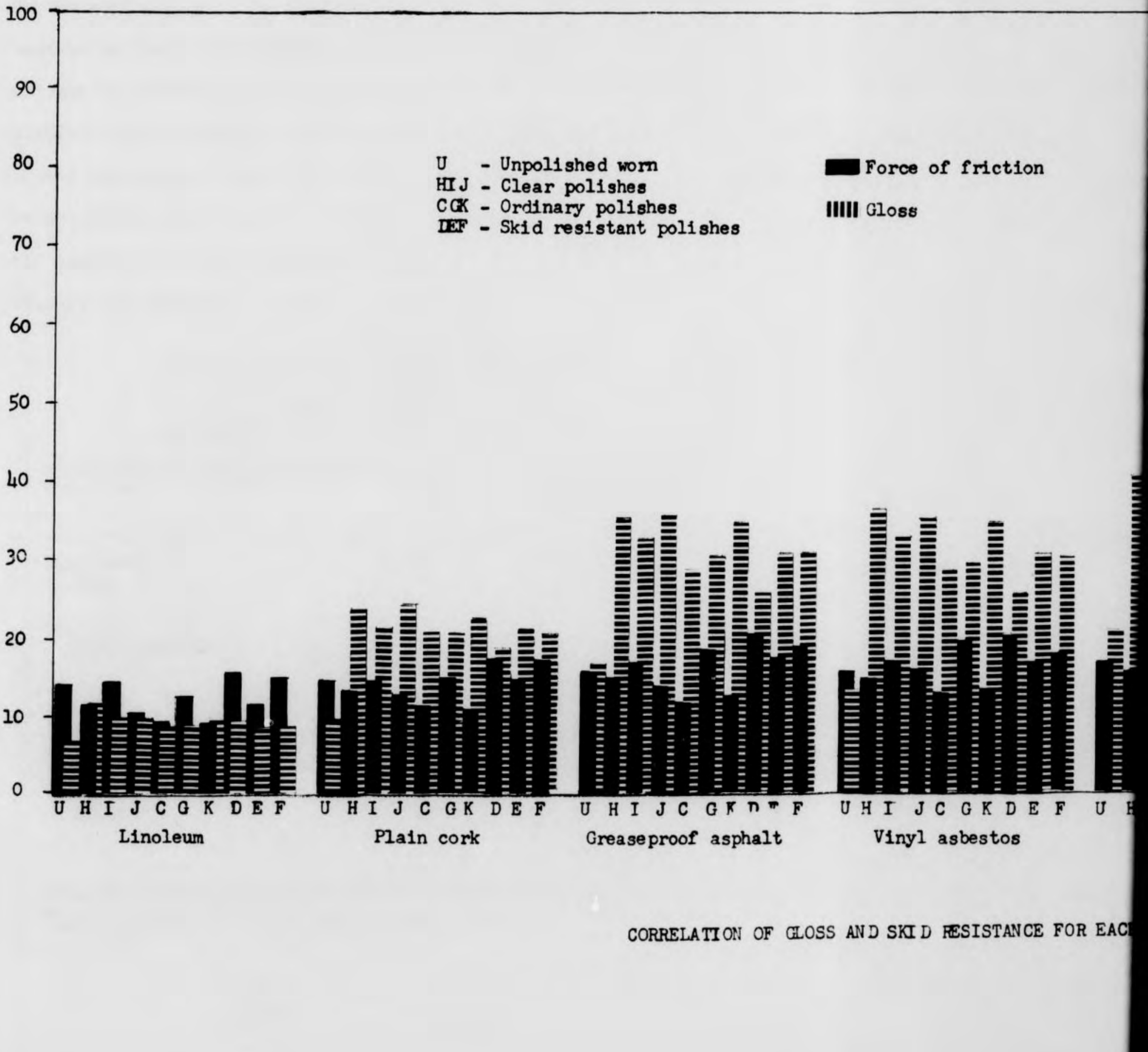
CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH RESILIENT FLOOR MATERIAL UNDER ALL SURFACE CONDITIONS TESTED

Floor material	Correlation coefficient
Linoleum	-0.376**
Asphalt	-0.097
Vinyl asbestos	-0.050
Rubber	-0.048
Vinyl cork	-0.025
Greaseproof asphalt	0.020
Solid vinyl opaque	0.029
Solid vinyl translucent	0.053
Plain cork	0.119

**Significant at the one per cent level.

Floor Surface Conditions (Floor materials allowed to vary)

A positive relationship between gloss and skid resistance was evidenced for each floor surface condition with correlation coefficients ranging from 0.711 for the unpolished condition to 0.915 for one of the polished conditions, all were significant at the one per cent level (Table V). For a given surface condition, with an increase in gloss there was also an increase in skid resistance; this is easily discernable



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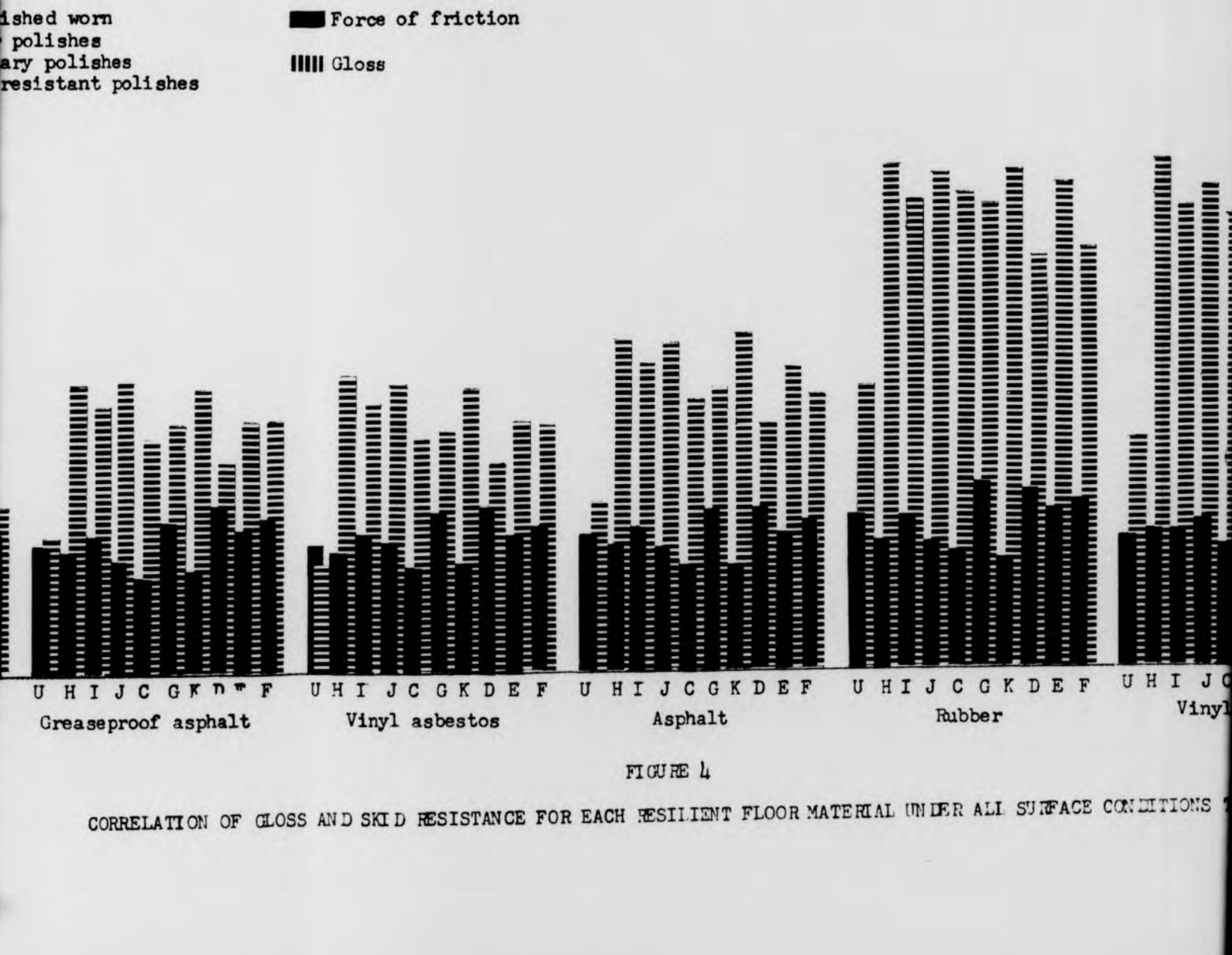
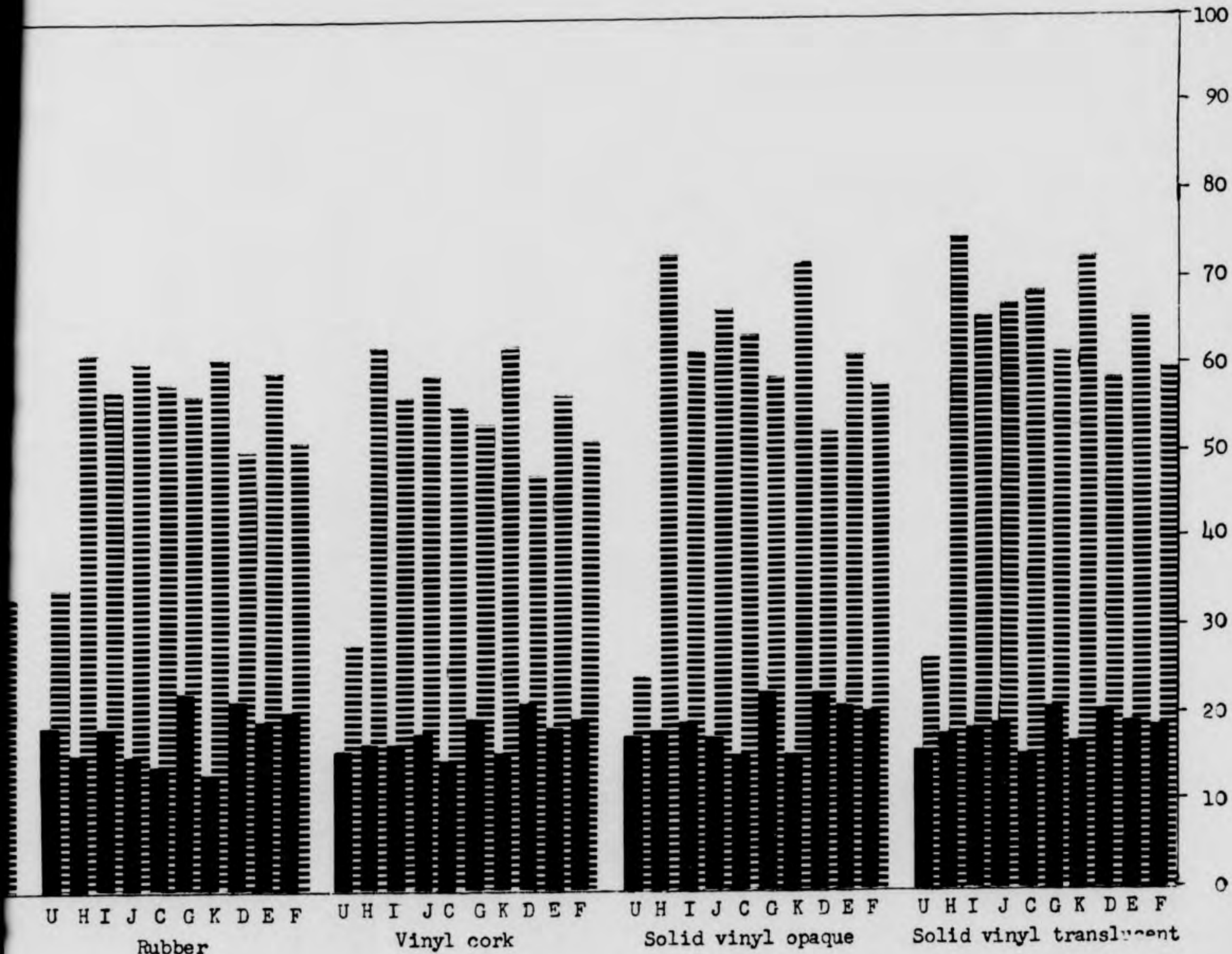


FIGURE 4

CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH RESILIENT FLOOR MATERIAL UNDER ALL SURFACE CONDITIONS

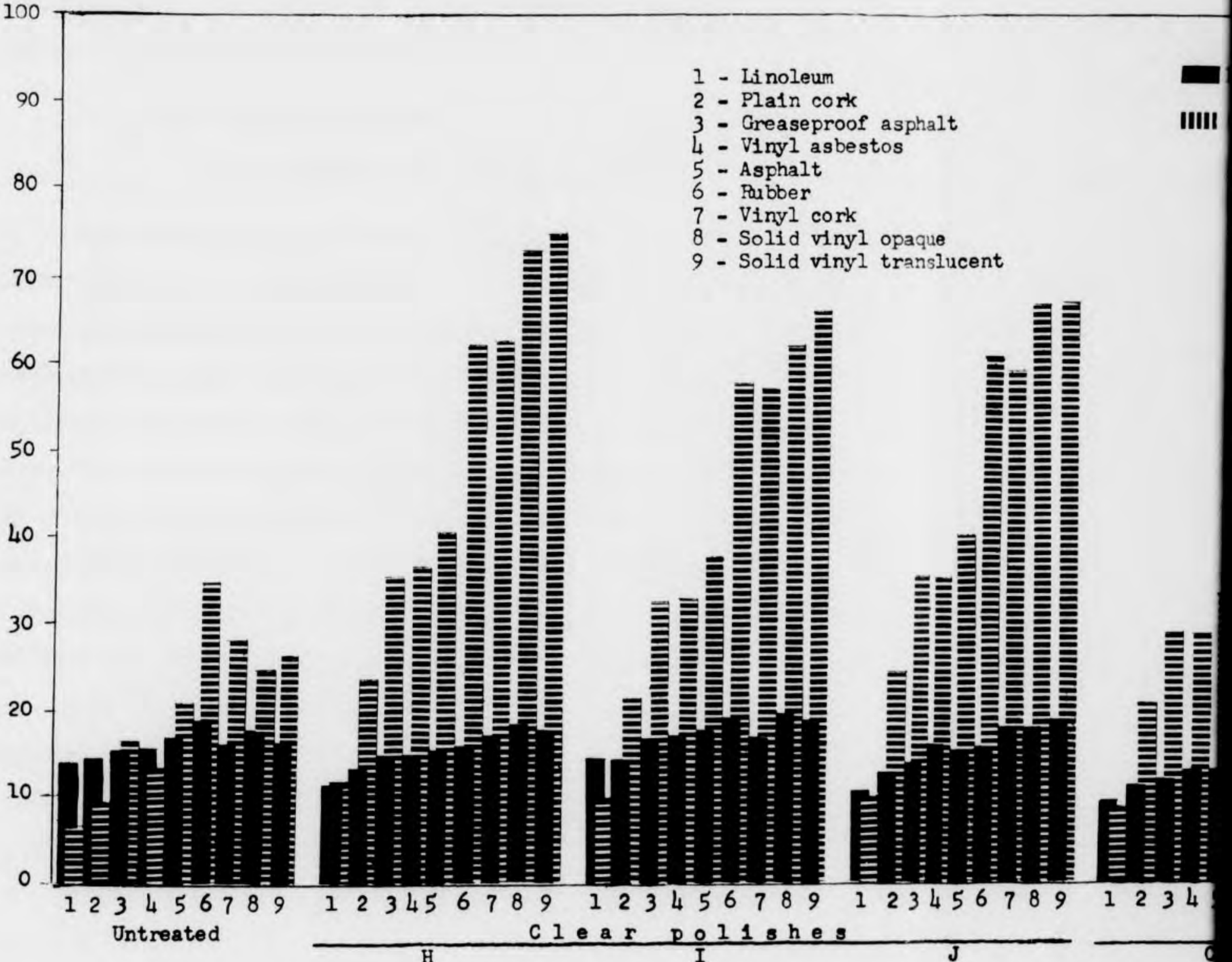


MATERIAL UNDER ALL SURFACE CONDITIONS TESTED by examination of Figure 5. The degree of increase in skid resistance did not correspond to the degree of increase in gloss. Since this was found to be true, the positive correlation between gloss and skid resistance was attributed to the difference in the nature of the floor materials rather than an increase in gloss indicating likewise an increase in skid resistance. Since this was in opposition to the expected results, the hypothesis that there is a negative relationship between gloss and skid resistance of floor surfaces in an unpolished condition and when polished with different polishes was rejected.

TABLE V
CORRELATION OF GLOSS AND SKID RESISTANCE
FOR EACH FLOOR SURFACE CONDITION
FOR THE RESILIENT FLOOR MATERIALS TESTED

Floor surface conditions	Brand	Correlation coefficient**
Unpolished		
Worn	--	0.711
Polished		
Skid resistant	D	0.718
	F	0.723
	E	0.833
Ordinary	C	0.844
	G	0.862
	K	0.869
Clear	I	0.805
	H	0.900
	K	0.915

**All significant at the one per cent level.



CORRELATION OF GLOSS AND SKID RESISTANCE FOR EACH

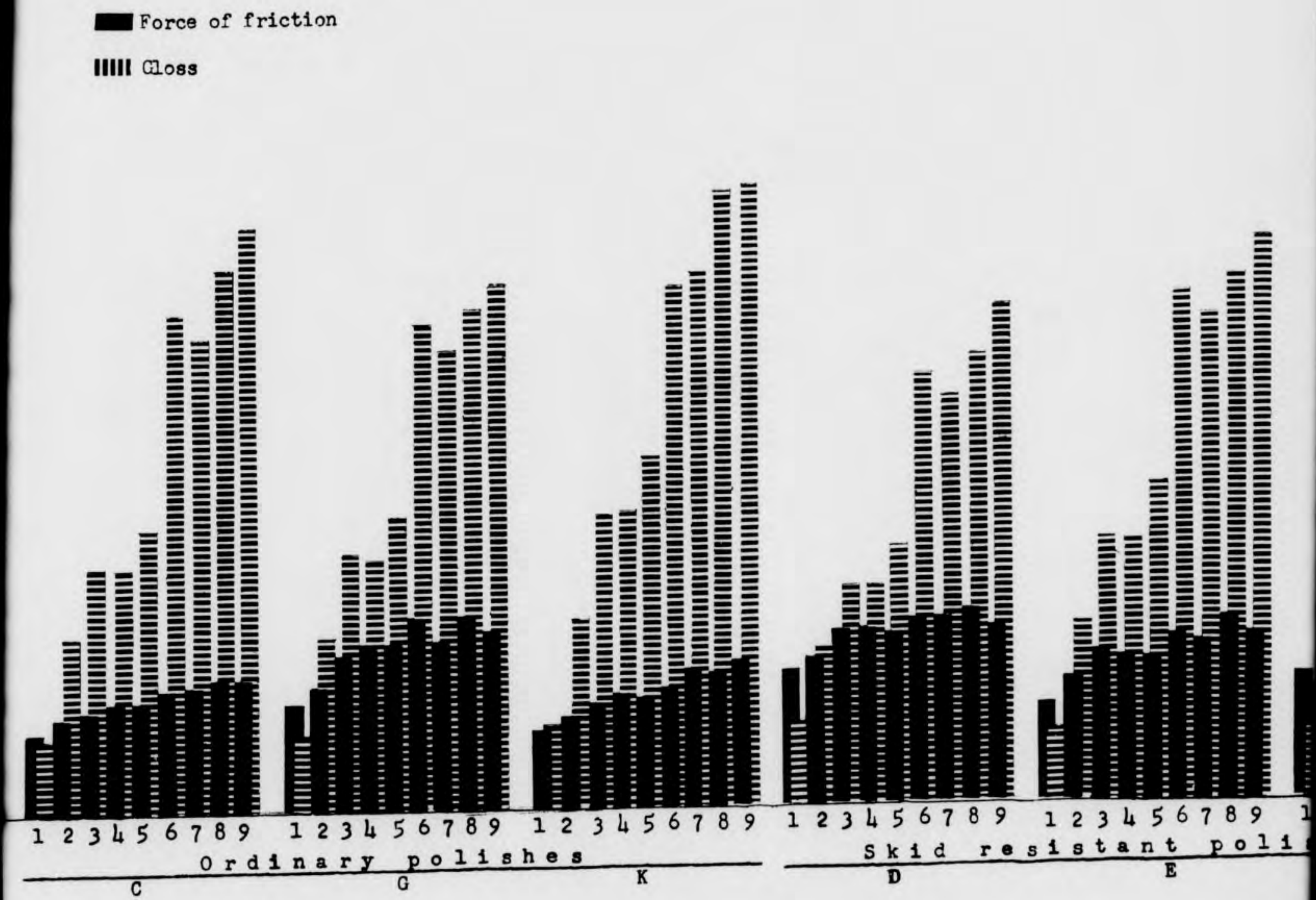
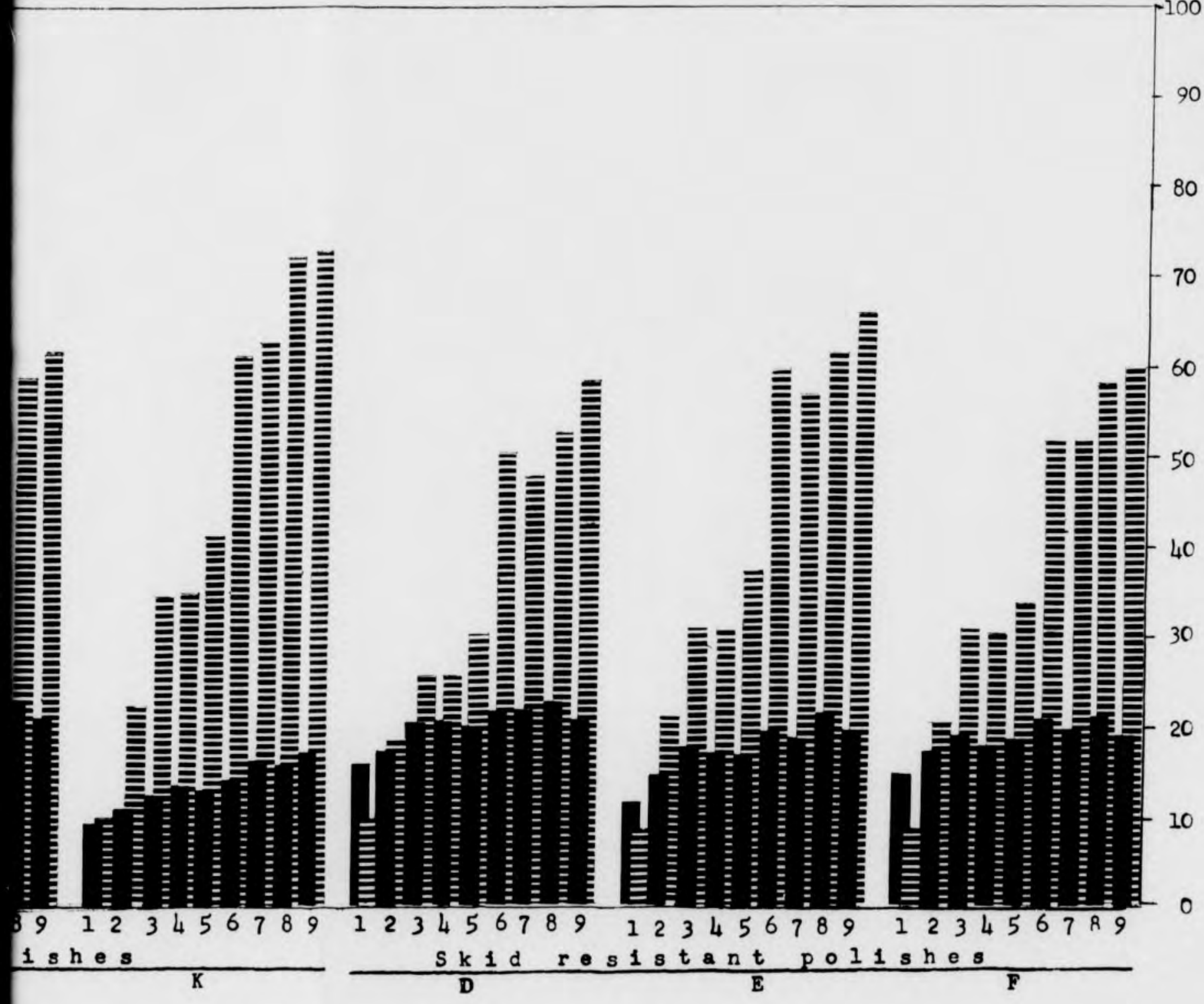


FIGURE 5

NCE FOR EACH FLOOR SURFACE CONDITION FOR THE RESILIENT FLOOR MATERIALS TESTED



THE RESILIENT FLOOR MATERIALS TESTED

The within cell correlation coefficient of 0.390 was significant in this case only by the fact that a large number of degrees of freedom (450 d.f.) or observations, were involved.

IV. SUMMARY OF THE RELATIONSHIP OF GLOSS AND SKID RESISTANCE FOR THE SPECIFIC FLOOR MATERIALS TESTED

The correlation coefficients calculated for the hard floor materials tested with varying surface conditions were essentially negative, and led to not rejecting the hypothesis that there is a negative relationship between gloss and skid resistance of hard floor surfaces tested in an unpolished condition and when polished with different polishes. The results from correlations calculated for the wood floor finishes, and for the hard and resilient floor materials tested with varying surface conditions led in all other cases, to rejecting the hypothesis that there is a negative relationship between gloss and skid resistance for wood floor surfaces with different finishes, and for resilient and hard floor surfaces tested in an unpolished condition and when polished with different polishes.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

This study involved correlation of gloss and force of friction values determined by instrument measurement for wood floor finishes, and for the varying surface conditions of wood, hard, and resilient floor materials. Documentation in literature indicated that the limited exploration in this field has been generally confined to the psychological aspect involving visual estimation of gloss and skid resistance. The references found expressed two concepts relative to this approach. One opinion suggested that glossiness of a floor surface indicated a slippery surface, the other opinion was in direct opposition. Data substantiating either judgment were not presented. One reference was found correlating instrument measurement of gloss and coefficients of friction.

The gloss and force of friction data used in this study for the hard and resilient floor materials were collected in two earlier investigations. However, correlations of these data were not included as a part of the earlier studies. The seven hard floor materials investigated in the study completed in 1964, were specimens of aggregate, ceramic unglazed and glazed, ceramic in vinyl or rubber, concrete, quarry tile, and terrazzo. Six surface conditions were tested, the new and worn unpolished surface and the surfaces after polishing with four different brands of water emulsion polish.

The nine resilient floor materials investigated in the study completed in 1963, were specimens of linoleum, asphalt, vinyl asbestos, rubber, vinyl cork, greaseproof asphalt, solid vinyl opaque, solid vinyl translucent, and plain cork. Ten surface conditions were tested, the worn unpolished surface and the surfaces after polishing with nine different brands of water emulsion polish.

The gloss and force of friction data for the wood floor finishes were collected as a part of this study. Red and white oak flooring, procured from a local manufacturer, were selected for testing. This was in conformance with the wood species and the widely used standard pattern found in homes today. Trapezoid-shaped test panels were constructed from strips of these two species. Surface preparation for finishing was in accordance with standards established by the National Oak Manufacturers' Association. The wood floor finishes appraised were typical of those used by wood floor finishing companies in the Greensboro area and represented products of four manufacturers. Included were a penetrating seal, satin and gloss varnish, shellac, lacquer, an epoxy, and a polyurethane. The order was randomized for assignment of finishes to the test panels. The method prescribed by the specific manufacturer was followed for application of the finishes.

A sixty-degree Gardner Portable Glossmeter was used to obtain gloss measurements for each varying surface condition of the wood, hard, and resilient floor materials. Gloss readings were taken in the center of each test panel and in each of the four corners. An average value was computed from the five readings.

The Bowen Friction Tester was used for obtaining the force of friction values of each varying surface condition for each test panel of the wood, hard, and resilient floor materials.

The data were subjected to correlation analysis. A wide range of varying relationships was indicated between gloss and skid resistance for each of the specific floor materials tested. Correlation coefficients were calculated for the seven wood floor finishes tested, and for the new wood floor material. Likewise, correlation coefficients were respectively calculated for each hard floor material tested with the six surface conditions, and for each resilient floor material tested with the ten surface conditions. Using the same method, correlation coefficients were respectively calculated for each surface condition tested for the seven hard floor materials, and for each surface condition tested for the nine resilient floor materials.

Both significant and insignificant, negative and positive relationships were indicated between gloss and skid resistance for the wood floor finishes. In contrast, significant negative, and insignificant negative and positive relationships were indicated for the hard and resilient floor materials tested with varying surface conditions.

A significant positive relationship was indicated between gloss and skid resistance for the new surface condition of the wood floor material and for the varying surface conditions tested for the resilient floor material. Significant and insignificant positive relationships were indicated for the varying surface conditions tested for the hard floor materials. As gloss increased for a given surface condition tested for the hard and resilient floor materials, the skid resistance increased.

However, for a given surface condition tested for both floor materials, the degree of increase in skid resistance did not correspond to the degree of increase in gloss. These positive correlations between gloss and skid resistance, in each case, were attributed to the nature of the floor materials rather than to an increase in gloss indicating an increase in skid resistance.

These results led to rejecting the hypotheses that there is a negative relationship between gloss and skid resistance for wood floor finishes and for the resilient floor materials, but to not rejecting this same hypothesis relative to the hard floor materials.

II. CONCLUSIONS

From correlation of gloss and force of friction data obtained by instrument measurements of different wood floor finishes, for specific wood, hard, and resilient floor materials tested under various surface conditions the following conclusions were drawn:

1. Wood, hard, and resilient floor materials tested with varying surface conditions did not indicate a consistent pattern of relationships between gloss and skid resistance.

2. The nature of the different wood floor finishes tested may have accounted for the varying pattern of relationships between gloss and skid resistance for this material.

3. The nature of the resilient floor materials tested may have accounted for an increase in skid resistance with an increase in gloss for a given surface condition.

4. The degree of skid resistance of floor surfaces cannot be predicted by the degree of glossiness of the surface. A glossy floor surface may or may not be a slippery surface.

III. RECOMMENDATIONS FOR FURTHER STUDY

Suggestions for extension of the study of floor surface materials with reference to the relationship between gloss and skid resistance, are as follows:

1. Instrument testing of gloss and force of friction of polishes on the diversely finished wood floor surfaces, correlating the data for indication of the relationship between gloss and skid resistance.

2. Instrument testing of prefinished oak flooring for gloss and force of friction, correlating the data for indications of the relationship between gloss and skid resistance.

3. Analysis of the correlation of gloss and force of friction between specific floor surface materials and specific heel materials. This would allow evaluation of the effect of different heel materials on the relationship between gloss and skid resistance.

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